

**FOREST AND NATURE CONSERVATION CODE OF  
BEST MANAGEMENT PRACTICES OF BHUTAN**

**VOLUME III: SUSTAINABLE FOREST MANAGEMENT**



**Department of Forests and Park Service**



## DEDICATION

*A tribute to our benevolent Druk Gyalpo, His Majesty Jigme Khesar Namgyel Wangchuck, for His Selfless Service and Leadership to the People and Country*









MINISTER

ཕྱི་ནང་དང་ནགས་ཚལ་ལྷན་ཁག།  
ROYAL GOVERNMENT OF BHUTAN  
Ministry of Agriculture and Forests  
Tashichhodzong  
Thimphu: Bhutan



### MESSAGE



I applaud the Department of Forest and Park Services for coming up with the Forest and Nature Conservation Code of Best Management Practices of Bhutan which is an updated version of the erstwhile Forest Management Code of Bhutan, 2004. The erstwhile code only covered sustainable management of Forest Management Units. However, with the shift of forest management paradigm to include other important aspects such as climate change, wetland and watershed management, biodiversity conservation & monitoring, agroforestry, payment for ecosystem services etc., a more comprehensive guideline has become imperative. The revised *Code* broadens the scope of applicability covering wide range of contemporary forestry practices providing detailed guidelines on the technical aspects of forest resources management and biodiversity conservation.

The revision of the *Code* is timely and will play a significant role towards sustainable management of our forest resources especially in light of the global climate change and its anticipated impacts on our fragile mountain ecosystems. The *Code* will also take into account the application of advanced technologies in forest management and biodiversity conservation and will provide strong emphasis on monitoring and evaluation of forest and forestry programs which has always been our weakness.

The revised *Code* will also become handy to our colleagues in the field as it will serve as the single source of scientific guideline for all forestry management regimes in the country.

With the publication of this *Code*, Bhutan joins many countries who manage their forest through such technical guidelines. Our country now establishes a robust technical guideline for management of all forest resources in the country and I am confident that it will fulfill our aspiration of bringing all forest resources under sustainable management fulfilling the objectives of our National Forest Policy and the Constitutional mandate of maintaining 60% of forest cover all times to come.

I would like to commend the efforts and hard work of our colleagues in the Department of Forest and Park Services, particularly those who were involved in the revision of this *Code* and I hope this code will be useful to wide range of stakeholders outside of the Department as well.

Tashi Delek!

Yeshe Penjor



ཕྱི་ནང་འཕེལ་རྒྱུ་ལྟན་འགྲུལ་  
ROYAL GOVERNMENT OF BHUTAN  
Ministry of Agriculture and Forests  
Tashichhodzong  
Thimphu: Bhutan



SECRETARY

### MESSAGE



I commend the Department of Forest and Park Services in bringing out the revised Forest and Nature Conservation Code of Best Management Practices of Bhutan which presents a comprehensive technical guideline for sustainable management of forest resources and biodiversity conservation in the country.

The intricate combination of several programs and activities on sustainable forest management and biodiversity conservation is fundamental to sustainable development, from their vital role as climate regulator, carbon sequestration and the vital ecosystem services they provide. Sustainable management of these forest resources are therefore essential if these benefits for the environment and societies are to be maintained for future generations. Such long-term feats can be achieved only if we are able to manage the huge forest base resources holistically.

Such holistic achievement can only be possible through a science based technical guideline - the *Code*. Its implementation will also ensure that the forests in Bhutan are managed through the integration of good science, research, technology and decades of forest management experiences.

The code also provides consistent and transparent approach to planning and implementation of sustainable forest management plans, conservation plans and activities at all levels and across all other cross-cutting management regimes. The *Code* now provides the deep nexus in making appropriate science-based decisions on several forestry and conservation issues.

I would like to congratulate the Department and in particular the technical working group members for coming up with this code which is a milestone in our effort towards sustainable forest management and biodiversity conservation.

I urge all relevant stakeholders, government and non-government, besides the colleagues of the Department of Forest and Park Services to actively use and implement the Code in managing our forest resources for the benefit of present and future generations.

Tashi Delek!



Rinzin Dorji



དངམ་རྩོན་འཁུགས་གཞིར། སོ་ནམ་དང་ནགས་ཚལ་རྩོན་ལས། ནགས་ཚལ་དང་གླིང་ཀ་ཁབས་ཏྲིལ་ལས་ཁྱེད་ལྟུངས།

**ROYAL GOVERNMENT OF BHUTAN**

Ministry of Agriculture and Forests

**Department of Forests and Park Services**

DIRECTOR

## Thimphu: Bhutan



## FOREWORD



Forests have always played a key role in the livelihood of Bhutanese and is intrinsically intertwined with the social, culture and tradition of our country. In view of its pivotal role not only on socio economic development but also on climate regulatory function through several means and vital ecosystem services, sustainable forest resources management has always played a key role in sustaining our natural forest resources. Bhutan is one of the few countries in the world that enshrines forest and environmental conservation aspects in its Constitution. Article 5 of the Constitution of the Kingdom of Bhutan reflects commitment to ensure that, in order to conserve

the country's natural resources and to prevent degradation of the ecosystem, a minimum of sixty percent of Bhutan's total land shall be maintained under forest cover for all time. Bhutan also committed to remain carbon neutral at the 15th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2009 in Copenhagen, Denmark. In addition, the Intended Nationally Determined Contribution (INDC) submitted in September 2015 towards finalization of Paris Agreement further re-iterated Bhutan's pledge to remain carbon neutral. Today with over 71% of the total land of Bhutan under forest cover (2,717,161 ha), forests form an important and indispensable national asset sequestering around 8.5 million tonnes of carbon, generating continuous water flow to sustain our hydro power systems, providing timber and firewood resources to Bhutanese citizens etc.. Out of the total forest area (2,717,161 ha) about 33.29% (904,423.78 ha) fall within the Protected Area Systems (National Parks, Wildlife Sanctuaries and Strict Nature Reserve) and about 19.96% (542,346.32 ha) is managed as Forest Management Units, Community Forests and Local Forest Management Areas.

Therefore, in order to fulfill our international commitment to remain carbon neutral and constitutional mandate of maintaining 60% forest cover for all times to come besides harnessing other benefits such as social, cultural, economic and ecosystem services, it is imperative that the Department possesses a *Code* outlining science based management of the overall forests and biodiversity resources which will enhance the productive and ecological functions of our forest ecosystems. This *Code* has been developed through integration of good science, research, technology and decades of forest management experiences. It gives me a great pleasure in congratulating the entire Technical Working Group involved in the preparation of this *Code*. This *Code* will definitely strengthen the sustainable forest resources management and biodiversity conservation practices in Bhutan for eons to benefit the present and future generations.

Tashi Delek!



Lobzang Dorji

## **INTRODUCTION**

Volume III of the Forest and Nature Conservation of Bhutan Code of Best Management Practices of Bhutan (hereinafter referred to as the *Code*) provides technical guidance on the preparation of forest management plans for Forest Management Units (FMU), Local Forests Management Areas (LFMA), Community Forests (CF), and Private forests. The Forest Management Code of Bhutan (FMCB) 2004 included only the FMU Planning and implementation guidelines. In order to include other sustainable management aspects, and to make the *Code* more comprehensive, Volume III of the *Code* has been updated and includes the following chapters.

Chapter 1: Forest Management Unit

Chapter 2: Community Forest Management

Chapter 3: Local Forest Management Area

Chapter 4: Private Forest Management

The Department identifies potential forest production areas based on the forest potential resources assessment carried out as per the prescriptions defined in Volume II of this *Code*. This volume, therefore, includes guidelines on the purpose, principles and process of preparation, approval and implementation of forest management plans by field offices and other authorized implementing agencies.

While the *Code* shall guide the forest managers in the preparation and implementation of forest management plan for state reserved forest (SRF), it shall also provide or suggest appropriate management practices for private forest, if necessary or as and when private owners wish to seek technical guidance for scientific management of their private forest.

## ACRONYM

AAC	Annual Allowable Cut
A	Adjustment period (the period during which the difference between normal and actual GS is adjusted)
AAC	Annual allowable cut
AGB	Above Ground Biomass
BA	Basal Area
BGB	Below Ground Biomass
CF	Community Forest/Community Forestry
CFMG	Community Forest Management Group
CFMP	Community Forest Management Plan
CFO	Chief Forestry Officer
cft	Cubic foot/feet
CV	Coefficient of variance
dbh	Diameter at Breast Height
DEM	Digital Elevation Model
DFO	Divisional Forest Offices
DoFPS	Department of Forests and Park Services
DT	Dzongkhag Tshogdu
EA	Environmental assessment
EFS	Economic Feasibility Study
FMCB	Forest Management Code of Bhutan
FMP	Forest Management Plan
FMU	Forest Management Unit
FNCA	Forest and Nature Conservation Act, 1995
FNCRR	Forest and Nature Conservation Rules & Regulations, 2017
FRA	forest resources assessment
FRMD	Forest Resources Management Division
FYP	Five Year Plan
GIS	Geographic Information System
GPS	Global Positioning System
GS	Growing stock
GSa	Present (actual) GS
GSr	Desired (normal) GS
GT	Geog Tshogde
ha	Hectare
I	Increment of the entire forest
IEE	Initial Environmental Examination
IPCC	Intergovernmental Panel on Climate Change
LFMP	Local Forest Management Plan
LG	Local Government
LULC	Land Use and Land Cover
M <sup>3</sup>	Cubic meter
MA&D	Market Analysis and Development
MAI	Mean annual increment
MoAF	Ministry of Agriculture and Forests

NB	Biodiversity Protection
NRDCL	Natural Resources Development Corporation Limited
Nu	Ngultrum
NWC	Wildlife Conservation
NWFP	Non-Wood Forest Produce
NWP	Wildlife Protection
OP	Operational Plan
PFMP	Participatory Forest Management Project
PRA	Participatory Rural Appraisal
R	Rotation (or felling cycle)
RFI	Reconnaissance Forest Inventory
RRA	Rapid Rural Assessment
SES	The Socio-Economic Study
SFM	sustainable forest management
SocL	Social (Local Use Only)
SocRS	Social (Religious Site Protection)
SRFL	State Reserves Forest land
TMB	Tree marking book
UWICER	Ugyen Wangchuck Institute for Conservation and Environmental Research

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## 1. Forest Management Units

**Authors:**

1. Tashi Norbu Waiba, Dy. Chief Forestry Officer, FRMD
2. Arun Rai, Principle Forestry Officer, FRMD
3. Dorji Wangdi, Dy. Chief Forestry Officer, FRMD
4. Dawa Zangpo, Dy. Chief Forestry Officer, FRMD
5. Kinley Dem, Dy. Chief Forestry Officer, FRMD

**Contributors:**

1. Norbu Wangdi, Chief Forestry Officer, FRMD
2. Saran Pradhan, Dy. Chief Forestry Officer, FRMD
3. Jamyang Choden, Forestry Officer, FRMD
4. Ugyen Tshering, Sr. Forest Ranger II, FRMD
5. Tsheddar, Senior Forest Ranger, FRMD
6. Norbu Wangchuk, Senior Forester, FRMD
7. Choney Wangmo, Forest Ranger II, FRMD
8. Namgay Bidha, Forest Ranger II, FRMD



## **1. Forest Management Units**

### **1.1. Management Context**

#### **1.1.1. Background**

Forest is seen as a major component of the socio-economic development of Bhutan and a means to alleviate rural livelihood. The Thrimzhung Chenmo, 1953 provided for open access to use of forest resources, which led to unregulated extraction of timber. A need for scientific management of forest was increasingly realized and the first working plan division was established in Samtse before the advent of the first five-year plan. The first working plans for two areas viz., Manas and Gaylegphug were approved by the Government and implemented as working schemes in 1964-65 (Seltzer 1991).

The National Forest Policy 1974 provided the foundation for scientific management of forests which was reiterated in the Forest and Nature Conservation Act 1995, which further emphasized to bring all forests under scientific management. As a result, more areas were managed under scientific management through the establishment of Forest Management Units (FMU) and subsequently, Forest Management Code of Bhutan (FMCB) was developed in 2004 to guide and standardize the planning and implementation of scientific management of FMUs.

The Code provides an updated guidance and prescriptions for the preparation and implementation of management plan for FMU and derive the legal basis from the forest legislations. Further, the Code also provides guidance on the preparation of an annual operational plan (OP) for the FMU. The OP shall be prepared for all FMUs to ensure that the operation is in accordance with the prescriptions of the Forest Management Plan (FMP) or any other revisions hereafter.

#### **1.1.2. General Principles**

FMP shall be prepared following some of the important principles which are based on national policies, and best sustainable forest management practices.

##### ***Objective-led***

FMU management plans should be objective-led and inclusive. Activities (e.g. timber harvesting, grazing management, NWFP collection, watershed management, management of protection, conservation areas, etc.) need to be identified to achieve specified management objectives.

Identifying and stating the management objectives shall make the FMP more logical and science based. Objective setting and agreement on objectives should be one of the first planning steps which can be done in a participatory manner with the FMU-level management committee.

##### ***Inclusive***

A management plan for an FMU needs to combine national with locally derived (FMU specific) forest management objectives which sometimes gives rise to conflicting objectives. Often it requires compromise or trade-off between such conflicting objectives. Such trade-offs, if any, should be decided during the stakeholder consultation meeting.

##### ***Adaptive***

Ideally, a FMP implementation needs to be carried out as per prescriptions. However, in the event of unforeseen natural events such as pest and disease outbreak, forest fire disasters, etc., the FMP needs to be amended with suitable prescription for that particular forest stand/area.

##### ***Time-bound***

FMU plans should be time-bound. The current system in Bhutan is to prepare science based FMP for a 10-year period. There shall be a mid-term evaluation (reviewing the level to which forest management objectives have been achieved) during the fifth year and during which alterations can be made to the plan. A

similar evaluation shall take place during the last quarter of the ninth year, to review the level of achievement of management objectives. Results of this final evaluation shall be incorporated into the next 10-year plan.

## 1.2. Roles and Responsibilities

The Divisional Forest Offices (DFO) shall prepare the management plan with technical support from Forests Resources Management Division (FRMD). The FMP is a holistic science based sustainable forest management plan prepared in consultation with the Local Government (LG) and other relevant stakeholders. The implementation of FMU activities should be based on annual OP approved by the Department of Forests and Park Services (DoFPS) (hereinafter referred to as the Department). The Natural Resources Development Corporation Limited (NRDCL) or any other authorized agency shall ensure that the activities are implemented as per the prescription of the OP and the management plan. Some of the most important roles of the key actors in the management planning and implementation process are suggested in Table 1.1.

*Table 1.1 Roles and responsibilities*

Offices	Roles and Responsibilities
<b>FRMD</b>	<ul style="list-style-type: none"> <li>• Conduct Forest Resources Potential Assessment (FRPA)</li> <li>• Provide technical support for the conduct of Reconnaissance Survey (RS).</li> <li>• Provide technical support for the conduct of resource inventory.</li> <li>• Provide technical support for forest function mapping.</li> <li>• Conduct cold and hot check during forest resource inventory</li> <li>• Review the FMP prepared by the field offices and process for approval from the Ministry.</li> <li>• Process for Environmental Clearance (EC) from National Environment Commission Secretariat (NECS).</li> <li>• Review and approve the operational plan (OP) prepared by the field offices.</li> <li>• Monitor and evaluate the implementation of FMU activities.</li> </ul>
<b>DFO</b>	<ul style="list-style-type: none"> <li>• In coordination with FRMD, identify new potential FMU areas recommended by the FRPA 2013.</li> <li>• Prepare the FMP following the steps detailed out in the <i>Code</i>.</li> <li>• Coordinate the formation of and participate in FMU-level management committee meetings and discussions (CFO acts a chairman of the committee).</li> <li>• Prepare and ensure the implementation OP.</li> <li>• Regulate and monitor the implementation of the FMPs.</li> <li>• Report on progress in implementing activities within OP (annually through an FMU annual monitoring report).</li> </ul>
<b>Authorised agency</b>	<ul style="list-style-type: none"> <li>• Participate in preparation of FMP and OP.</li> <li>• Implement the FMP and OP activities.</li> <li>• Fund the FMU implementation activities.</li> <li>• Participate in FMU-level forest management committee meetings.</li> <li>• Carry out afforestation and reforestation.</li> </ul>
<b>LG</b>	<ul style="list-style-type: none"> <li>• Participate in the planning and implementation of social and extension-oriented activities.</li> <li>• Participate in FMU-level forest management committee meetings as representatives of local stakeholders.</li> </ul>



The DFO shall ensure that the approved plan is implemented effectively through establishment of FMU-level Forest Management Committee. The objectives, legal basis, membership, meeting cycles and terms of reference of the committee are provided in Table 1.2.

*Table 1.2 Composition and ToR of FMU-level Forest Management Committee*

<b>FMU-Level Forest Management Committee</b>	
Objective(s)	Ensure effective participation of stakeholders in FMU planning and implementation
Basis	FNCRR 2017  Forests and Nature Conservation Code of Best Management Practices of Bhutan  FMP
Membership	<b>Members</b>  <ol style="list-style-type: none"> <li>1. CFO (Chair), DFO</li> <li>2. Regional Manager, NRDCL or any other Authorized Agency</li> <li>3. Unit Incharge, FMU</li> <li>4. Production Incharge, NRDCL or any other Authorized Agency</li> <li>5. Gup of concerned Gewogs</li> </ol>
Meeting cycle	During preparation of FMP: Up to four meetings  Thereafter: minimum once a year (at discretion of chair)
Terms of reference	<b>FMP preparation</b> <ul style="list-style-type: none"> <li>• Consult with stakeholders &amp; represent their interests during planning</li> <li>• Discuss &amp; agree management objectives</li> <li>• Review &amp; endorse the draft FMP</li> </ul> <b>Operational planning &amp; implementation</b> <ul style="list-style-type: none"> <li>• Represent interests of stakeholders during operational planning</li> <li>• Review achievements of previous year, advise &amp; act on any issues identified in FMU annual report</li> <li>• Endorse activities, priorities &amp; funding arrangements within the draft OP before submission to FRMD</li> <li>• Hold additional meetings as required in response to specific issues arising from FMP &amp; OP implementation</li> </ul>

### 1.3. Forest Management Planning Process

The FRPA identifies potential area for production forest. Thereafter, the creation of FMU involves a series of processes from reconnaissance survey to the implementation of the management plan. The overall framework is depicted in Figure 1.1 and described briefly in Table 1.3.

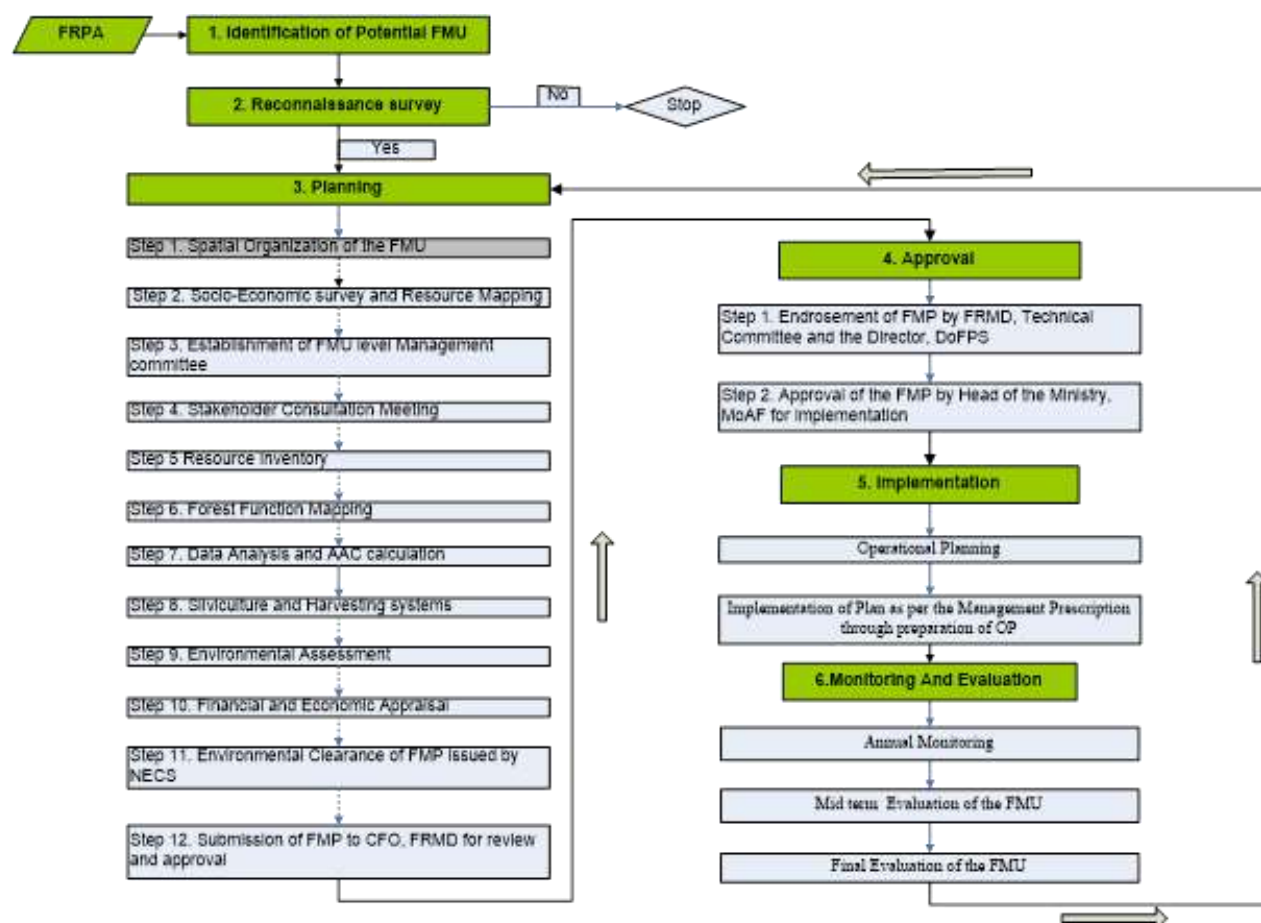


Figure 1.1 FMU Planning Process

Table 1.3 Steps for FMU Planning

1. Identification of potential FMU						
Activity	Objective	Output	Lead agency	Collaborators	Comments	
Identification of potential FMU area	To identify potential FMU based on FRPA results	Potential FMU area identified	DFO	FRMD	FRPA results must be referred	
2. Reconnaissance Survey						
Activity	Objective	Output	Lead agency	Collaborators	Comments	
Reconnaissance Survey	To carry out preliminary assessment of the identified FMU area	Decision on establishment of FMU based on reconnaissance survey report	DFO	FRMD	Socio-economic survey (SES), Initial Environmental Examination (IEE), Reconnaissance Forest Inventory (RFI), Economic Feasibility Study (EFS).	
3. Planning						
Steps	Activity	Objective	Output	Lead agency	Collaborators	Comments
1	Spatial Organization of the FMU	To finalize the FMU area. To establish or review block, compartment & sub-compartments	Exclude managed area and Private Forests. Map of block, compartment & sub-compartment boundaries	DFO	NRDCL or any other authorized agency	
2	Socio-Economic Survey (SES) and Resource Use Mapping	To provide information on the local use of the forest area	Participatory resource use map and social information on stakeholders	DFO	LG	
3	Establishment of FMU-level forest management committee	To agree on the composition and role of the FMU-level forest management committee	a. List of committee members b. Agreed ToRs for FMU-level forest management committee	DFO	NRDCL	The committee needs to ensure that all stakeholder groups are represented. Commitment of members is needed to ensure their involvement in planning steps.

4	Stakeholder consultation meeting	To take on board the interest of stakeholders in FMP and decide how their interests can best be represented	Local Government / Public endorsement	DFO	NRDCL/ LG	Emphasis on institutional representation of all stakeholder groups including local government. Representatives must have local knowledge of the FMU.
5	Forest function mapping	To segregate the FMU area into protection, non-production and production zones. restrictions	Prepared map showing zones and sub-zones based on forest functions	DFO	NRDCL/LG	Revisions of plans should include review and update of forest function mapping
6	Resource Inventory	To collect and map the forest resource data	Generate Forest Inventory data report	DFO / FRMD	DFO / FRMD	Start one year before new plan is due to begin
7	Data analysis, Annual Allowable Cut (AAC) calculation	To assess the growing stock of the FMU To determine the AAC of the FMU	Determine the Volume per ha and other parameters Estimate of the AAC	DFO	FRMD	Zones determined by their primary management objective
8	Silvicultural & Harvesting systems	To determine appropriate silvicultural and harvesting strategies and systems for the FMU	Appropriate silvicultural and harvesting systems recommended	DFO	NRDCL	
9	Environmental assessment	To identify environmental issues, potential impacts & mitigating measures	Environmental statement as integral part of FMP	DFO	LG, Dzongkhag Environment Officer (DEO)	FMP (with integral environmental statement) to be approved by NECS (i.e. environmental clearance granted)
10	Financial & economic appraisal	To identify factors affecting supply and demand, to assess cash flow & financial viability, to undertake cost-benefit analysis including consideration of non-market costs and benefits	Statement of factors affecting supply & demand for forest products in FMU & implications for forest management. 10-year cash flow forecast. Long-term cost-benefit analysis.	DFO	NRDCL	

				Statement of non-market costs & benefits & implications for forest management.			
11	Environmental clearance of FMP by NECS	To obtain environmental clearance for all proposed activities in FMP		Environmental clearance obtained from NECS	FRMD	NECS	
1. Approval							
Steps	Activity	Objective	Output	Lead agency	Collaborators	Comments	
1	Endorsement of FMP by FRMD, Technical Advisory Committee (TAC) and the Head of Department	To ensure that the plan is consistent with the technical standards and other legal provisions as enshrined in Acts, Policies and Rules.	FMP technically reviewed and endorsed by FRMD, TAC and the Head of Department.	FRMD	DFO		
2	Approval of FMP by the Head of the Ministry	Approve the FMP for Implementation	FMP approved for implementation	FRMD	DFO		
2. Implementation							
	Activity	Objective	Output	Lead agency	Collaborators	Comments	
1	Preparation of OP	To prioritize activities for the two-year rolling plan based on FMP	OP prepared	DFO	FRMD, NRDCL		
2	Implementation of OP	To implement the activities prescribed in the OP	OP implemented	DFO	NRDCL		

<b>3. Monitoring and Evaluation</b>						
	<b>Activity</b>	<b>Objective</b>	<b>Output</b>	<b>Lead agency</b>	<b>Collaborators</b>	<b>Comments</b>
1	Annual Monitoring of FMU by Unit Incharge	To annually monitor the implementation of FMU activities	1. Physical and Financial Form 1 to 3. 2. Environmental Form 4 to 10 3. Physical, Financial and Environmental Summary form 11	FMU	NRDCL	
2	Annual Monitoring of FMU by DFO	To annually monitor the implementation of FMU activities	Annual Monitoring Form A	DFO	NRDCL	
3	Annual Monitoring by FRMD	To monitor the implementation of FMU activities	Review and monitor the progress of the implementation of the OP	FRMD	DFO, NRDCL	
4	Mid-Term Evaluation	To review progress against FMP objectives and amend the FMP if required	Mid-Term evaluation report along with due observations and recommendations	FRMD	DFO, NRDCL	
5	Final Evaluation	To review progress against FMP objectives	Final Evaluation Report	FRMD	DFO, NRDCL	

## **1.4. Reconnaissance survey**

Reconnaissance survey is a preliminary survey conducted in the area proposed for creation of FMU. The reconnaissance survey shall examine the area with respect to forest types, wildlife, NWFPs, general topography, road connectivity and accessibility, cultural significance, past and current management history, socio-economic status of the people living within the area, climate, weather, etc. The reconnaissance survey is a first step in the FMU planning process and is a more detailed assessment of a particular forest area that has been defined as a potential FMU by the FRPA.

### **1.4.1. Objective**

To provide the decision makers of the Department and authorized agency with all the social, environmental and economic information that is required to decide whether or not an FMU should be operationalized and managed on a commercial basis.

### **1.4.2. Preparation of Reconnaissance Survey**

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

#### **1.4.2.1 Identification of FMU and Verification of Boundary**

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

- Topography (slope);
- Forest condition (type and density); and
- Exclude already protected and/or managed areas.

At this stage, the boundaries of the proposed FMU should be checked whether they are practical and logical. Once, the boundary has been identified, it has to be marked on a topographic map 1:50,000 and set of photocopies should be prepared (at least 10).

However, before the actual work starts, it needs to be ensured, that the proposed FMU is not located in a protected or otherwise restricted area, Community forest (CF), or included under some other form of management regimes.

#### **1.4.2.2 Collection of Information and Preparation for Field Work**

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

1. Topographic map with 40 m contour lines at a scale 1:50,000 (including FMU boundary);
2. Land Use and Land Cover (LULC) map at a scale 1:50,000;
3. Satellite image (if available); and
4. Aerial photos (if available).

The preparation of the preliminary forest type map should be done based on the latest LULC maps. Experiences made during field truthing exercises in forest management planning have shown that LULC maps are quite accurate as far as forest/non-forest boundaries are concerned. Forest land-use, however, has been often misinterpreted by LULC. Therefore, the forest/non-forest boundary should be determined based on LULC working map (if available, verify with satellite imagery or aerial photographs), the forest types, however, should be derived from the forest type maps.

(GIS) A slope map at a scale 1:50,000 with 90 m contour intervals based on the Digital Elevation Model data (or better contour maps with smaller intervals if available), should be prepared with the following slope



classes marked on: (i) < 46.63 % (25°), (ii) 46.63 % (25°) - 70.02 (35 °), (iii) 70.02 % (35 °) - 100 % (45 °) , (iv) > 100 % (45 °).

Areas with slopes above 100 % (45 °) should be considered as inoperable<sup>1</sup>. Overlay the inoperable area from the slope map to the preliminary forest type map. This shall be the base map for the reconnaissance survey. This map should be available at a scale of 1:25,000 and 1:50,000.

### **1.4.3. Components of the Reconnaissance Survey**

Before the actual Reconnaissance Survey takes place, a *Pre-RS Field Check* must be carried out to check whether the area is suitable for commercial forest management. This step is very important. A short field visit may provide a quite different view of the proposed FMU and should reveal any obvious errors. Information available may have been superseded or may be wrong. For example, an area may already have been logged. Local people should be informed at that stage, that the Government has the intention to check whether this area is suitable to be opened as FMU on a commercial basis. They should also be informed about the subsequent steps of the reconnaissance survey, in particular on the Reconnaissance Forest Inventory (RFI). During the Pre-RS Field Check, an experienced forester should assess:

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

This field check should take approximately two to three days. Based on its result, which has to be summarized in the form on Pre-RS Field Check (Table 1.4), the CFO should decide whether or not a Reconnaissance Survey shall be carried out.

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<sup>1</sup> According to § 14 a (iii) of the Forest and Nature Conservation Act (1995) "no permits shall be issued to fell and to take any timber where the slope is greater than 45 degrees (100%) unless authorized under an approved management plan or by the Head of the Department."

Table 1.4 Pre-RS Field Check Form

Reconnaissance Survey	
Pre-RS Field Check	
<b>Name of FMU:</b>	<div style="border: 1px solid black; width: 200px; height: 60px; margin: 5px;"></div>
<b>Area:</b>	<div style="border: 1px solid black; width: 60px; height: 30px; display: inline-block;"></div> ha
<b>Gewogs:</b>	<div style="border: 1px solid black; width: 240px; height: 20px;"></div>
<b>Confirmation that the FMU boundaries as defined are reasonable:</b> <div style="border: 1px solid black; height: 100px; margin-top: 5px;"></div>	
<b>Is the forest type classification map updated? (including degraded forests)?</b> <div style="border: 1px solid black; height: 100px; margin-top: 5px;"></div>	
<b>Is the mapping of operable and non-operable areas reasonable? If not, suggest changes</b> <div style="border: 1px solid black; height: 100px; margin-top: 5px;"></div>	
<b>Describe significant environmental risks:</b> <div style="border: 1px solid black; height: 100px; margin-top: 5px;"></div>	

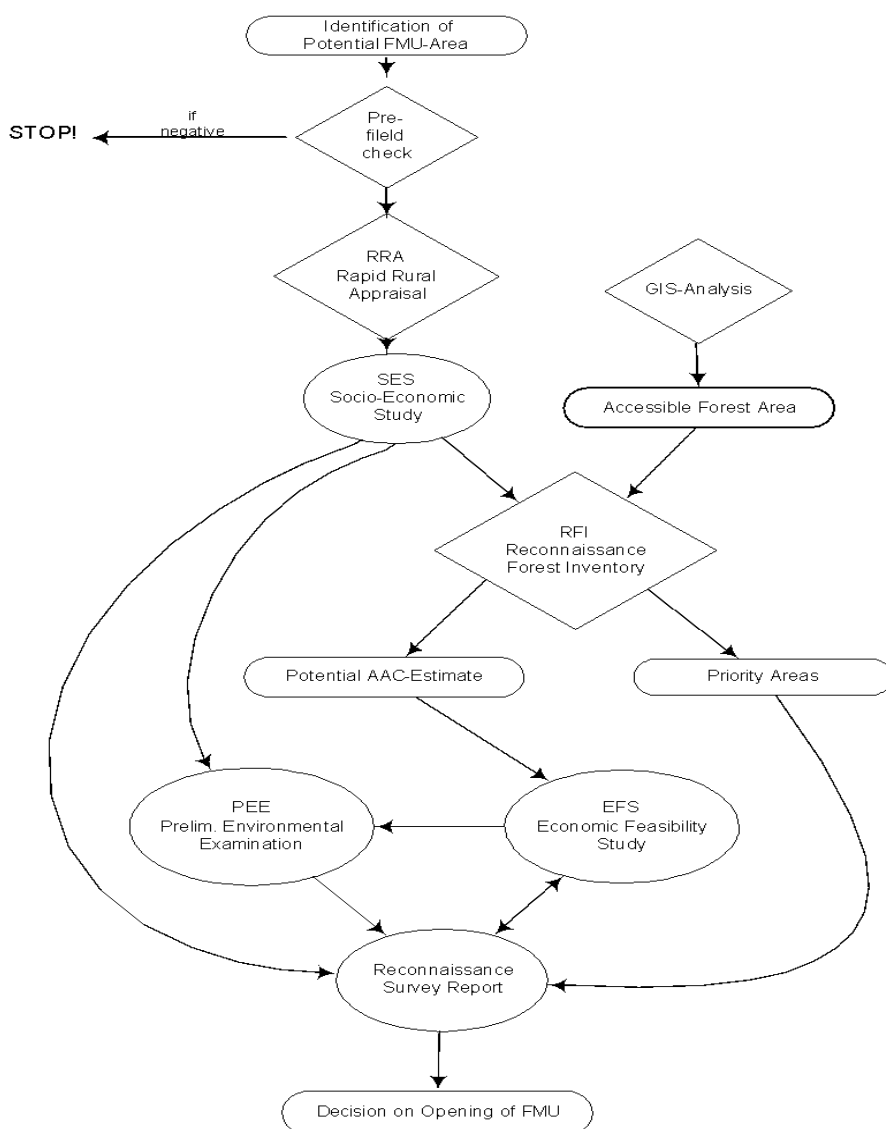
<b>Describe current forest uses (legal, illegal, local) and concerns with respect to forest use:</b>	
<b>For the field work, describe general conditions (food and accommodation, transport options, camp sites</b>	
<b>Other observations, personal opinion/recommendation:</b>	
Date:	<div></div>
Completed by:	<div></div>
Name and Rank	

If this check comes to a positive result, the actual reconnaissance survey is carried out. This consists of the following four components:

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

The results of the individual components have to be compiled into a *Reconnaissance Survey Report* and submitted to the head of the Department for decision making.

Figure 1.2 shows the process of conducting a Reconnaissance Survey.



*Figure 1.2 Process of conducting a Reconnaissance Survey*

### 1.4.3.1 Socio-Economic Study (SES)

The SES is based on a Rapid Rural Assessment (RRA) as well as key social data. Information on local resource use should also be collected. The most important aspect, however, is to identify whether there is any social opposition, perception or constraint which might affect the management of FMU.

#### 1.4.3.1.1 Objective

The objective of the SES is to:

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

#### 1.4.3.1.2 Data Collection and Source of Information

The information required for the SES are provided through the RRA and the RNR Census data.

- **Rapid Rural Assessment**

The RRA, in this context, is an informal meeting with the villagers and local people living in the concerned FMU area. It should be conducted, whenever possible, during the course of the Pre-RS Field Check. It is of importance, that the RRA is headed by a forester who has experience in participatory approaches and in the implementation of village meetings. During the RRA the following topics should be dealt with.

- Information on the intention to open FMU:** The objective of the RRA is, first of all, to inform the local people on the intention of the Government to open a FMU in their area. They have to be informed at this early stage about the consequences and possible effects (positive and negative) of forest management on their livelihood and on the environment.
- Informal discussions to identify objections and constraints:** During informal discussions (attention should be paid that male and female are equally addressed) the local people should be informed of the intended commercial forest management. It is the objective of these meetings to identify potential management constraints.  
If the people are actively involved from the very beginning in the whole FMU establishment process, future conflicts can be avoided. If during the course of this discussion, strong opposition against the establishment of the FMU comes up; this needs to be recorded and convince people.
- Analysis of problems of local people:** The local people should be encouraged to discuss openly about their problems and should try to rank them. Special attention should be paid to those problems that have a potential interlinkage with forest and land use (e.g. accessibility, forest and agricultural products, water availability, crop damage by wildlife, etc.).
- Assessment of the expectations of the local people and possible changes in livelihood and land use:** It is of importance, that the expectations of the local people that are linked with future commercial forest management (i.e. road access, job opportunities, etc.,) are discussed objectively. Exaggerated or unrealistic expectations should not be discussed at this stage in order to avoid future disappointment and resulting conflicts.
- Assessment of present forest resource use:** For the economic assessment, it is of importance to know the approximate operable area for commercial operation. Forest areas, which are intensively used by the local population should be set aside for their local use only (Section 1.9). A rough estimate of the area is sufficient at this stage. Furthermore, information should be collected on types and quantities of forest products, grazing rights (*tsamdo*) and other forest and land uses.
- Information on wildlife and environmental issues:** For the IEE, information should be collected on the occurrence of protected or rare wildlife species and their respective habitats, rare flora and ecosystems, problems with erosion or water availability and quality, etc.

- vii. **SES-Format:** The Socio-Economic Study should contain a brief analysis of the socio-economic conditions within the potential FMU area. It consists of a standardized cover page, where the most essential information is summarized and of an informal and unformatted report, which should not exceed two pages. The SES report should be prepared by the officer in charge of the RRA and has to be submitted to the CFO for onward submission to FRMD.

• **RNR Census data.**

The analysis of Dzongkhag and other statistics should be done before the RRA is conducted, in order to make the forester familiar with the basic socio-economic information on the potential FMU area. The following data should be collected from Gewog/ Dzongkhag/ National Statistical Bureau (NSB):

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

Information on forest production, logging activities or afforestation should be compiled. Furthermore, the demand of the local wood-based industry in the vicinity of the potential FMU should be assessed.

### **1.4.3.2 Reconnaissance Forest Inventory (RFI)**

The Reconnaissance Forest Inventory (RFI) is essential step in assessment of the suitability of the proposed area for management as FMU. The RFI is expected to provide important information for the economic analysis of the proposed FMU and provide necessary information to decide whether investment is worthwhile to open a particular potential forest area as an FMU on a commercial basis.

#### **1.4.3.2.1 Objectives**

In general, the objective of RFI is to generate preliminary information such as

- estimate of average gross volume per diameter class and species/species group
- estimate of exploitable commercial timber volume and potential AAC; and,
- observations on wildlife, minor forest products, human impacts and biodiversity

Specifically, estimates of following information shall be handy for planning and investment for establishment of FMUs.

- i. Number of trees per ha
- ii. Basal area per ha
- iii. Growing stock
- iv. Coefficient of variation
- v. Margin of error
- vi. Standard error
- vii. Sample variance

#### **1.4.3.2.2 Sampling Design**

There are various sampling designs suitable for RFI. Unless there is intention to maintain consistency of sampling design with National Forest Inventory and Forest Management Inventory, which uses the systematic sampling grid, simple random sampling or stratified random sampling can be adopted. Based on the number of sample size required for the assessment, generate sampling points using either SRS, SS or any other sampling design method.

#### **1.4.3.2.3 Sample Size**

The minimum sample size recommended for RFI is 30 samples. However, based on availability of the resources and time, the sample size can be increased. For large forest area encompassing different forest types,

it is recommended to lay 30 samples for each forest type to generate reliable estimate of average tree parameters as well as coefficient of variation, which may be useful for determining final sample size. In general, the larger the sample size, smaller the variance of mean. However, for RFI, sampling error of about 20% at 95% confidence interval is assumed to provide reasonable estimate.

#### **1.4.3.2.4 Sampling Plot/Point sampling**

There are two basic methods of sampling commonly used in forestry, fixed area plots and point sampling. Fixed area plots are simply a fixed size plots of rectangular, square, circular or any appropriate shape that is selected within which all trees are measured. In case of point sampling, the area is not fixed and plot radius is determined by the diameter/basal area of the trees.

Both fixed area plot and point sampling are statistically valid method. The inventory estimates generated from point sampling are comparable and as accurate as estimates generated with fixed area plot (Lund, 1981; Druszcz et. al., 2015; Mulyana, Rohman & Purwanto, 2018). This method is used for resource inventories in many countries such as Finland (Kangas et al., 2006), USA (Lund, 1981; Druszcz et. al., 2015), Bhutan (FRMD, 2004), Indonesia (Mulyana et al., 2018; Jinguji, 2014) and other countries. In point sampling, each sample tree represents a fixed basal area per unit area and is used for the rapid assessment of resources.

#### **1.4.3.2.5 Data Collection**

##### ***Point Sampling***

Point sampling estimates the stand parameters from sample plots with imaginary plot boundaries (Laar & Akea, 2007) and it is suitable rapid assessment of area (Lund, 1981; Bellhouse, 1981) and other stand parameters (Lund, 1981; Laar & Akea, 2007; UNFCCC, 2015). The commonly used instruments for point sampling are wedge prism, relascope, angle gauge (Lund, 1981; Laar & Akea, 2007; UNFCCC, 2015; Kohl & Magnussen, 2016). The basal area factor or critical angle factor is used to determine whether the tree is “IN” or “OUT”. The inventory field method for data collection using wedge prism is described below:

##### **Steps of Point Sampling using wedge prism**

- Select the sampling locations as determined in the sampling design by random/systematic sampling
- Stand at the plot centre location and establish the plots
- Collect plot information and complete the Form 1.1 (Form F1/7) based on instruction provided in table Table 1.5.
- Correct holding of the wedge prism is important. It should be held straight and shall not be tilted
- Establish a reference direction from where to start a sweep (typically the north). A flag can be fixed on a distant tree in this direction so as to make this direction clearly visible and to avoid overshooting the sweep beyond 360 degrees.
- Wedge prisms bend reflecting light rays causing an image to be displaced along a desired angle by diffraction of light. When viewing trees through a prism, a section of the tree appears to be offset. If the offset section of the tree overlaps the tree stem, then the tree qualifies to be tallied. With no overlap, the tree is "out". Borderline trees are those in which the edge of the offset section exactly meets the edge of the tree stem is tallied as half. Refer Figure 1.3 to decide whether tree is to select or deselect.



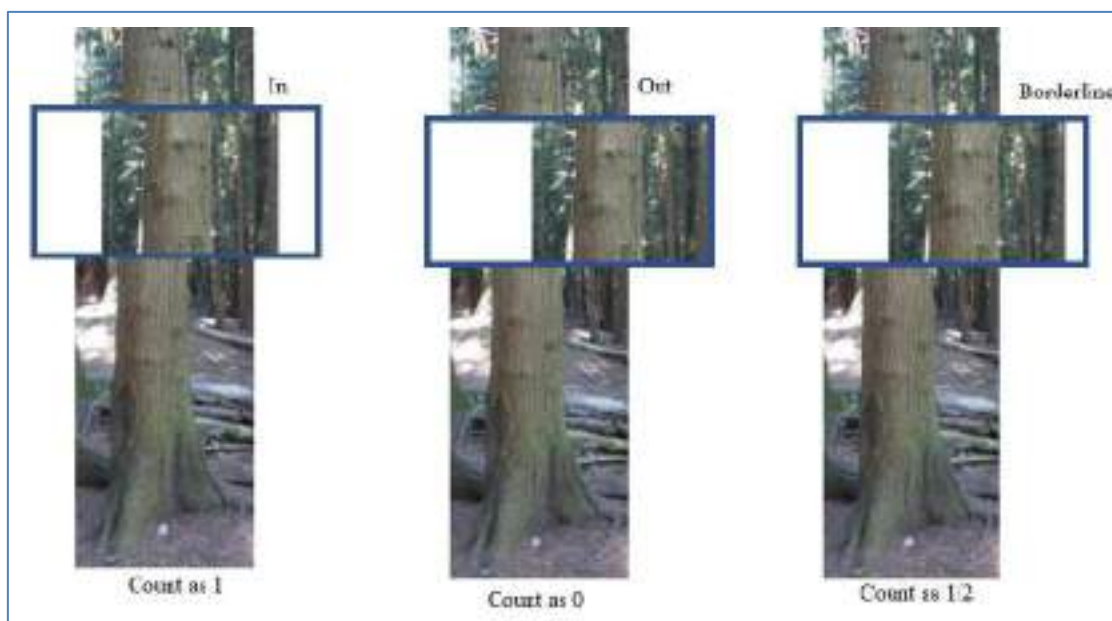


Figure 1.3 Counting trees using wedge prism

For all counted or selected trees, identify the species, measure the diameter and record the following instruction provided in Table 1.6 record in Form 1.2. Also summarize the number of trees recorded in plot in summary sheet.

- If a tree cannot be viewed by virtue of being hidden behind another tree, the observer should move sideways in such a way that the distance from the observation point to the tree being sighted remains constant. If that is not possible, following methods may be adopted
  - i. Look for a tree of same or smaller diameter within same distance from the observation or further away and view through the prism, if that tree is “in”, the tree in question shall be tallied
  - ii. Otherwise use the limiting distance method to determine whether the tree isn “in” or “out” (UNFCCC, 2015). Measure the distance between observation point and dbh of tree and then apply the limiting distance formula

$$D_l = \frac{0.5 \times dbh}{\sqrt{BAF}} \quad (1)$$

Where,

$D_l$  is limiting distance, BAF is basal area factor

If the distance between tree and observation point is same or smaller than limiting distance, the tree shall be tallied otherwise not.

- The basal area is obtained by multiplication of number of ‘in’ trees by constant factor (Basal Area Factor of prism) which is usually inscribed on the prism itself.

Table 1.5: Instruction of collection of plot information

SN	Data Item	Definition/Description	Instructions
1	District Name	Name of the District in which proposed LFM is located	Type in the field form
2	Name of the Geog	Name of the geog for which is LFM is proposed	Type in the field form
3	FMU Name	Refers to the proposed name of the FMU.	Type in the field form
4	Plot No.	This is the unique identification number given to RFI Inventory Plots	Type in the field form
5	Date	Refers to date of day of data collection	Record the date
6	Time	Refers to time at the time of data collection	Record the time
7	Altitude	Refers to the elevation from mean sea level at which the plot is located. It is measured in meter.	Use the GPS to obtain altitude reading. Record altitude in meter, as it appears on GPS.
8	Accessibility	Refers to if the Inventory Plot is accessible or not.	Select 'Yes' if the Plot was accessible, 'No' if it was not accessible.
9	Land use	Refers to class of land cover and land use. Land cover and land type and definition is provided in BOX 1.3.	Use the technical definition provided in <b>Error! Reference source not found.</b> for identifying the Land cover class and select the appropriate land use/ Land cover
10	Forest type	Refers to Forest type as classified in the Flora of Bhutan. The characteristic features of different forest types are provided in <b>Error! Reference source not found.</b>	Refer <b>Error! Reference source not found.</b> to classify the forest type and type forest type code in the field form. Select the appropriate forest type.
11	Slope up	Slope Up describes the gradient, inclination of the up-hill slope from the Plot Center (PC).	From the plot center, measure the slope up using clinometer and record in degrees
12	Slope down	Slope down describes the gradient, inclination of the down-hill slope from the PC.	From the plot center, measure the slope down using clinometer and record in degrees
13	Management type	Refers to suitability of plot for different management functions. 1. Production 2. Protection 3. Conservation	Based on the slope of the plot and accessibility, plot location such as (riparian, presence absence of key wildlife species)

<b>Department of Forests and Park Services</b> Forest Resources Management Division Plot Information (Form I)		F1/7
<b>1. District Name:</b>		
<b>2. Geog Name:</b>		
<b>3. Local Forest Management Name:</b>		
<b>4. Plot No:</b>		
<b>5. Date</b>	/ /	<b>6. Time</b> <span style="border: 1px solid black; text-align: center;">/</span>
<b>1. Altitude (m)</b>		
<b>8. Accessibility:</b>	a) Yes <span style="border: 1px solid black; width: 30px; height: 15px; display: inline-block;"></span> b) No <span style="border: 1px solid black; width: 30px; height: 15px; display: inline-block;"></span>	
<b>2. Land use:</b>		
i. Forest land		ii. Cropland <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
iii. Grassland		iv. Wetland <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
v. Settlement		vi. Other land <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
<b>3. Forest Type:</b>		
i. Subtropical Forest		ii. Warm Broadleaf Forest <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
iii. Chirpine Forest		iv. Cool Broadleaf Forest <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
v. Evergreen Oak Forest		vi. Blue Pine Forest <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
vii. Spruce Forest		viii. Hemlock forest <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
ix. Fir forest		x. Juniper-Rhododendron Scrub <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
xi. Dry Alpine Scrub		
<b>4. Slope (Degrees):</b>		
i. Slope Up		ii. Slope Down <span style="border: 1px solid black; width: 50px; height: 20px;"></span>
<b>5. Forest Management Function</b>		
i. Production		ii. Protection <span style="border: 1px solid black; width: 30px; height: 20px;"></span>
iii. Conservation		
<b>Remarks:</b>		
<b>6.</b>		

Table 1.6: Instruction collection of tree data

SN	Parameters	Description/ Definition	Instructions or how to fill in Data Dictionary
1	Plot No	This is the unique plot number for inventory data collection	Type the plot number
2	Date	Date of data collection	
3	Time	Time of data collection	
4	Scientific Name	Refers to scientific or botanical name which conforms to the <i>International Code of Botanical Nomenclature (ICBN)</i>	Type/record the appropriate tree name
5	Common Name/Local Name	“Common name” herein is referred to the commonly used name of a tree in English.	Type/record the appropriate tree name if know. Can be English, dzongkhag or any other language.
6	DBH	Refers to Diameter measured at Breast Height.	Measure the DBH and record accordingly.
7	Tally	Refers to whether the tree is “in” or “borderline”	Fill as “I” for in trees and “B” for borderline trees
7	Condition of Tree	Refers to state of the tree, whether live or dead.	Observe and record the condition of tree
8	Summary sheet	Summary of tree count in each plot by DBH class	Count of number of trees in each plot by diameter class and record in the appropriate diameter class. For example, if there are three trees of <i>Abies densa</i> diameter 10, 25 and 50. Then record one each in diameter class 10-20, 20-30 and 50-60.

**Department of Forests and Park Services**  
Forest Resources Management Division  
Tree Data Collection Form-2

1. Plot No

2. Date

4. Time

Tree Data Form ( $\geq 10$  cm DBH)

SN	Scientific Name	Local Name	DBH (cm)	Tally (I/B)	Condition	
					Live	Dead

Summary of live trees in a plot: (Sum the trees of each species in a plot)

SN	Species	DBH CLASS (total count of each species in each dbh class)										
		10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110+

#### 1.4.3.2.6 Data analysis

If the data is collected by point sampling or variable radius plot, use the data analysis methodology described in chapter 3, section 3.3.5. You can also use following to generate some useful information

- i. Estimate the forest area as proportion of the sample plots multiplied by total area

$$A_i = \frac{\sum P_i}{P} \times A \quad (2)$$

Where,

$A_i$  is area under stratum i (e.g. Forest, grassland, settlement, wetland, cropland, other land);

$P_i$  is the sample plots falling on stratum i (e.g. Forest, grassland, settlement, wetland, cropland, other land);

$P$  is total number of sample point/plot; and

$A$  total forest management area

- ii. Area of production area is estimated as the number of plots falling in forest with slope less than 35 degrees divided by all plot multiplied by total LFM area

$$A_{fp} = \frac{\sum P_{fp}}{P} \times A \quad (3)$$

Where,

$A_{fp}$  is area of forest with slope less than 35°

$P_{fp}$  sample plots falling on forest with slope less than 35°

$P$  is total number of sample point/plot

$A$  total forest management area

The basal area, stem density and volume per hectare is estimated based on general formula (Laar & Akea, 2007) as described below.

- iii. Basal Area of Individual tree

$$BA = \pi \left( \frac{d}{2} \right)^2 \quad (4)$$

- iv. Basal area per hectare

$$BA_{ha} = T_{in} \times BAF \quad (5)$$

- v. Volume per ha

$$V_{ha} = BAF \times \sum_i^n \frac{V_i}{g_i} \quad (6)$$

- vi. Number of trees per hectare

$$T_{ha} = BAF \times \sum_i^n \frac{1}{g_i} \quad (7)$$

Where,

BA is basal area;

d is dbh of a tree;

BAF is basal area factor of prism;

BA<sub>ha</sub> is the basal area per hectare;

V<sub>ha</sub> is the volume per hectare;

T<sub>ha</sub> tree count per hectare;

g<sub>i</sub> is the basal area of the trees counted “in”; and

v<sub>i</sub> is the volume of the trees counted “in”

### **1.4.3.3 Initial Environmental Examination (IEE)**

#### **1.4.3.3.1 Objective**

The objective of the IEE is to:

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

This is not a full environmental assessment (EA) but the information generated by this step should contribute to EA that is conducted as part of the FMU Planning process.

#### **1.4.3.3.2 Sources of Information**

Information for the IEE is collected during the courses of:

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

#### **1.4.3.3.3 IEE-Format**

The Preliminary Environmental Examination should contain a brief description of the environmental conditions within the potential FMU area and an analysis of the environmental risks of forest management. It should include a map indicating proposed protected areas for wildlife, soil and watershed protection and recommendation for forest road construction and harvesting systems. It consists of one standardized page (Table 1.7) with an attached map indicating proposed protected areas and buffers.



*Table 1.7 Initial Environment Examination Form*

Reconnaissance Survey			
Initial Environmental Examination			
1	Name of FMU:		<div>Area:</div> <div>Gewogs:</div>
2	Occurrence of Wild-life	Provide the list of wild animals found in the FMU area:	
3	Ecosystems and flora	Provide the list of plants found in the FMU area:	
4	Soil Protection and water catchments	Verify the slope and water catchment with the map and note any differences found:	
5	Length of road required (Km)		
6	General analysis of environmental risks	List the possible impact of the operation of FMU on sl. No 2, 3, 4 and 5.	
	Date:		<div>Completed by:</div> <div>Name and designation</div>

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

#### **1.4.3.4 Economic Feasibility Study (EFS)**

##### **1.4.3.4.1 Objective**

The objective of the EFS is to forecast, whether commercial forest management of the FMU can be financially viable in the long run or not and whether it is worthwhile to operate the concerned area as a commercial FMU. The EFS is the most important component of the RS as it helps to avoid expensive and uneconomic investments in future.

The EFS at the reconnaissance level, needs to be simple without time consuming analysis. It shall, therefore, not replace a full-fledged economic assessment later on at forest management planning level. The EFS should be conducted by the concerned planner, DFO in collaboration with the authorized agency and FRMD.

#### **1.4.3.4.2 Sources of Information**

The EFS is based on the results of the RFI, SES, IEE, and basic economic data of authorized agency. Preliminary decision on the harvesting system and a draft road construction and accessibility plan have to be prepared during the EFS, taking into consideration the proposals made by the IEE, in order to allow an estimate of the investment and operational costs.

#### **1.4.4 Reconnaissance Survey Report**

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

- Pre-RS Field Check
- Socio-Economic Study
- Reconnaissance Forest Inventory
- Initial Environmental Examination
- Economic Feasibility Study

It should be prepared by the CFO of concerned field office and submitted for approval to the Head of Department, DoFPS. The table of contents including some keywords for the content of the Report is listed in Table 1.8.

*Table 1.8 Content for the Reconnaissance Report*

<b>Section heading</b>	<b>Information to include</b>
1 Brief Summary	<ul style="list-style-type: none"> <li>• brief description on different activities carried out (when by whom);</li> <li>• recommendation whether to open FMU or not;</li> <li>• main constraints and problems</li> </ul>
2 General Information	
2.1 Location and Terrain	<ul style="list-style-type: none"> <li>• names of Dzongkhag and Gewogs;</li> <li>• boundary alignment and adjoining FMUs, national parks, protected areas, etc.;</li> <li>• size of potential FMU and approximate size of operable area;</li> <li>• topographic features such as altitude, slopes, exposition, drainage, watershed;</li> <li>• accessibility.</li> </ul>
2.2 Climate	<ul style="list-style-type: none"> <li>• brief description of climate (climatic zone, temperature, rain/snowfall, etc.).</li> </ul>
2.1 Soils	<ul style="list-style-type: none"> <li>• brief description on soil types, rocky areas, waterlogged sites and swamps, etc.;</li> <li>• brief valuation of site suitability for forest production.</li> </ul>
2.2 Wildlife	<ul style="list-style-type: none"> <li>• describe most common wildlife species,</li> <li>• occurrence and habitat of protected and rare species;</li> <li>• describe problems with animal pest (i.e. wild boars)</li> </ul>
2.3 Flora	<ul style="list-style-type: none"> <li>• specify most common tree species;</li> <li>• briefly describe ground flora;</li> <li>• mention occurrence of rare and protected plants.</li> </ul>
2.4 Forest Types and Forest Condition	<ul style="list-style-type: none"> <li>• describe different forest types and their spatial distribution;</li> <li>• describe forest condition (development stages, damages, diseases, natural disasters, natural regeneration, etc.).</li> </ul>
3 Socio-Economic Study (maximum 2 days)	<ul style="list-style-type: none"> <li>• brief analysis of the socio-economic conditions within the potential FMU area.</li> </ul>
3.1 RRA	<ul style="list-style-type: none"> <li>• information on the intention to open FMU</li> <li>• informal discussions to identify objections and constraints</li> <li>• analysis of problems of local people</li> </ul>

	<ul style="list-style-type: none"> <li>• assessment of the expectations of the local people and possible changes in livelihood and land use</li> <li>• assessment of present forest resource use</li> <li>• information on wildlife and environmental issues</li> </ul>
3.2 RNR Census data	<ul style="list-style-type: none"> <li>• number of villages and settlements;</li> <li>• number of households and population;</li> <li>• figures on livestock (number of cattle, horses, mules, goats and sheep); and,</li> <li>• information on grazing rights (<i>tsamdos</i>).</li> </ul>
4 Initial Environmental Examination	<ul style="list-style-type: none"> <li>• add IEE-Report</li> </ul>
5 Reconnaissance Forest Inventory	
5.1 Introduction	
5.2 Inventory Results	
5.3 Operable Area and Areas of Priority for Forest Management	
5.4 AAC-Estimate	
6 Economic Feasibility Study	<ul style="list-style-type: none"> <li>• add EFS-Report</li> </ul>
Annexes	1 Forest type map 2 Map on protected and inoperable areas, proposed road alignment

## 1.5 Contents of Forest Management Plans

This section provides an outline of the contents of a FMP along with guidelines on the information that should be included under the various headings (Table 1.9). A common format or structure should be applied to FMPs; however, the guidelines presented here should not be considered as absolutely prescriptive, some customization may be done if required.

As described, a FMP is the result of a process or series of steps. Whilst preparing a FMP, it is important to keep in mind both the importance of the process and the intended final structure and contents of the plan in order to ensure that the process is providing the information necessary for the production of the final document. Within this section, cross-references are made between the relevant sections of the forest management plan content and the stages or steps in the forest management planning process. These cross-references can serve as a check for the planner to ensure that all areas are effectively covered.

The structure or format of the management plan should be designed in such a way as to best communicate the relevant information to those involved with operational planning and implementation. To achieve this, it is essential that forest management planners consult thoroughly and effectively with the users of the management plan from the start of the management planning process.

Planners should continually reflect upon the suitability of the format, structure and contents of the management plan and strive to continually improve them. This *Code* should incorporate revised guidelines as and when appropriate.

The preparation of management plans for new FMUs shall involve, to some extent, a different set of steps to the preparation of revised (i.e. second or subsequent) management plans for existing FMUs. The structure and contents of each management plan shall need to reflect this accordingly.

A structure with detailed headings and sections for the FMP is provided as a guide that should be included within the management plan. Any other additional information which is critical can be included as a part of the management plan.

Table 1.9 Guidelines on contents of FMP

Section heading	Information to include	Sources of information
Authority for preparation, revision and approval		
Abbreviations & acronyms	List all abbreviations and acronyms used	
Executive summary	A highly concise summary of all parts of the FMP	
Table of contents	Automatically generated using the appropriate function in MS Word or other word-processing software. Include lists of text boxes, tables, figures, maps & annexes. Table of actions and responsibilities	
<b>PART 1 GENERAL DESCRIPTION AND THE CURRENT SITUATION</b>		Code sections: FRPA, reconnaissance survey, socio-economic survey & participatory resource mapping, forest management inventory
<b>1. LOCATION, AREA, BACKGROUND AND STATUS</b>		
1.1. Location and extent	Latitude and longitude of boundaries. Location within administrative areas; Dzongkhags & Gewogs, proximity to towns, villages, settlements etc., location in relation to watersheds, access route(s) and direction, elevation range, gross area in hectares. Location map	
1.2. Area statement	Table showing area by land use type	LULC, GIS analysis
1.3. Historical background	Local use of forest, brief review of past management plan(s)	Semi-structured interviews with residents, previous management plan(s)
1.4. Forest condition	Forest degradation, pest and diseases, grazing impact	FMU Inventory
1.5. Legal status		
1.5.1. Ownership	Extent of State Reserve Forest, extent of human settlement and cultivated land, encroachment of forest boundaries	The Forest & Nature Conservation Act 1995 or any other revision hereafter

1.5.2.Rights and privileges	Communities/villages with traditional rights on forest resource utilisation	Land Act of Bhutan 2007 or any other revision hereafter
1.5.3.Grazing rights	Communities/villages with traditional grazing rights	
1.5.4.Water rights	Communities/villages with traditional rights to water use	Water Act of Bhutan 2011 SES
1.5.5.Historical monuments and monasteries	Name and location of Goenpas, Lhakhangs & Neys. Description of buffer zones.	GPS point SES
1.5.6.Proximity to protected areas	Location of FMU in relation to National Parks, Wildlife Sanctuaries, Biological Corridors & any other relevant protected areas.	GIS analysis
<b>2. PERMANENT SITE FACTORS</b>		
2.1. Topography and slope	Terrain type, gradient/slope class Map showing terrain and slope class.	Topo maps, field truthing, reconnaissance survey DEM
2.2. Climate	Sub-sections on meteorological stations (Location, functioning equipment, and data availability), temperature (graph showing monthly maximum and minimum), precipitation (graph showing mean monthly rainfall; statement of implications of rainfall & snow for forest operations).	Meteorological stations/offices
2.3. Geology and soils	Summary of underlying geology and soil types. Indication of fertility and pH. Likelihood of erosion and landslide	Soils & geology maps.
2.4. Hydrology	Brief description of watersheds & sub-watershed and their functioning. Hydroelectricity generation.	GIS data
<b>3. VARIABLE SITE FACTORS</b>		
3.1. Population and demography	Brief description and numbers of Gewogs, villages and households, estimated population	Dzongkhag/Gewog statistics, FIRMS and FMU records.
3.2. Agriculture and farming systems	Summary of crops grown, whether for home consumption or market, tree crops	

3.3. Traditional use of the forest	Summary of use for house construction, fuelwood, <i>sokshings</i> & <i>tsamdos</i> , bamboo etc.	socio-economic surveys & participatory resource mapping, forest management inventory.
3.4. Grazing	Head of cattle and yak in FMU, location/distribution and timing of grazing, impact of grazing on forest.	Observations during field truthing, reconnaissance survey
3.5. Wildlife	Date & summary of wildlife survey, species present, comments on location/range, habitat type, protection area designation	Forest management inventory. Wildlife survey/inventory
3.6. Forest fires	History, location, extent, causes. Statement of responsibilities.	FIRMS and/or FMU record
3.7. Pests and diseases	Species present, nature and extent of problem, impact on forest management, control measures, research activities & needs	Past record and FMU inventory
3.8. Non-wood forest products	Mushroom, medicinal & aromatic herbs, bamboo, leaf mold, etc., as appropriate.	NWFP report, FMU Inventory
3.9. Mineral extraction	Extraction of boulders, stone & gravel; location and extent, impact on forest environment and hydrology Mining for minerals.	FIRMS and/or Office record
<b>4. ECOLOGY</b>	Comment on East Himalayan biodiversity 'hot-spot'. Factors influencing biodiversity.	
4.1. Floral associations	Summary of plant communities by forest type, elevation & aspect. Statement on habitat types.	Flora of Bhutan 1983
4.2. Fauna	Summary of inventory/wildlife survey findings. Comment on trends in species present and population levels.	Inventory/wildlife survey; most recent and earlier reports
<b>5. SILVICULTURAL ASSESSMENT</b>		
5.1. Present forest types	Brief description of forest type, location & extent. Summary table.	Code section; silvicultural systems
5.2. Past silvicultural treatment	Brief description of working groups in past plan; by forest type & area. Silvicultural system(s) and logging systems used. Thinning operations undertaken. Method and success of regeneration. Comments on sanitation felling.	Office record, Review of literature, and/or previous plan FMU Inventory



5.3.	Plantations	Status of regeneration and recommendation/prescriptions	Code Section: Plantation FIRMS and/or office record
<b>6. SOCIO-ECONOMICS</b>			
6.1.	Common sources of Income	From agriculture, horticulture, NWFPs, local industries etc. Contract harvesters, territorial staff etc.	Code section: socio-economic surveys and participatory resource use mapping
<b>7. CURRENT TIMBER DEMAND AND SUPPLY</b>			
		Local, regional, national and relevant international demand and supply trends (i.e. increase or decrease), level of construction & restoration/restoration activity, rural use allocation, markets for lower grade sawlogs and residues. Excess supply or demand. Anticipated future trends. Summary of recent harvested volumes by allocation (over period of previous FMP if applicable).	FIRMS and/or FMU records
<b>8. ORGANISATION AND ADMINISTRATION</b>			
8.1.	Organisation	Forest Division & Range, location of offices, personnel numbers and designations.	
8.2.	Health and safety	Reference to health and safety policy, statement of responsibilities, risk assessment, accident reporting procedures.	
8.3.	Record keeping	Types of records kept, filing system, records dating back to when? Comment on completeness & order of record keeping.	
<b>9. INFRASTRUCTURE, TRANSPORT AND EQUIPMENT</b>			
9.1.	Roads	Road location/route, length and grade. Compliance with standards. Bridges; location, capacity & condition. Total road length within FMU. Road maintenance; history & ongoing programme.	
9.2.	Buildings	Offices and staff housing.	
9.3.	Transport	Quantity, type & users of vehicles (four & two wheelers). Whether adequate for needs. Implications for forest management.	
9.4.	Equipment	Computers, printers, photocopiers, walkie-talkies, telephones, fax machines etc.	

<b>10. EVALUATION OF PREVIOUS PLAN</b>		
10.1. Review of goals & objectives	Comment on the goals and objectives that were set for the last plan period. Comment on whether goals & objectives have been achieved in the plan period.	Mid-term and end of term evaluation reports.
10.2. Review of harvesting activities	Comment on suitability of harvesting system(s). Comment on issues/problems and means of improvement (e.g. felling technique, log piling, utilization, cable-line layout etc.).	Monitoring forms & evaluation reports
10.3. Review of road building activities	Comment on planning, construction & maintenance of roads. Comment on environmental considerations.	Monitoring forms & evaluation reports
10.4. Review of re-forestation	Comment on success or failure of regeneration and on factors contributing to success or failure. Comment on effectiveness of monitoring re-generation.	Monitoring forms & evaluation reports
10.5. Review of AAC	Comment on appropriateness/accuracy of AAC calculation for previous plan period. Comment on review and adjustment of AAC during the previous plan period.	Monitoring forms & evaluation reports
<b>PART 2 FUTURE MANAGEMENT</b>		Planning steps: Draft goal & vision for FMU, forest function mapping, Organisation of the forest, data analysis & AAC calculation, silvicultural & harvesting systems, economic & financial analysis.
<b>11. INTRODUCTION</b>	General statement about RGoB policy	
11.1. Forest Policy	Statement of requirement of F&NC Act 1995 for FMP approval and implementation. Statement of forestry policy goals. Statement of priorities for the forestry sub-sector.	Relevant laws and policies
11.2. Goals	Statement of the overall goal of the FMP: a single paragraph that encapsulates the reasons why a management plan is being prepared and why activities shall be taking place in the FMU. The goal must be consistent with national policy and goals, but may differ in some details.	

11.3. Objectives	Statement of objectives; consider dividing under the management circles (i.e. protection, non-production & production) and working circles.	
11.4. Management based on forest function		
11.4.1. Introduction	Brief description of concept. Statement of objectives of forest function mapping	Legal basis provided by Sections 5 & 21 of F&NC ACT 1995.
11.4.2. Function groups	Table showing list of forest function groups used in the FMP.	
11.4.3. Mapping forest functions	Table showing criteria used to prepare forest function maps. Forest function maps.	
11.4.4. Restrictions of forest functions	Table summarizing specific restrictions to be applied to the function categories	
<b>12. AREA ORGANISATION</b>		
<b>13. QUANTITATIVE RESOURCE ASSESSMENT</b>		
13.1 Forest management inventory	Summary of inventory results	Forest management inventory
<b>14. AREA ORGANISATION</b>		
14.1. Spatial organisation	Statement and rationale for territorial divisions within FMU; demarcation & delineation (and names where appropriate) of blocks, compartments & sub-compartments. Table showing the composition of blocks & compartments.	Code section; Organisation of the FMU
14.2. Determining operable area	Rationale for determining operable area; brief statement of functions that take precedence over commercial & rural forestry activities.	
14.3. Organisation into management circles and working circles	Rationale for delineation of management circles. Summary statement of management circle objectives & constraints. Table showing area statement for management circles & working circles.	
14.4. Management circles		

14.4.1. Protection Management circle	<p>Description of designation. Table with columns showing management objectives, management options &amp; responsibility. Statement of FMU Level Management Committee role in deciding on activities to achieve objectives. Statement of permitted operations for forest protection purposes (e.g. sanitation felling).</p>	
14.4.2. Non-production management circle	<p>Description of designation. Table with columns showing management objectives, management options &amp; responsibility. Statement of FMU Level Management Committee role in deciding on activities to achieve objectives.</p>	
14.4.3. Production management circle	<p>Description of designation. Summary of working circles Table with columns showing management objectives, management options &amp; responsibility. Statement of FMU Level Management Committee role in deciding on activities to achieve objectives.</p>	
14.5. Management of the working circles	<p>Table describing objectives, management options, responsibilities, monitoring &amp; evaluation and silvicultural systems specific to each working circle.</p>	
14.6. Implementing working circle management		
<b>15. YIELD REGULATION AND HARVESTING</b>		
15.1. Determination of AAC	<p>Review of AAC calculated for previous plan. Reasons for over (or under) estimation. Calculation method(s) used. Comment on check by age class and normality. Rationale for AAC calculation method(s) selected</p>	<p>AAC calculation based on the guidelines given in code</p>

15.1.1. Calculation of AAC for FMU	Conversion of gross to net operable area, percentage reduction assumed & contributing factors. Table showing gross & net operable area by working circle. Statement of and rationale for assumed rotation and re-generation periods (by working circle).	
15.1.2. Maturity class analysis		
15.2. Recording and accounting for AAC	Statement of monitoring requirements for commercial & local use harvesting.	
15.3. Allocation of the AAC	Statement of allocation by user (i.e. authorized agency, local, other).	
15.4. Distribution of the cut	Statement of distribution of cut by working circle.	
<b>16. SILVICULTURAL SYSTEMS</b>	Silvicultural systems to be used and rationale. Diagrams to illustrate layout. State regeneration artificial & natural regeneration characteristics and management requirements of trees species.	Code section; silvicultural systems
<b>17. FOREST PROTECTION</b>		
17.1. Fire	Statement of incidence of fire; scale, timing, & cause. Identification of fire hazards and risks and prescriptions	Code Section: Forest Fire Management
17.2. Pest and disease management	Monitoring requirements and responsibilities. Reporting procedures. Statement of known pests & diseases; species, extent, damage, control measures, predicted future scenarios, implications & recommendations for action.	Code Section: Forest and Wildlife Pests and Diseases
17.3. Grazing	Statement on implications of grazing for forest management. Recommendations on participatory approaches to management of grazing.	Code sections; socio-economic surveys & participatory resource mapping, silvicultural systems

<b>18. ENVIRONMENTAL STATEMENT</b>	Environmental statement (resulting from environmental assessment) including cross-reference to baseline information in Part 1 of FMP, prediction of impacts resulting from planned operations, evaluation of significant impacts and identification of mitigating measures. Summary table or matrix of adverse environmental impacts indicating significance of effect & planned mitigating measures	Code section; environmental assessment NEC Forestry Environmental Sectoral Guidelines
<b>19. FINANCIAL &amp; ECONOMIC APPRAISAL</b>	Summary of economic feasibility study from reconnaissance survey report (if available). 10-year cash flow/profit & loss forecast. Summary of spreadsheet based long-term economic analysis of FMU. Social & environmental cost-benefit analysis.	Code section; financial and economic appraisal of forest management units
<b>20. RESEARCH</b>	Research priorities and strategies.	Liaise with UWICER
<b>PART 3 IMPLEMENTATION OF THE PLAN</b>		
<b>21. IMPLEMENTING AGENCY</b>	Statement of responsibilities; CFO, FRMD/ CFO, DFOs/ authorized agency.	
21.1. Cutting Cycles	Determining factors	
21.2. Annual Coupe		
21.3. Tree marking guidelines	Refer to code section on silvicultural implementation	Code section; silviculture implementation
21.4. Harvesting		
21.5. Reforestation of harvested sites	State specific requirement for artificial regeneration if natural regeneration is not appropriate or successful. Refer to timing of operations.	
21.6. Sequence of operations relating to the annual coupe	Table showing sequence of operations and timing before and after felling.	



21.7. Road Construction	Summary of road construction standards. Diagram recommended road profile	Code section; road construction & maintenance
<b>22. PLANNING</b>		
22.1. Operational plan	Scope & function of operational plan. Table showing steps in preparation & implementation of operational plan; activity, objective, output, responsibility, comments.	
22.2. Mid-term evaluation of FMP	Statement of responsibility and process.	
22.3. FMU-level management committee	Function & terms of reference. Committee membership.	Code section; stakeholder analysis and establishment of the FMU-level management committee
22.4. Staff	Designations & responsibilities. Organisational structure diagram. Identification of needs & recommendations.	
22.5. Buildings	Identification of needs & recommendations.	
22.6. Vehicles and Equipment	Statement of existing resources, identification of needs & recommendations for change. Include mensuration/inventory equipment.	
<b>23. MONITORING AND EVALUATION</b>		
23.1. Monitoring	Definition, statement of responsibilities, composition of evaluation team	M&E forms for FMUs
23.2 Evaluation	Definition, statement of responsibilities, composition of evaluation team.	M&E forms for FMUs
<b>24. CONSTRAINTS AND RISKS</b>		
<b>25. DEVIATIONS FROM PLAN PRESCRIPTIONS</b>		
<b>26. REFERENCES</b>		
<b>ANNEXES</b>	Include as appropriate; compartment/sub-compartment description and prescription forms, inventory results, road standards, FMU-level management committee terms of reference	

## **1.6. Spatial Organization of the FMU**

### **1.6.1. Objective**

The objective of the spatial organization of the FMU is to sub-divide the FMU in order to aid in the preparation and effective implementation of annual activities.

### **1.6.2. Outputs**

At the end of this activity, it is expected that the FMU is mapped and described in terms of blocks, compartments and sub-compartments, as appropriate.

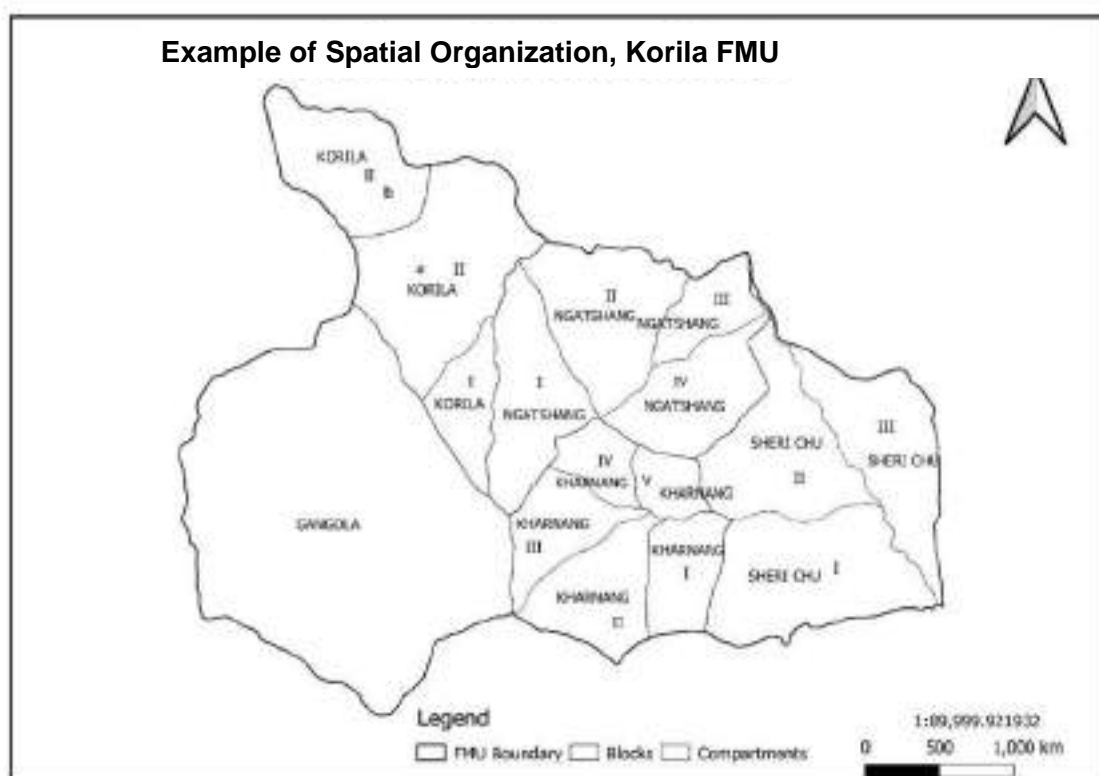
### **1.6.3. Lead Responsibility**

The respective DFO shall take the lead role with technical backstopping from FRMD.

### **1.6.4. Organization of the Forest Management Unit**

To facilitate management and administration, forests are subdivided in a number of ways. These are generally influenced by the topography, forest type, functions and land ownerships and the subdivisions are made primarily for the purpose of (1) organizing forest operations and controlling yield, and (2) defining territorial responsibility and providing a permanent basis for locating stands and maintaining records.

FMU is divided into blocks (identified by name of locality) which should be further divided into a compartment (identified by Roman numeral: I, II) and sub compartment (identified by a lowercase letter; a, b , c) for better administration and effective implementation purposes (Figure 1.4).



*Figure 1.4 Spatial Organization of an FMU*

## **Blocks**

FMUs are divided into blocks which are the basic orientation and administrative units within the FMU. They are essentially major water-catchments separating easily recognizable major parts of the FMU. Therefore, the block boundaries shall in most cases follow ridges separating individual water-catchments. Other prominent topographic features such as large streams or rivers can also be used to identify block boundaries.

For all practical purposes, the FMU should be divided into no more than 4 – 6 blocks with an average area of about 1,500 to 2,500 hectares each block (if determined by topography it can be much smaller, or larger). It should be kept in mind that eventually, with increased management intensity, the block could become an administrative unit within the FMU, such as a beat. The name of a block must be an easily recognizable, commonly used name for that particular area. In name selection, a care has to be taken to avoid using unfamiliar or confusing names.

## **Compartments**

Blocks are divided into compartments which are basically orientation units created to facilitate easy orientation within each block to provide for easy administration, recording and monitoring of operations within the FMU. The boundaries of the compartments follow easily identifiable topographic or planimetric features such as roads, streams, rivers, main ridges, etc. In some cases, boundaries could follow major forest type lines.

The size of the compartment would depend on the intensity of management, intensity of road network and a topographic makeup of the area. Typically, it would be anywhere between 100 and 500 hectares.

## **Sub-compartments**

Compartments are divided into sub-compartments which are both orientation and management units (unless a stand-wise approach to planning is applied, in which case a sub-compartment is an orientation unit and the stand becomes the management unit). They are created when required for planning, management and implementation purposes. This is especially in the situations when the compartments are too large or when the area obviously requires a separate management regime and prescription. (Example; an area of a clear cut that had been replanted to one or a mixture of species, thus creating a homogeneous area either in terms of species composition or age).

In most cases the sub-compartment boundaries follow the forest type lines, to clearly indicate the uniqueness of a certain area within the compartment for management purposes. The size can vary from one hectare in the intensively managed forest to an area of up to 50-100 hectares.

## **Stands**

A stand is a contiguous area that contains a number of trees that are relatively homogenous or have a common set of characteristics and form. It is the basis of silvicultural planning which is identified during operational planning. In some cases, the stand corresponds to a forest type. Most of the time the selection criteria is identical to that of a sub-compartment with the exception that the orientation criteria is a secondary consideration. In an intensively managed forest, a stand wise planning and subsequent monitoring of operations is carried out in each compartment.

*Box 1.1 Concept of a Stand*

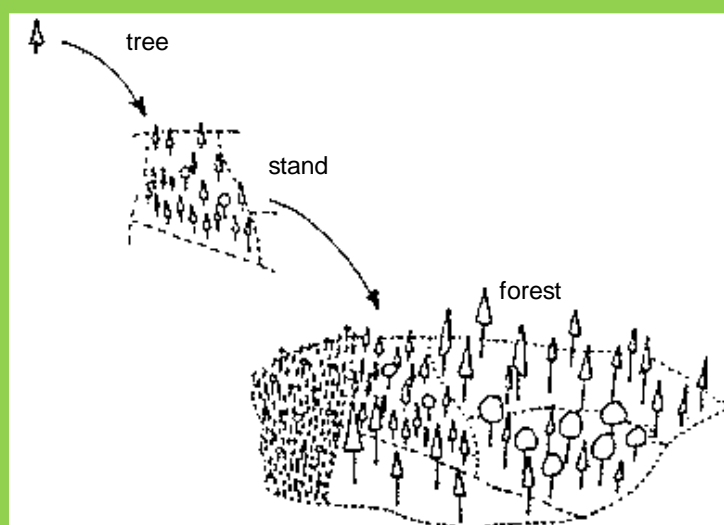
**Organisation of forest based on forest operation and controlling yield**

**Trees, Stands, and Forest**

A forest is a complex thing to manage for two main reasons: the large size and longtime horizons involved. A combination of tree, stand, and forest level perspectives is fundamental to an understanding of forest management.

A tree is the basic element of a stand which is made up of many trees of various species competing with each other for survival and growth. A stand is the basic element of a forest.

A forest is made up of many stands at various stages of development. Much as a tree is one element of a stand, so a stand is one element of a forest (see below).



The character of a stand in terms of species composition, size structure and canopy structure changes over time. Silvicultural measures such as creation of new stands, ability to speed up development of a stand, tending of a stand through thinning and other measures and finally regenerating a stand through harvesting are powerful tools of forest management.

An example of a basic organisation of a FMU is provided on the map (Figure 1.4).

Standardized annotation of each basic organisational unit on forest management maps follows international conventions.

Block is identified by a name only. An example of a block name is: Korila Block.

Compartment is identified by Roman numeral: I

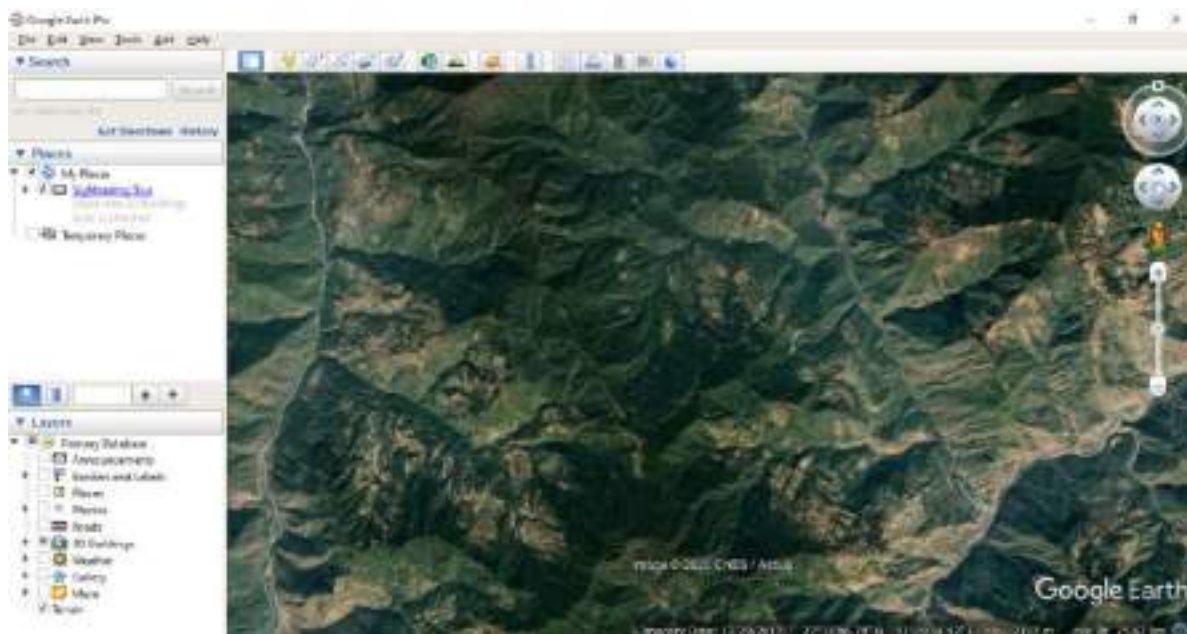
Sub-compartment is identified by a low case letter: a

Stand is usually identified with a silvicultural or forest type unit and may be identified by a forest type class (FCb).

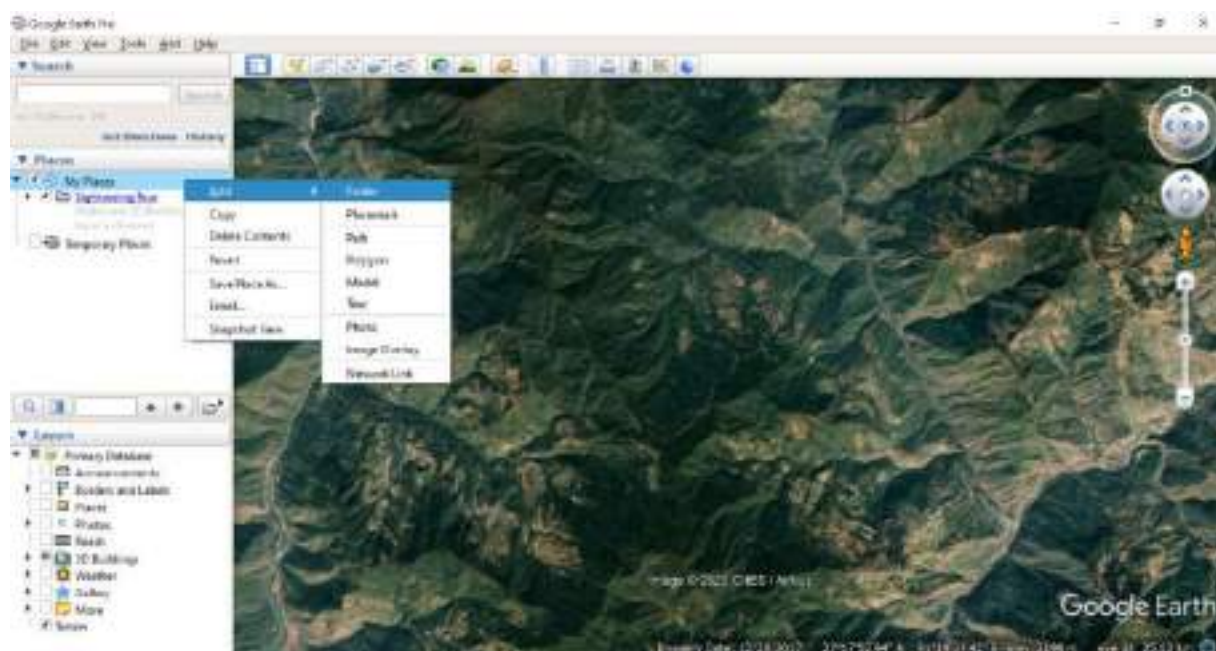
## **Delineation of Boundary, Blocks, Compartments and Sub-compartments**

Delineation of Boundary, Compartment and Sub-compartment shall be carried out using Google Earth Pro and QGIS 3.12. This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

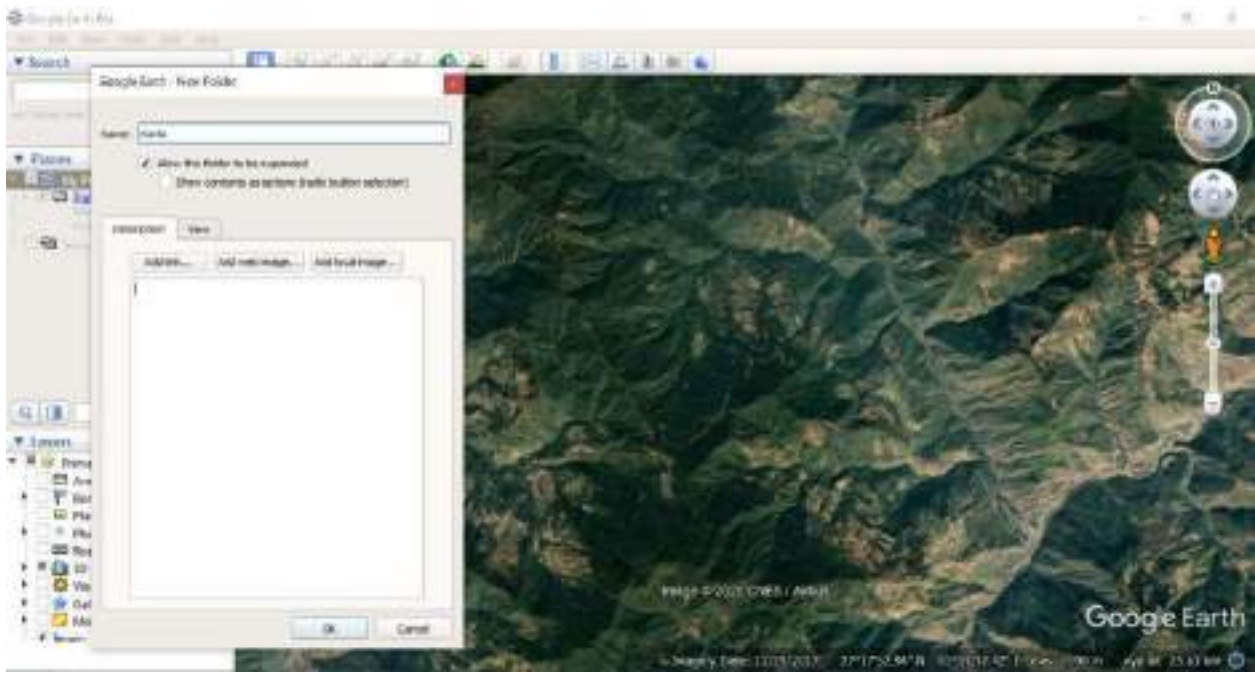
- *Open Google Earth Pro*
- *In Google Earth Pro, navigate to the area of interest where Boundary, Blocks, Compartments and Sub-compartments need to be delineated.*



- *Right click on My Place > Add > Folder*
- *Give appropriate name to the folder and save it*



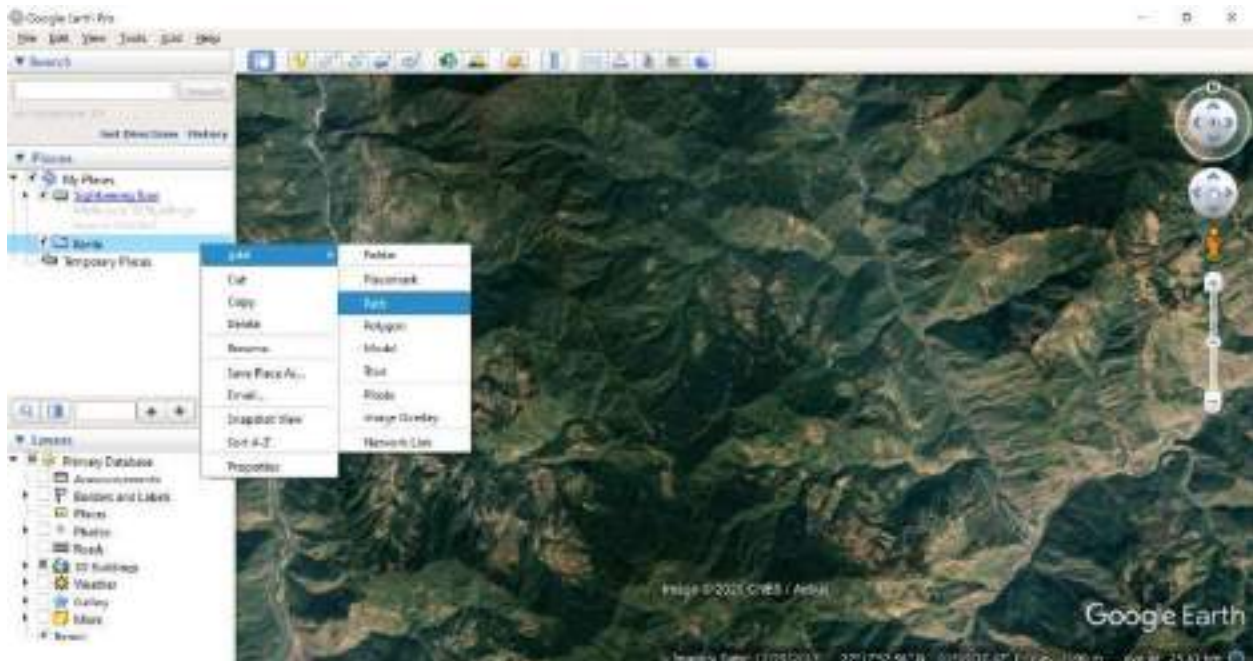




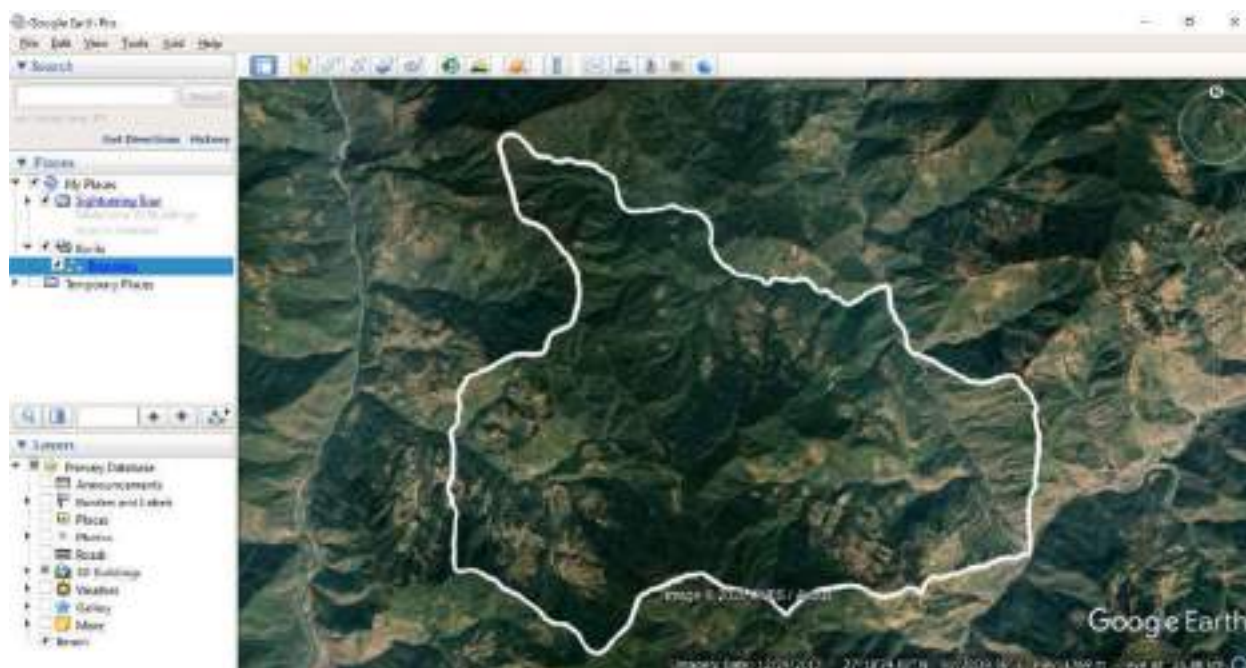
First the overall boundary of FMU need to be created (**Note:** in this case, boundary shall be created using line features and not polygon features)

Draw FMU boundary using line features

- Right click on newly created folder (Korila) > Add > Path (Path is line features in Google Earth)
- Draw the line taking natural features the boundary of area of interest (Note: it need not be one single line to cover the boundary of area of interest. Multiple segments of lines can be used to make the boundary by joining them, however, **make sure end on one segment of line is over lapped with starting point of another segment of line** as shown in the figure below)

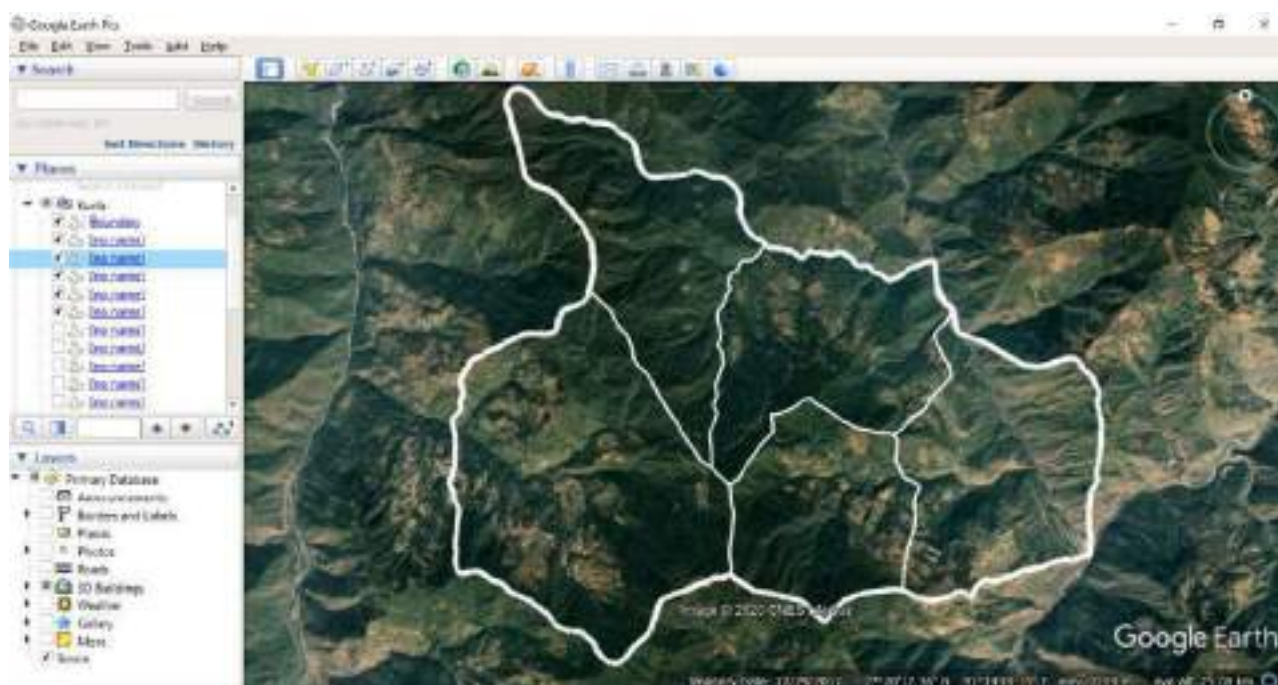






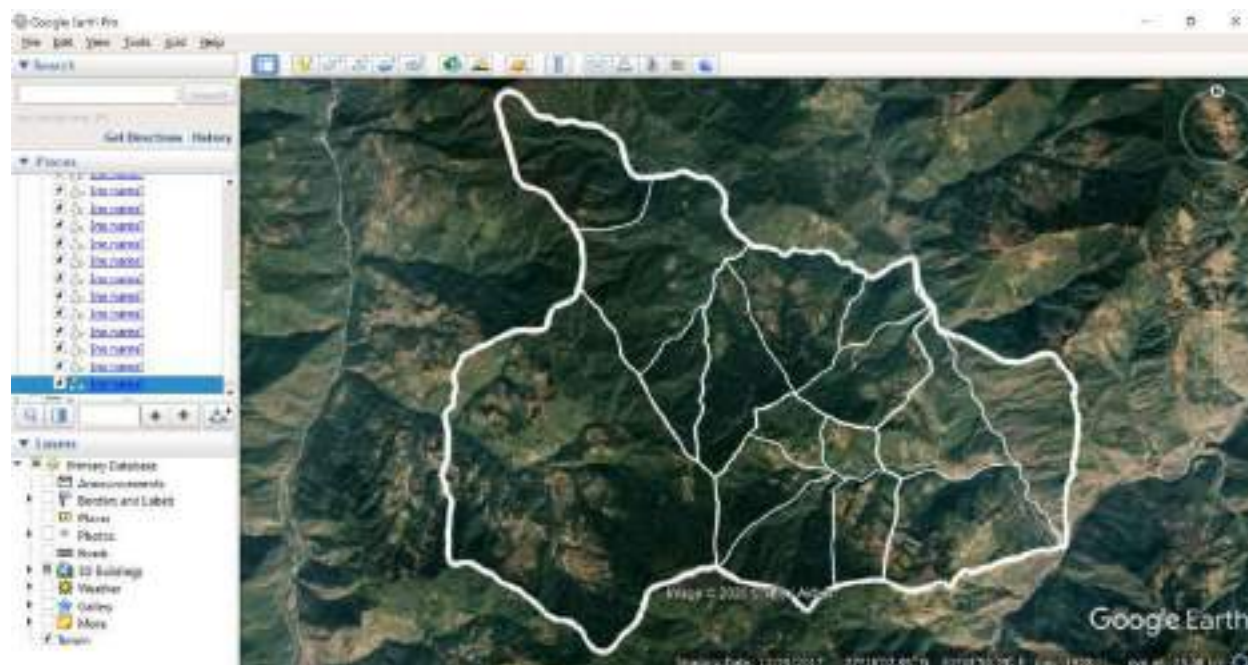
Draw lines for Blocks using line features

- *Right click on newly created folder (Korila) > Add > Path*
- *Draw the line taking natural features which can be served as boundary of Blocks (Note: it need not be one single line to cover the boundary of Blocks. Multiple segments of lines can be used to make the boundary by joining them, however, **make sure end on one segment of line is overlapped with starting point of another segment of line, overlap with boundary of area of interest**).*



#### Draw Lines for Compartments

- Right click on the newly created folder (Korila) > Add > Path
- Draw the line taking natural features which can be served as boundary of Compartments (Note: it need not be one single line to cover the boundary of Compartments. Multiple segments of lines can be used to make the boundary by joining them, however, **make sure end of one segment of line is over lapped with starting point of another segment of line, overlap with boundary of area of interest, Blocks and Compartments**).

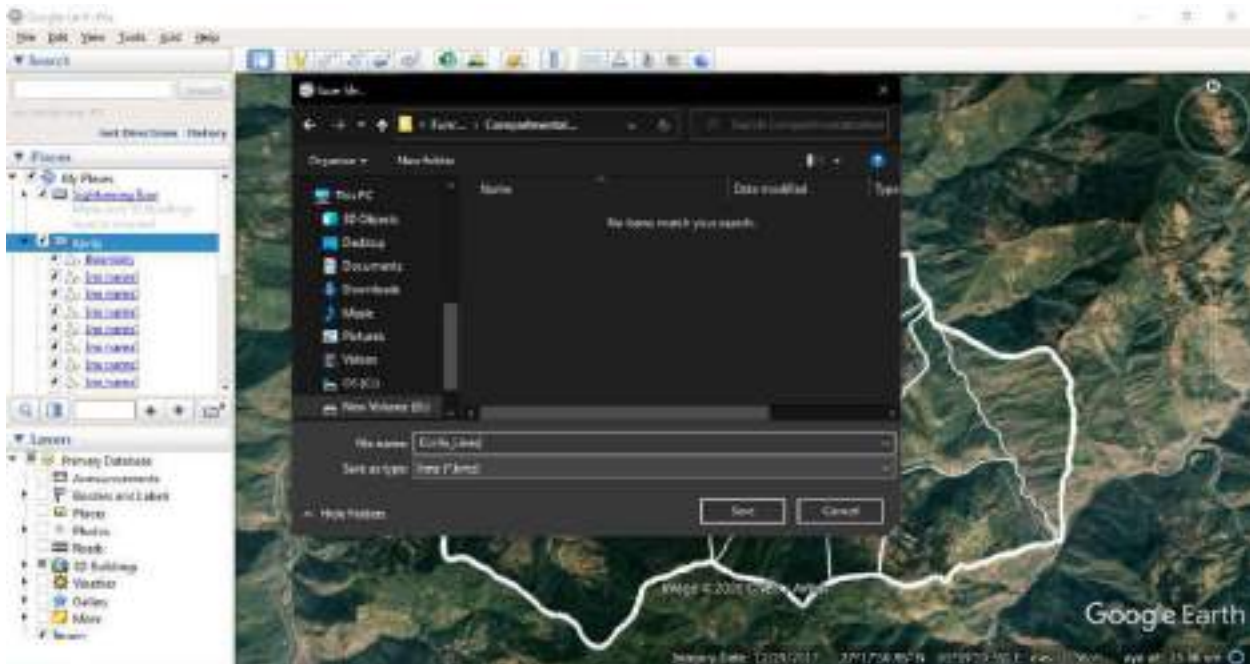
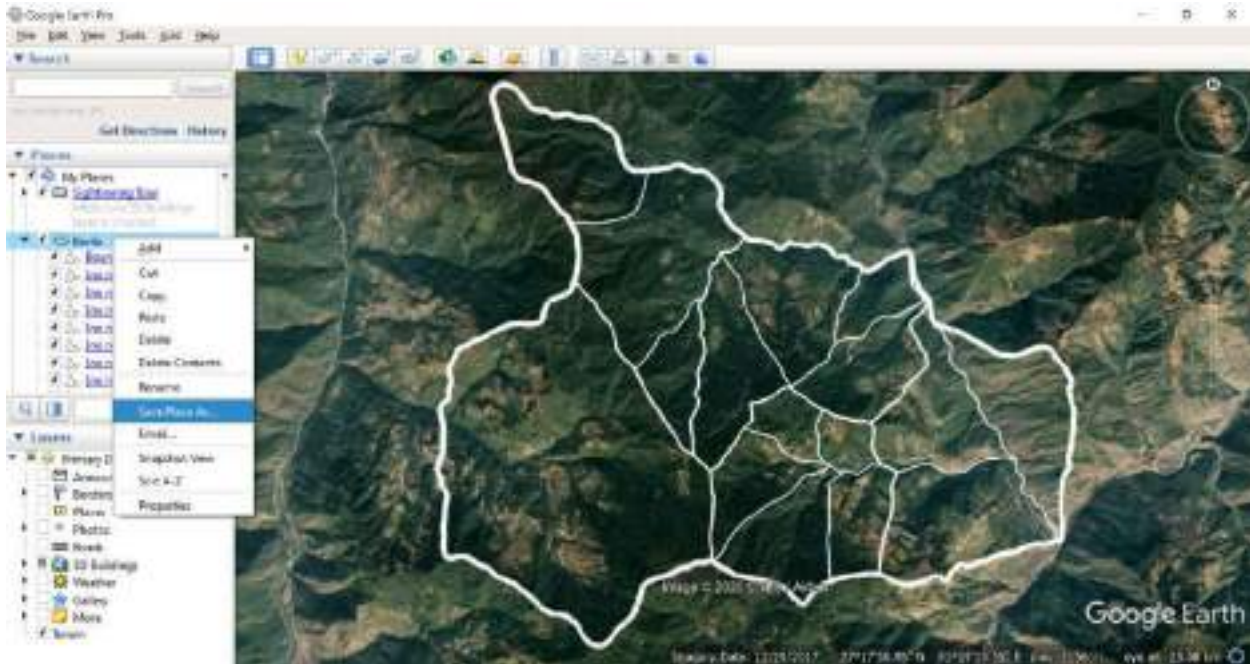




Repeat the process to draw the boundary of Sub-compartment if required.

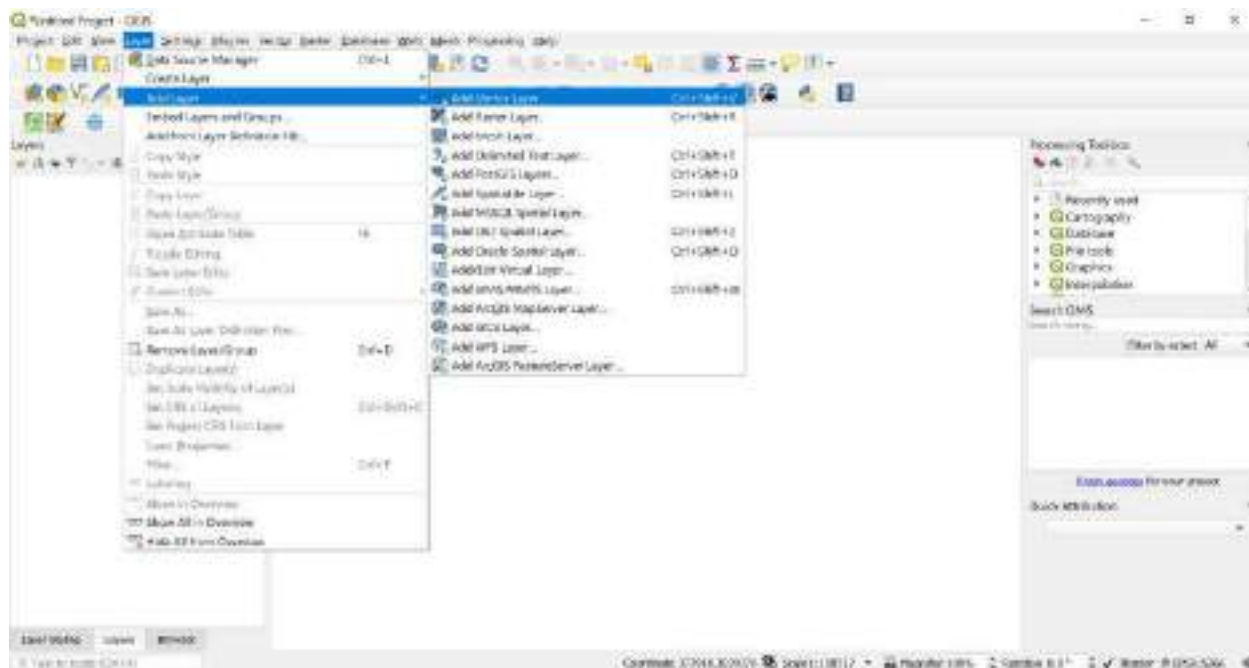
Once delineating of FMU boundary, Blocks, Compartments and Sub-compartment as line features is completed, import the Keyhole Markup Language (KML) file to QGIS.

- *Right click on newly created folder (Korila) > Save Place As*
- *Save the file KML file in the designated folder.*

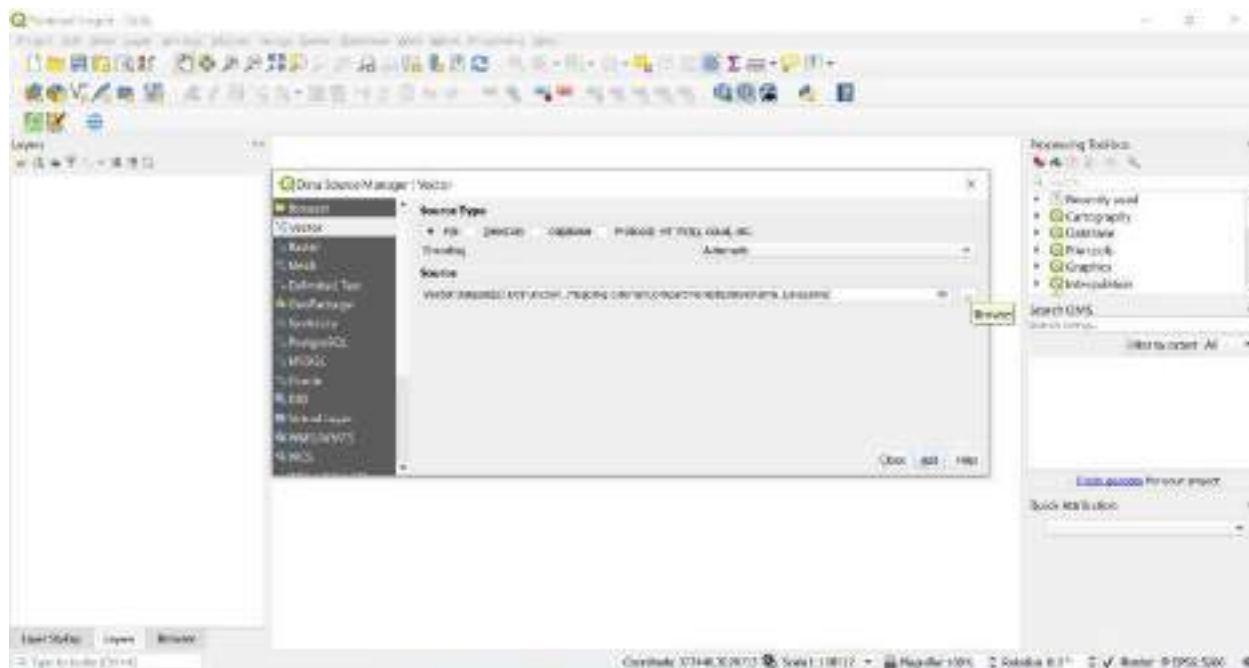


Opening KML file in QGIS

- *Open QGIS*
- *Navigate to Layer < click Add Layer > Click Add Vector Layer...*

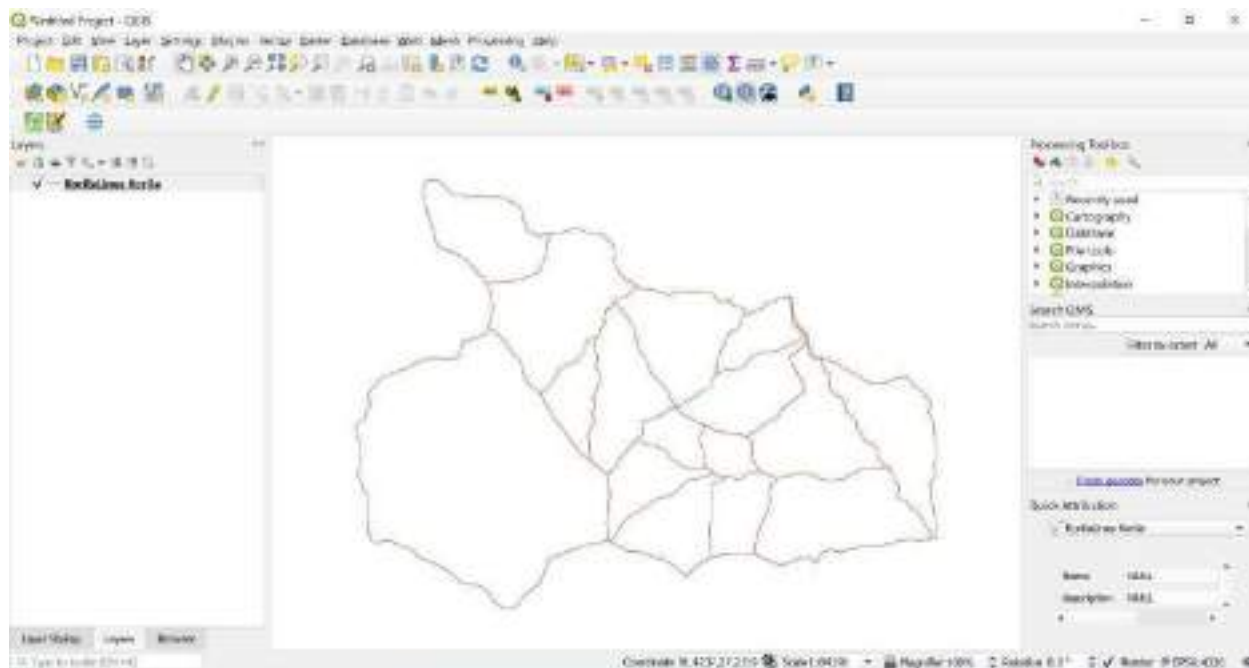


- In the source, browse your KML file



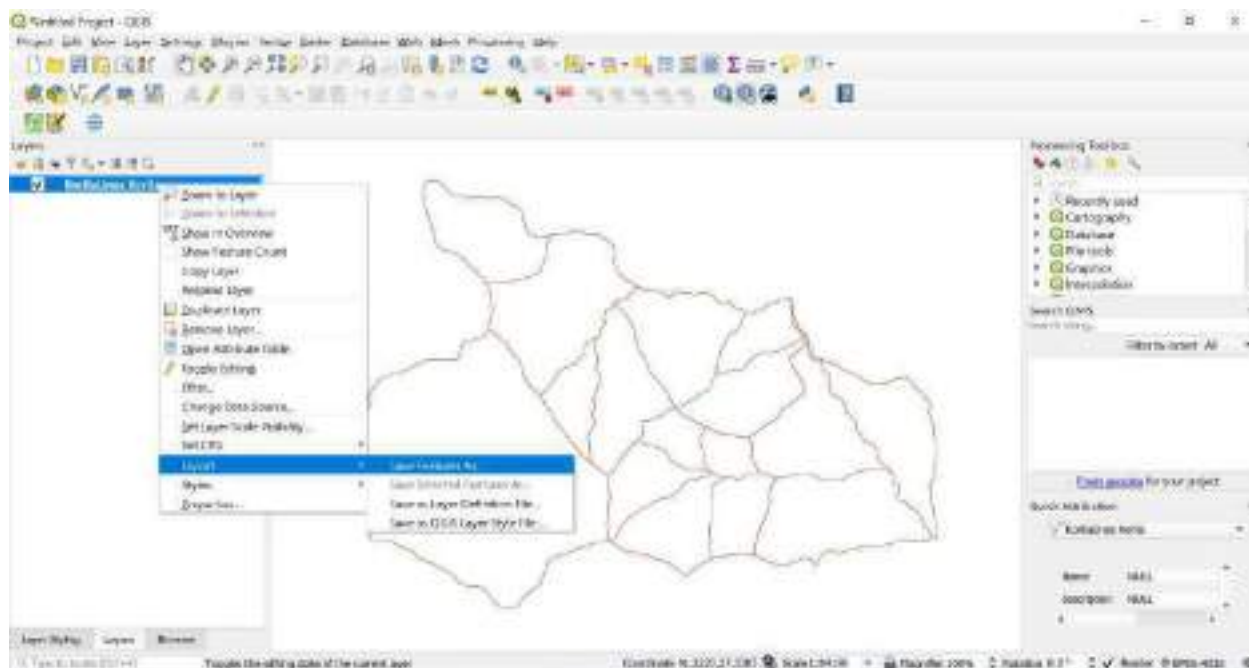
- Select the KML file > click open
- Click Add



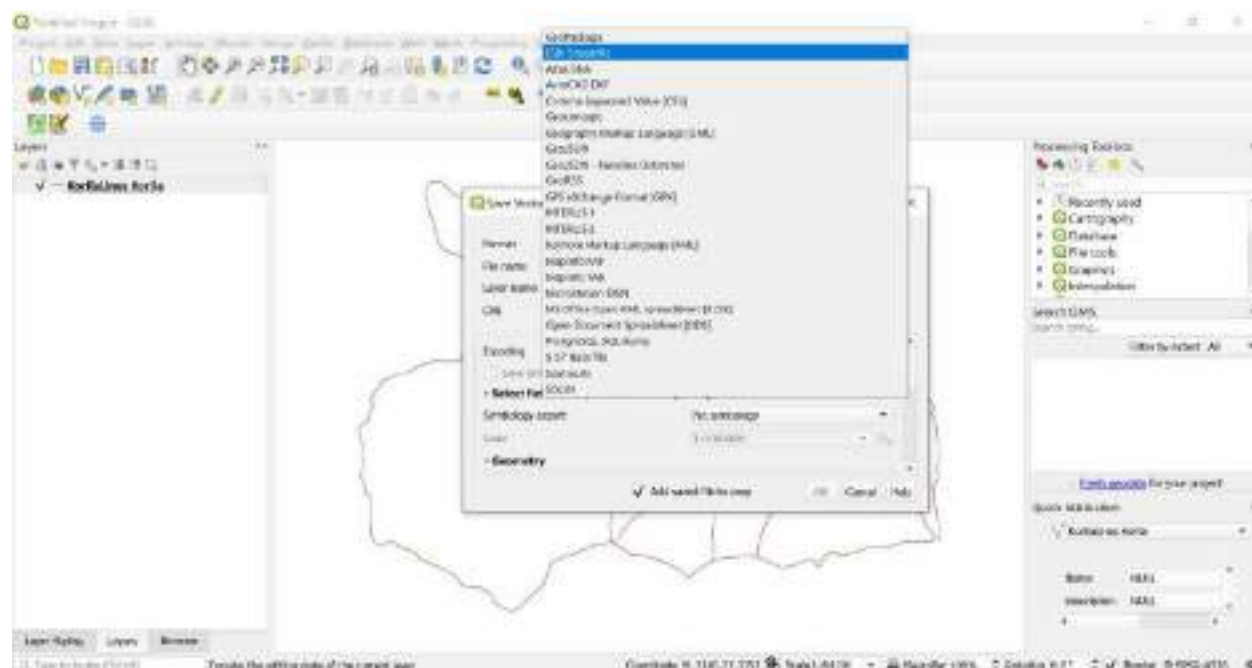
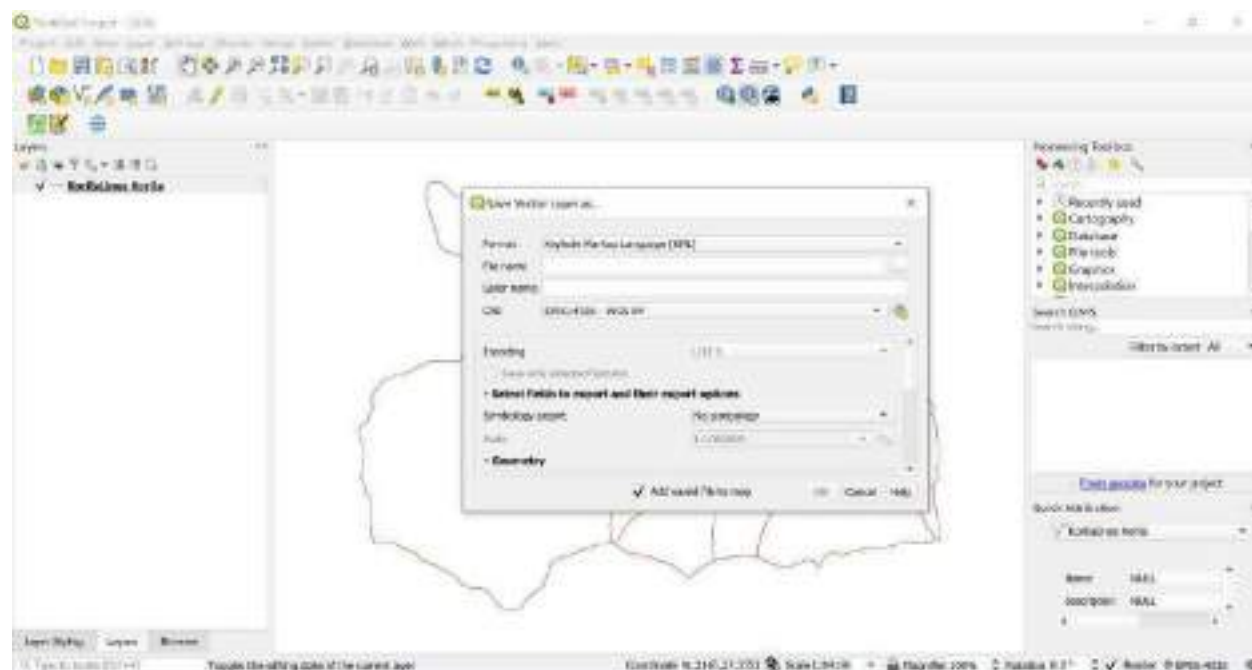


KML file need to be converted into ESRI Shapefile format for further analysis.

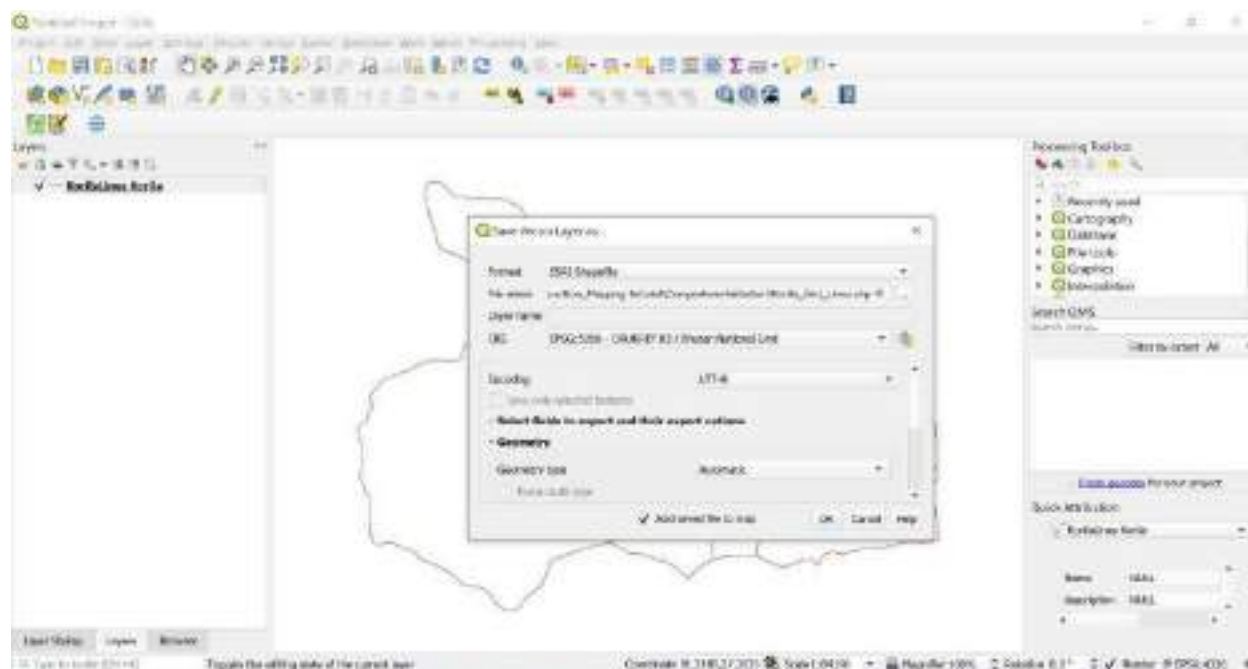
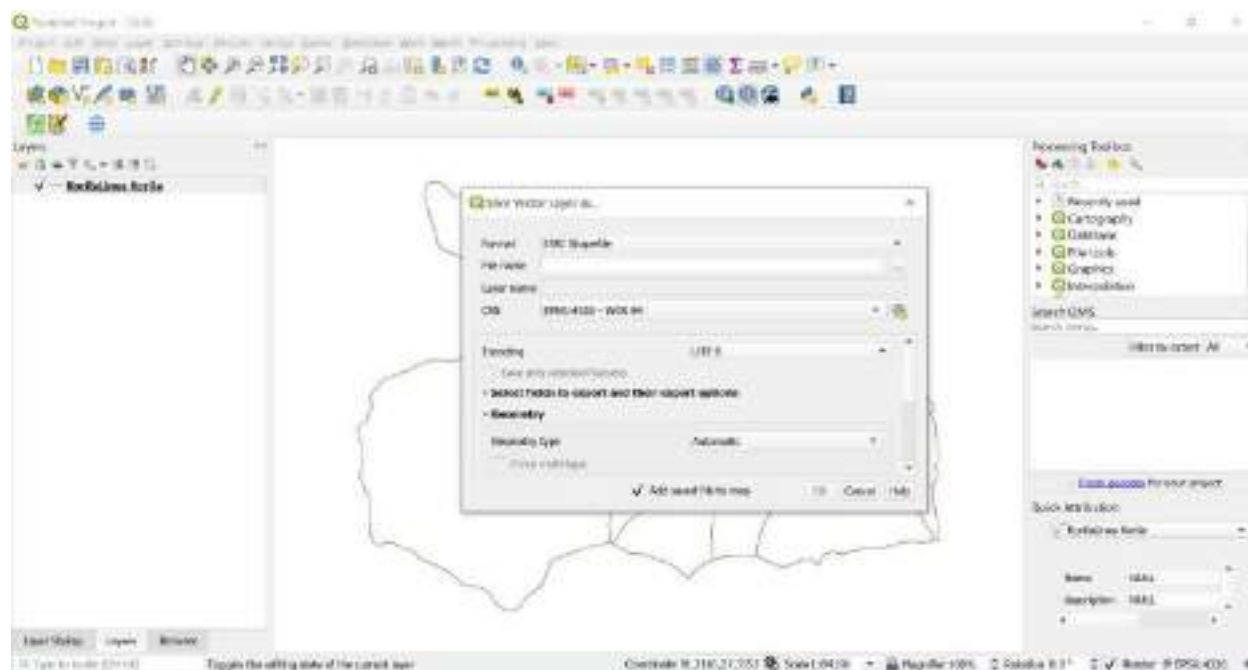
- *Right click on file > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *CRS: DRUKREF 03/ Bhutan National Grid*
- *Save the file with appropriate name in working directory*





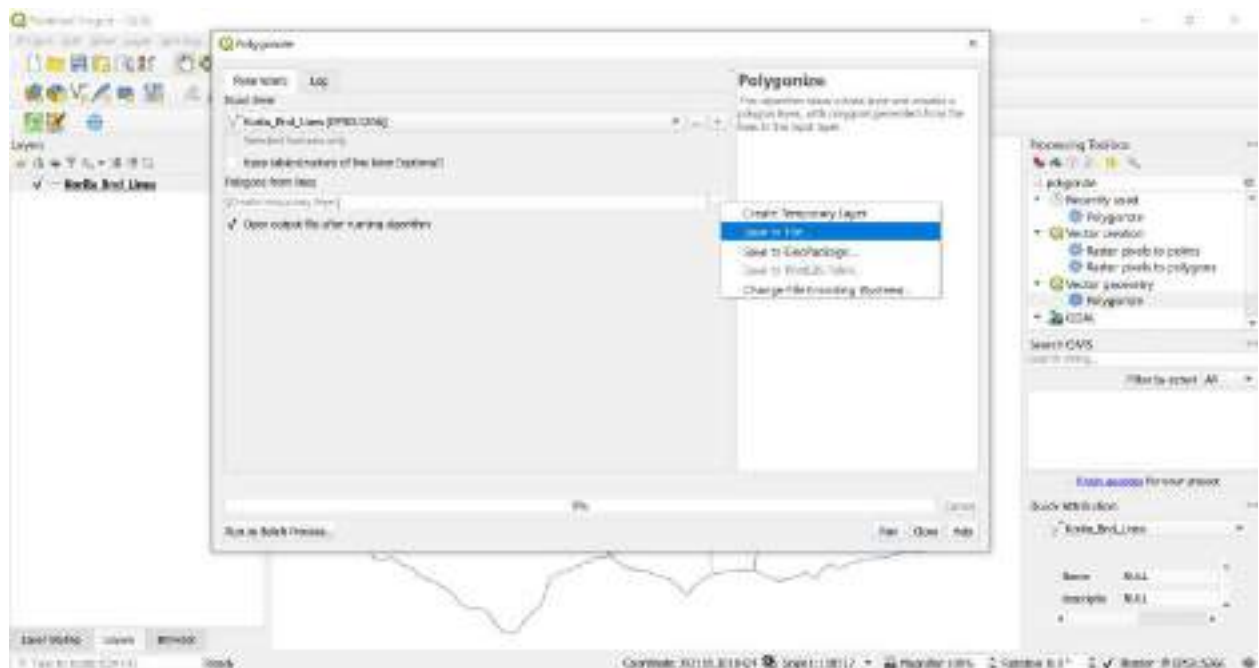
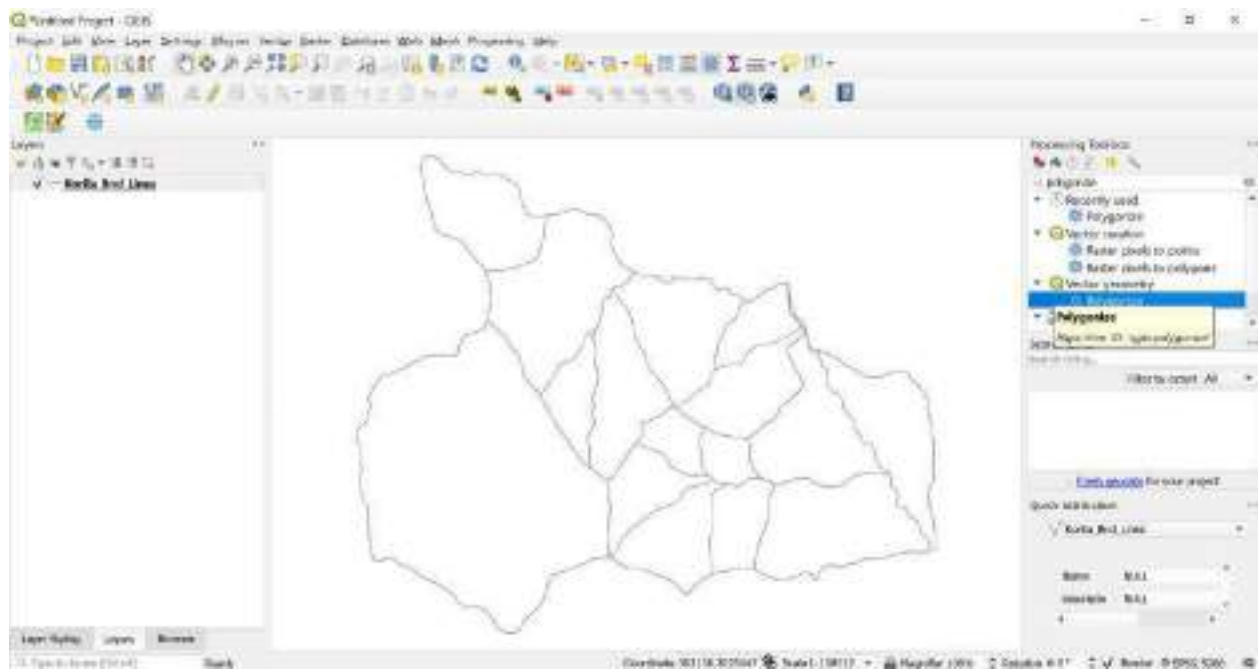


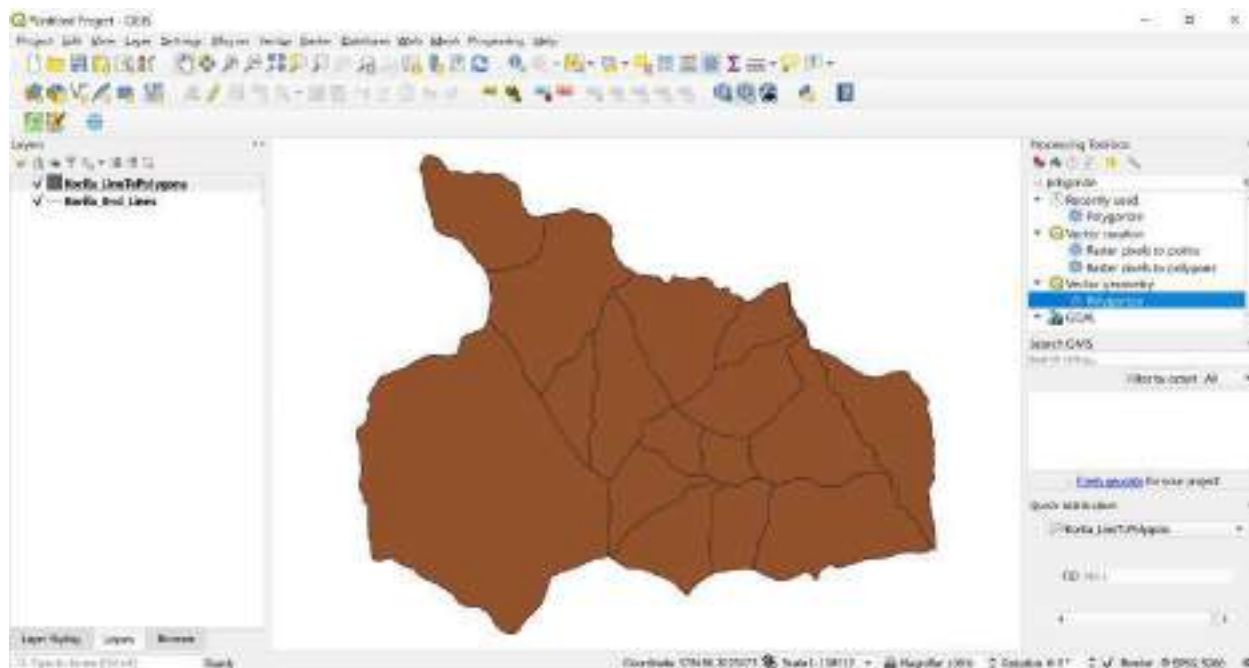




Converted shapefile is still in line features. We need to convert the line features into polygon features.

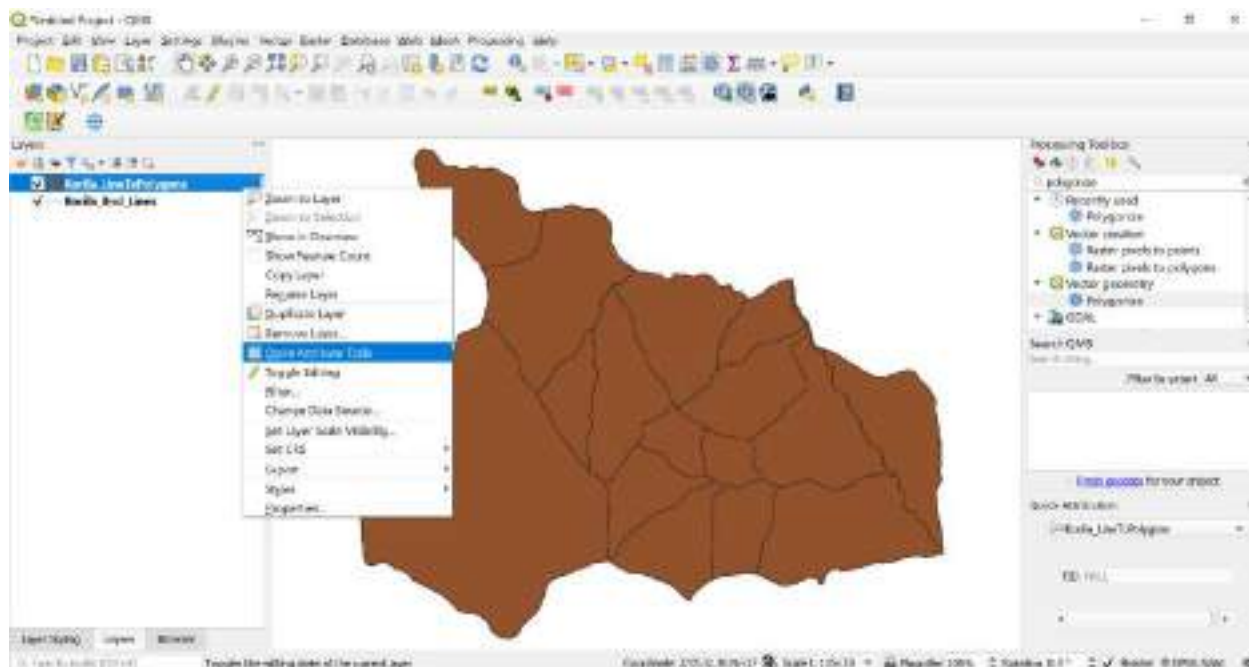
- Type **Polygonize** in processing toolbox
- Navigate to Vector geometry and select Polygonize tool
- In Input Layers: Select the file you want line feature file
- Save the file with appropriate name in working directory
- Click run

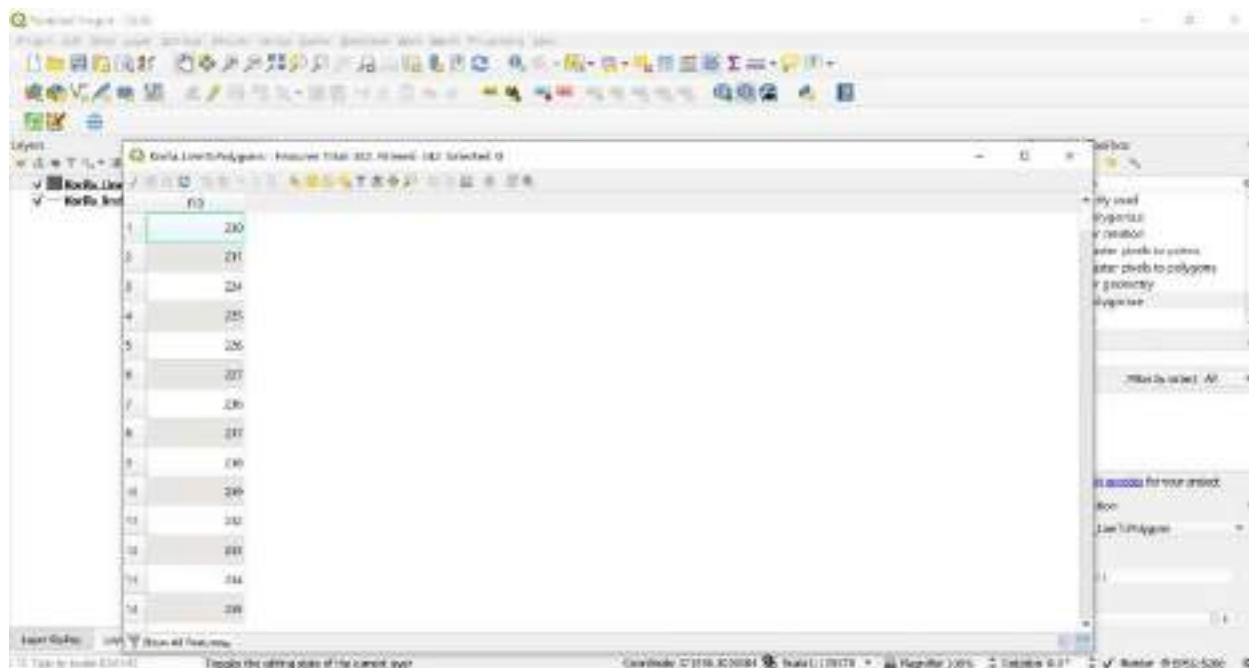




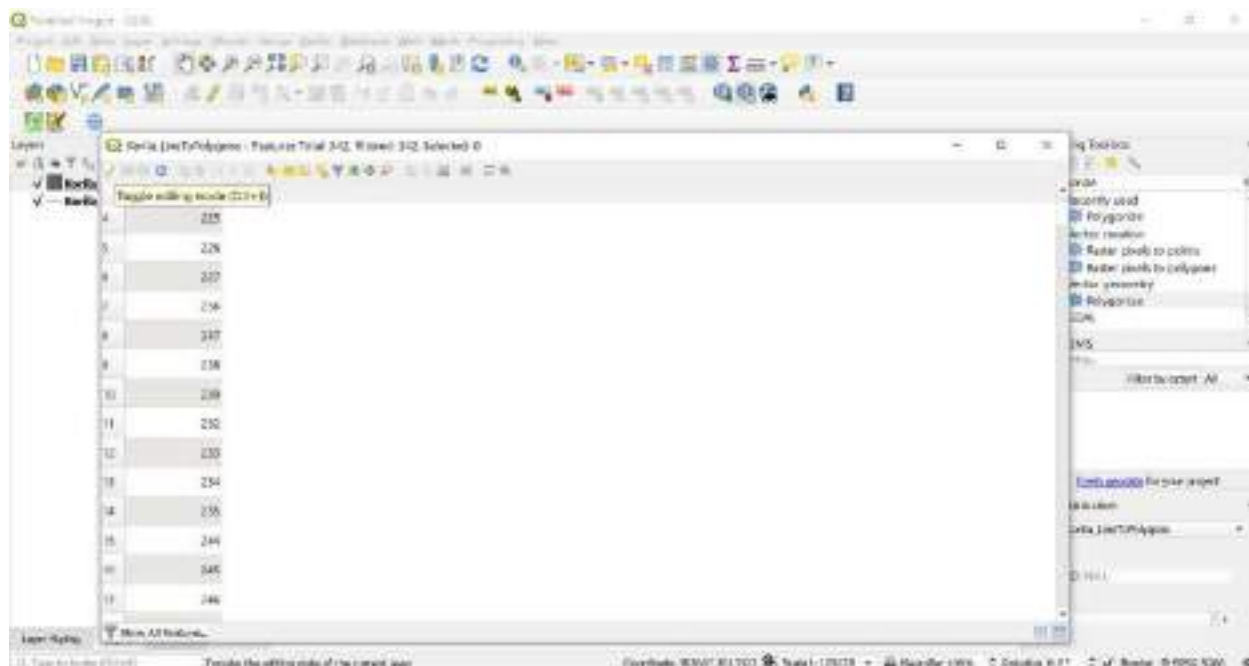
Now the line features have been converted into polygon features. We need to give the appropriate name of FMU, Blocks, Compartments and Sub-compartments.

- *Right click on polygon layer > Click Open Attribute Table*





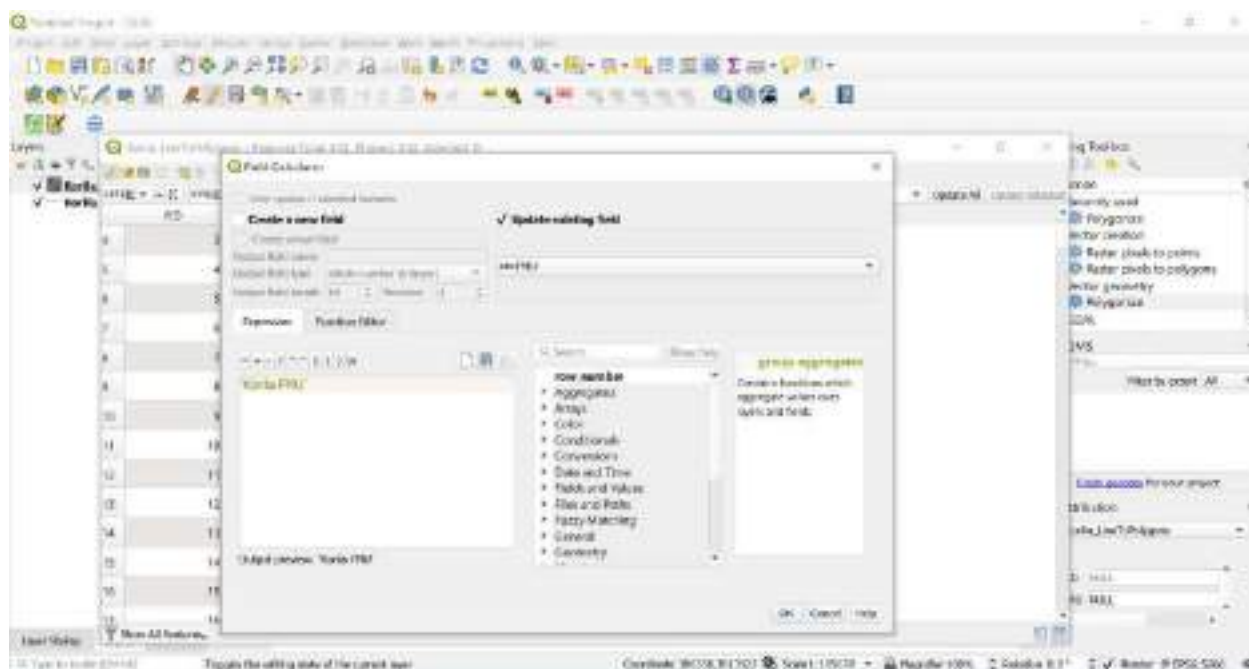
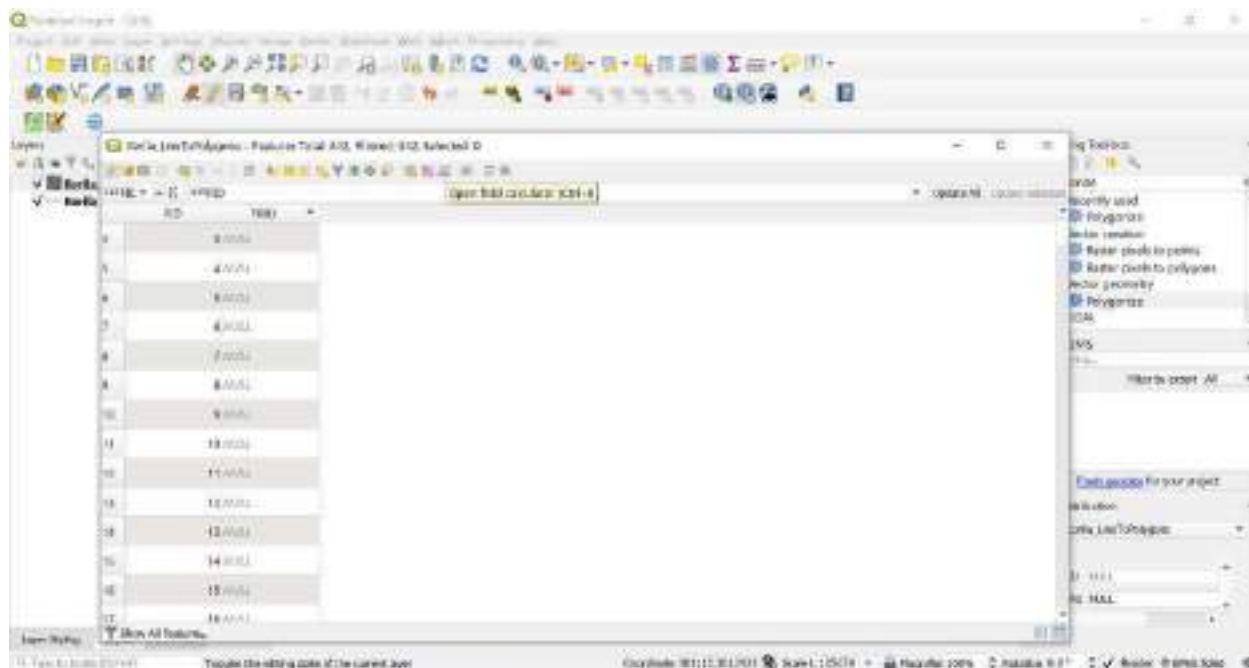
- Click Toggle Editing Mode



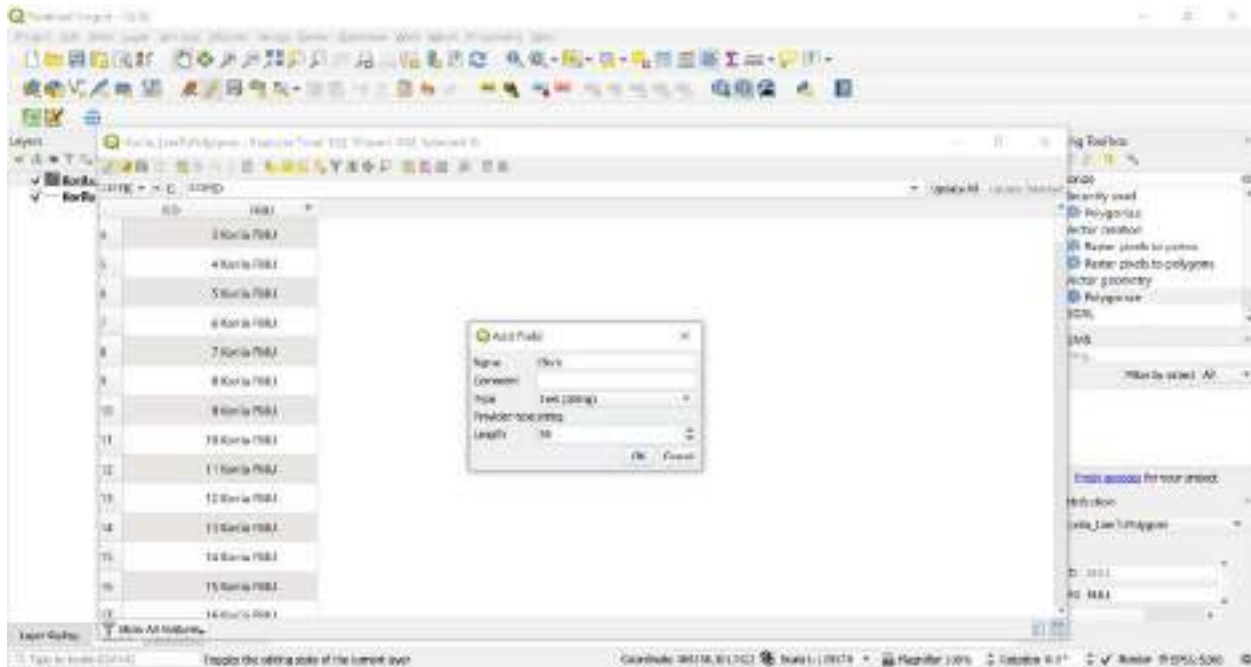
- Click on New field
- Name: Type FMU
- Type: Select Text (String)
- Length: 50
- Click Ok







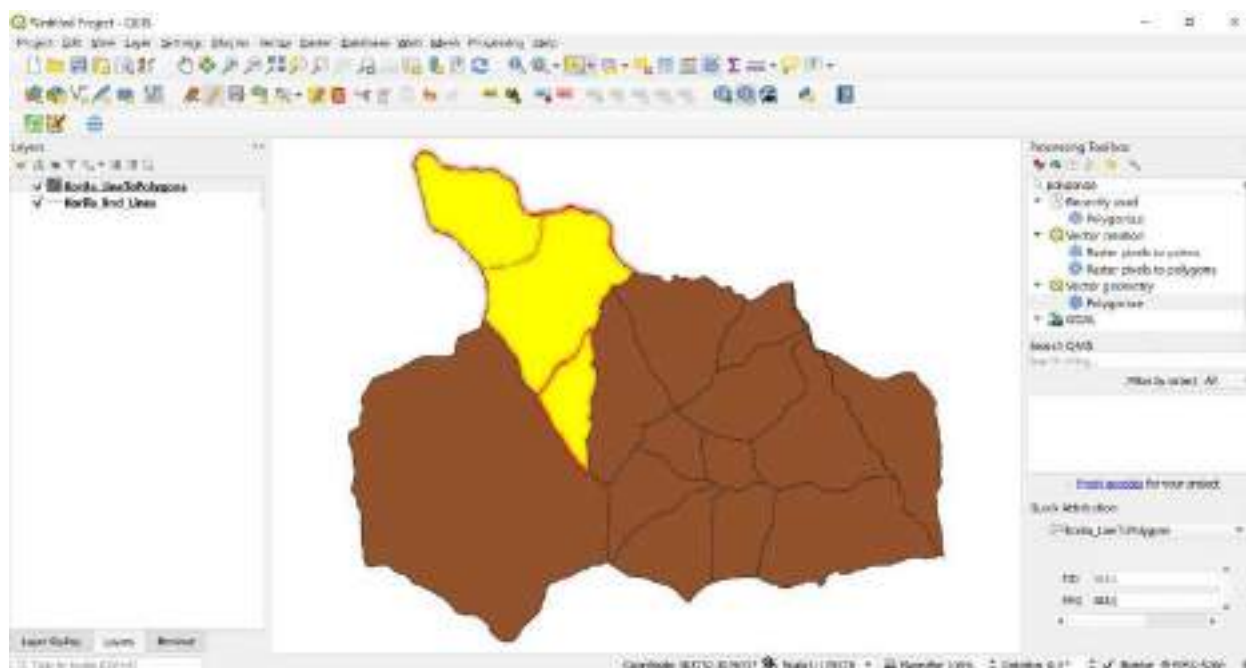
- Click on New field
- Name: Type Block
- Type: Select Text (String)
- Length: 50
- Click Ok



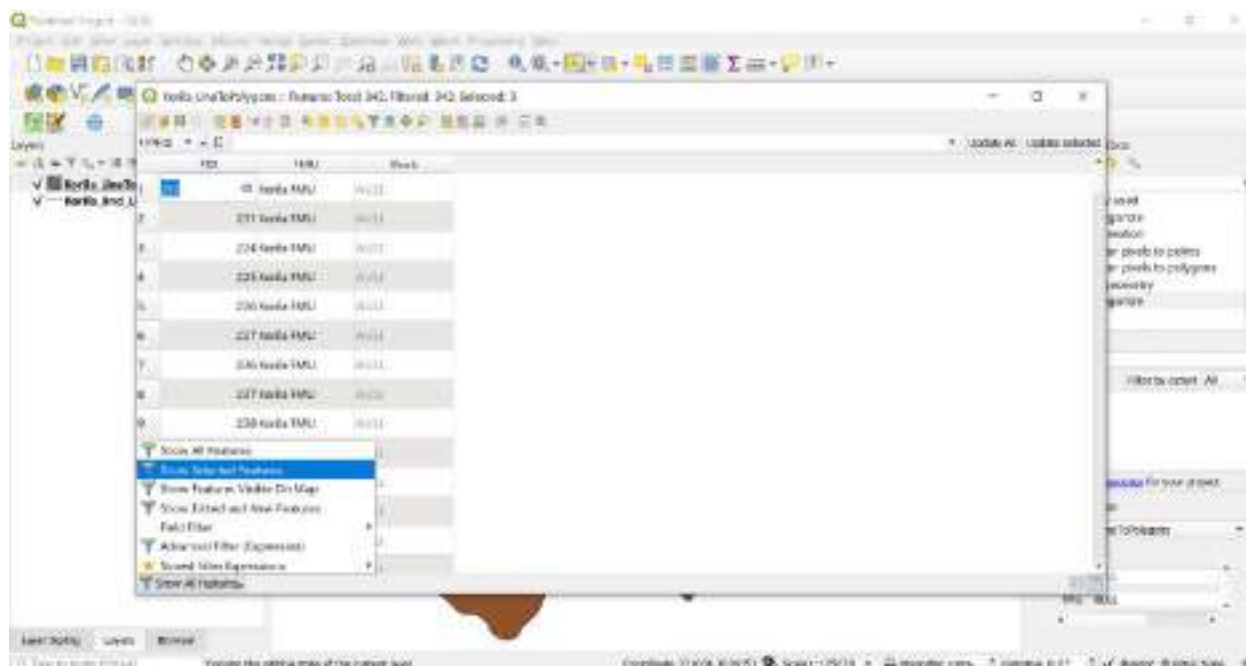
- Minimize attribute table
- Click Select Feature
- Identify each different Blocks, we need to name the block one at a time
- Move your mouse and click one polygon (it shall be highlighted yellow). We can also select multiple polygons by pressing control on keyboard and clicking on multiple polygons to be selected. Select all the polygons that falls under one Block



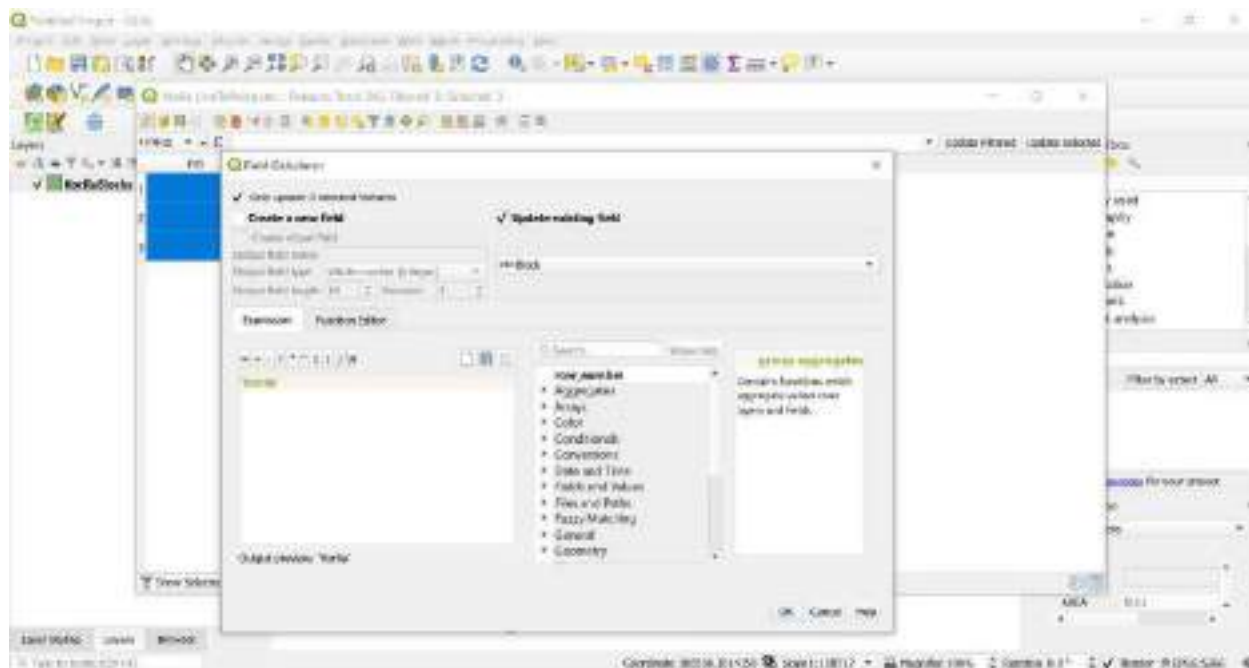




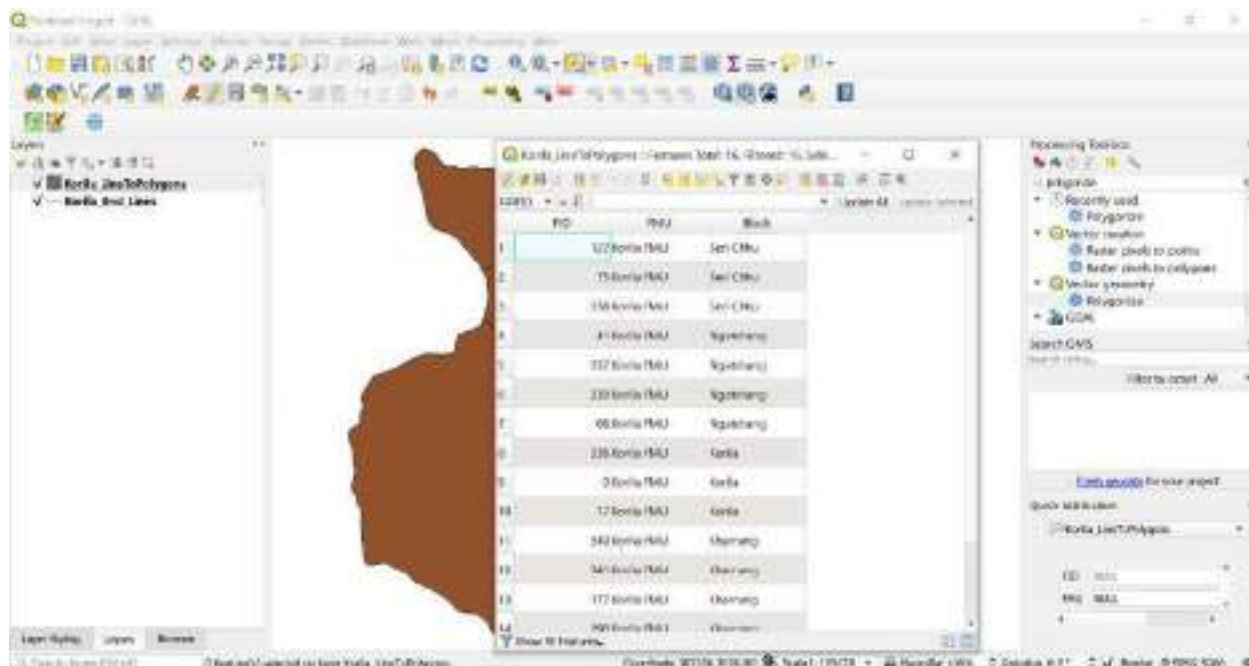
- *Open/maximize attribute table*
- *Select Show Selected Features (this shall show only polygons that are selected)*



- *Click Open Field Calculator*
- *Check Update existing field*
- *Select Block*
- *In the expression box; type Name of Block within inverted coma e.g. ('Korila')*
- *Click ok*

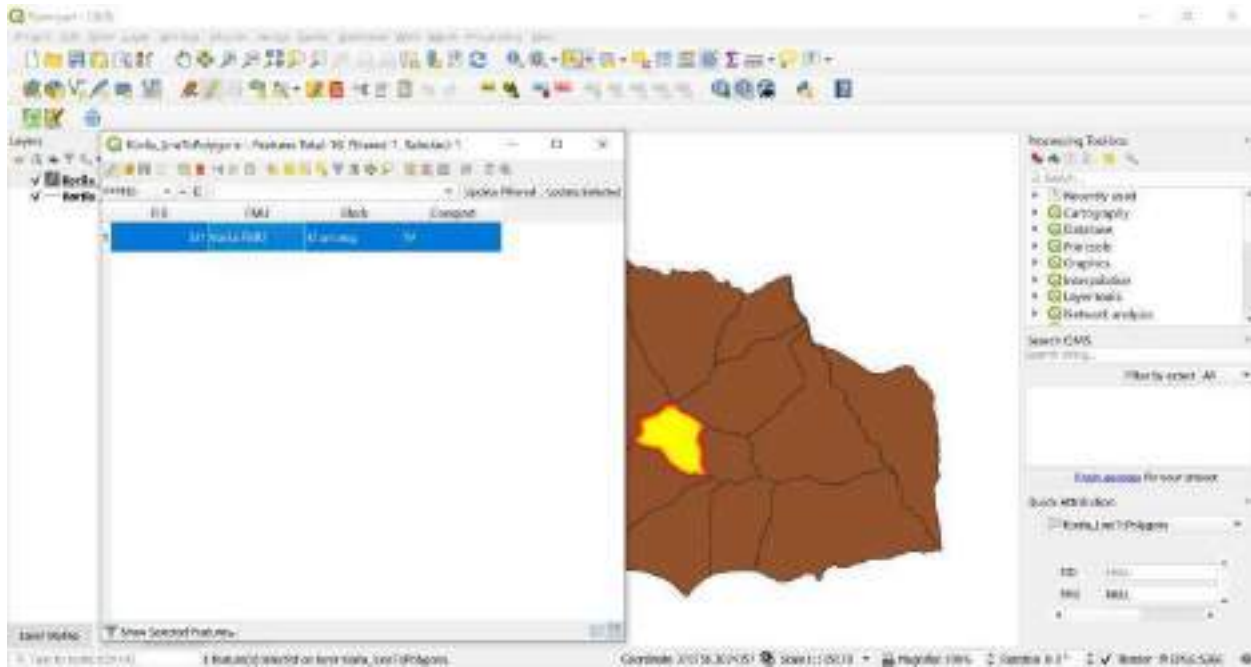


Repeat the process to name all the Blocks

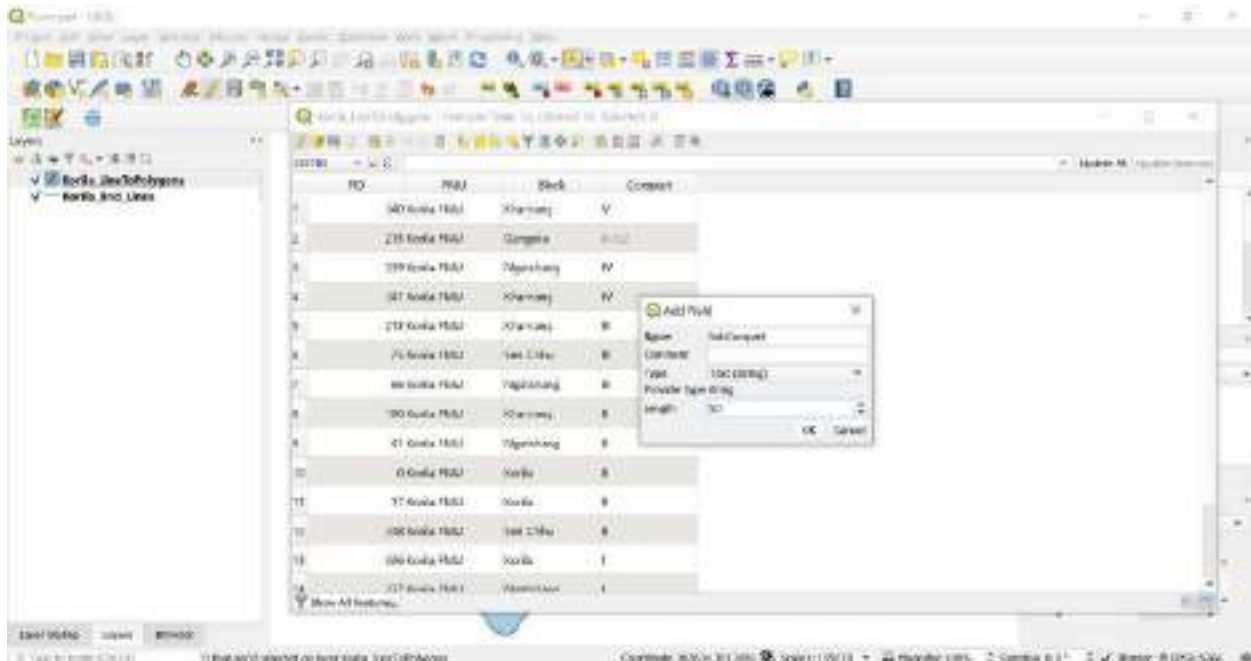


- Click on New field
- Name: Type Compart (Full compartment cannot be typed due to restriction in number of letters for field title)
- Type: Select Text (String)
- Length: 50
- Click Ok



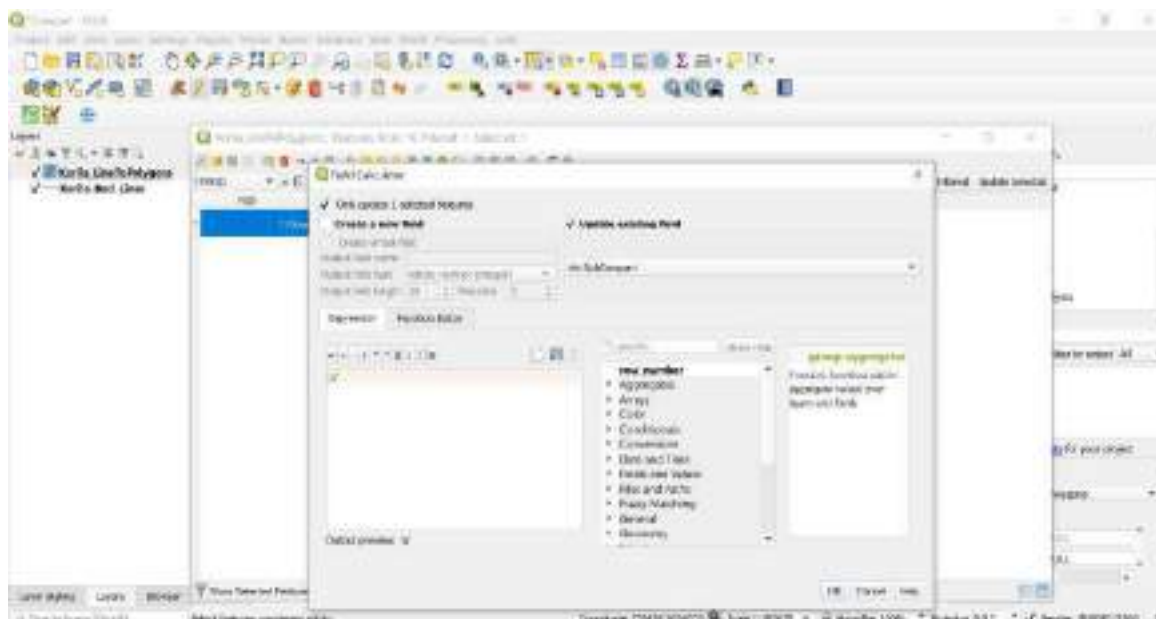


- Click on New field
- Name: Type SubCompartment (Full Sub-compartment cannot be typed due to restriction in number of letters for field title)
- Type: Select Text(String)
- Length : 50
- Click Ok



- Minimize attribute table
- Click Select Feature
- Identify each different Sub-compartment, we need to name the Sub-compartment one at a time
- Move your mouse and click one polygon (it shall be highlighted yellow).

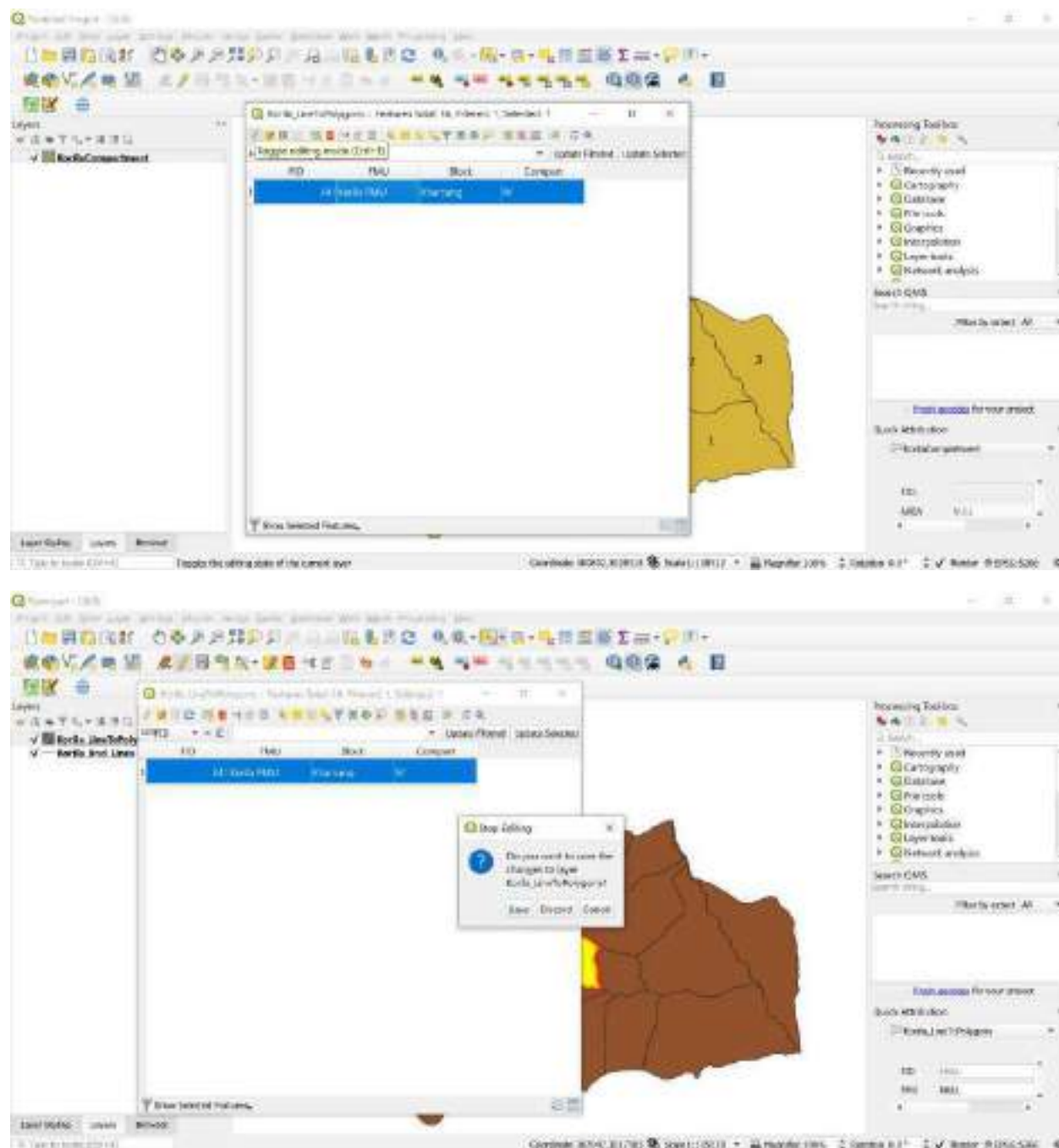
- Open/maximize attribute table
- Select Show Selected Features (this shall show only polygon that is selected)
- Click Open Field Calculator
- Check Update existing field
- Select SubCompartment
- In the expression box; type Number of Sub-compartment within inverted coma in small alphabetical letter e.g. ('a') or ('b') or ('c')
- Click ok



Once all the naming of FMU, Blocks, Compartments and Sub-compartment are completed save the edits

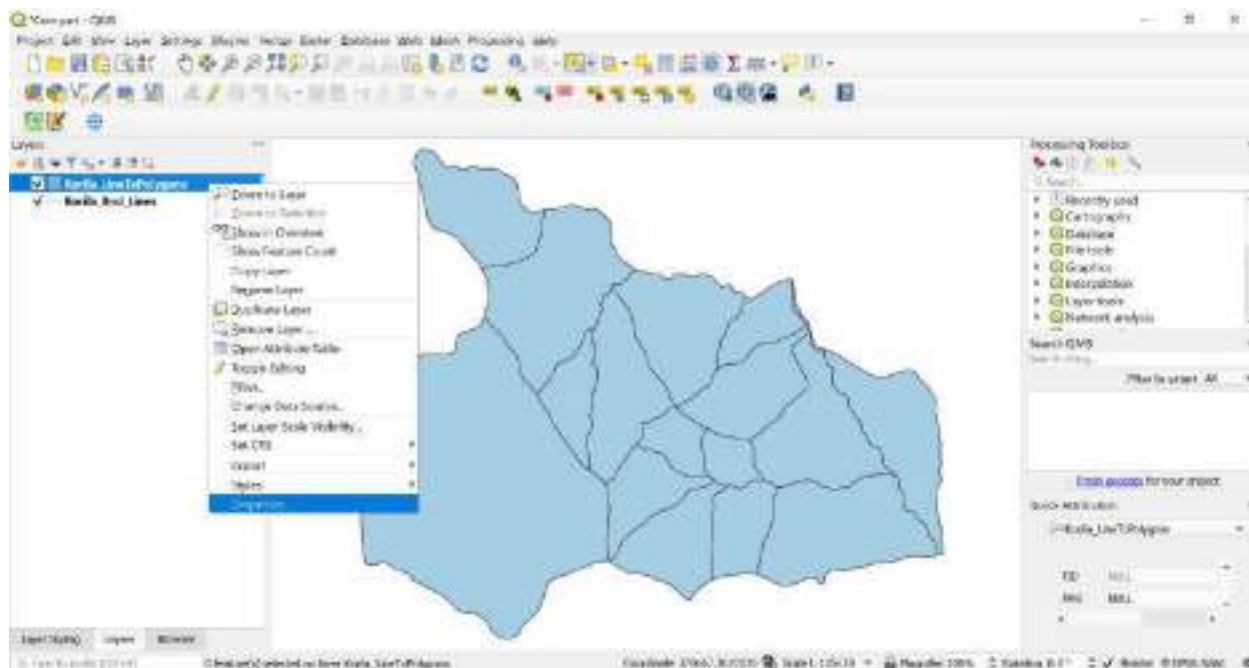
- Click Toggle editing mode > Click Save



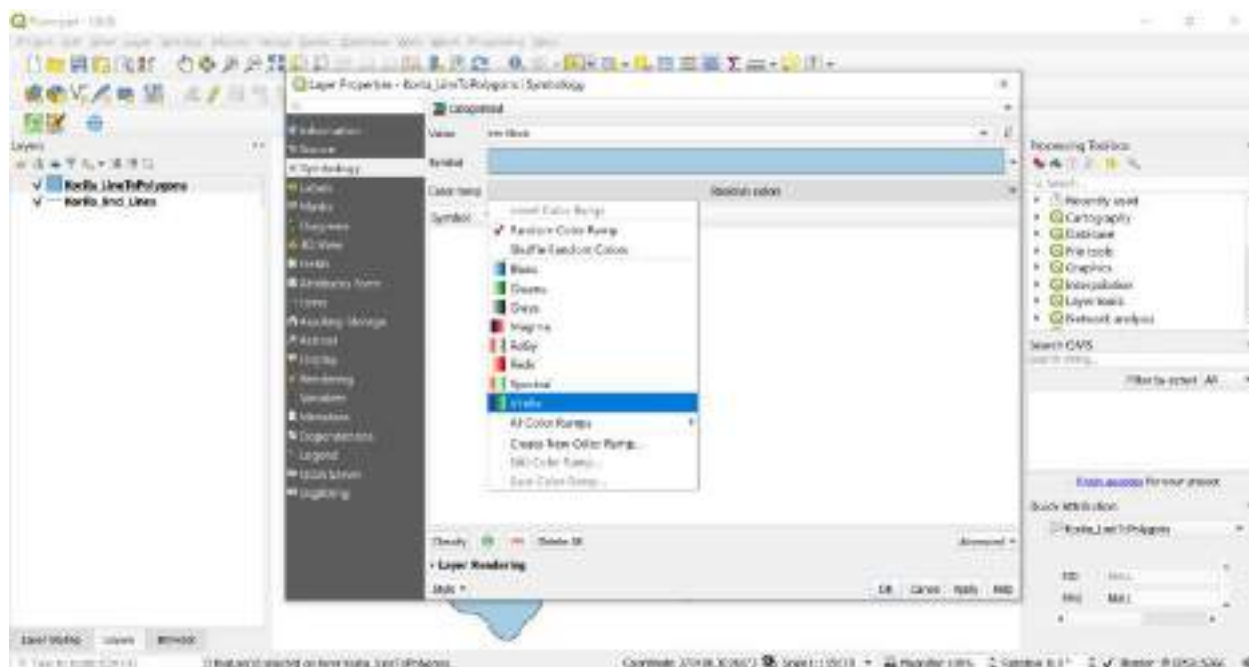


Display Blocks in different colour in map viewer.

- Right click on polygon layer > Click Open Attribute Table > Click Properties.

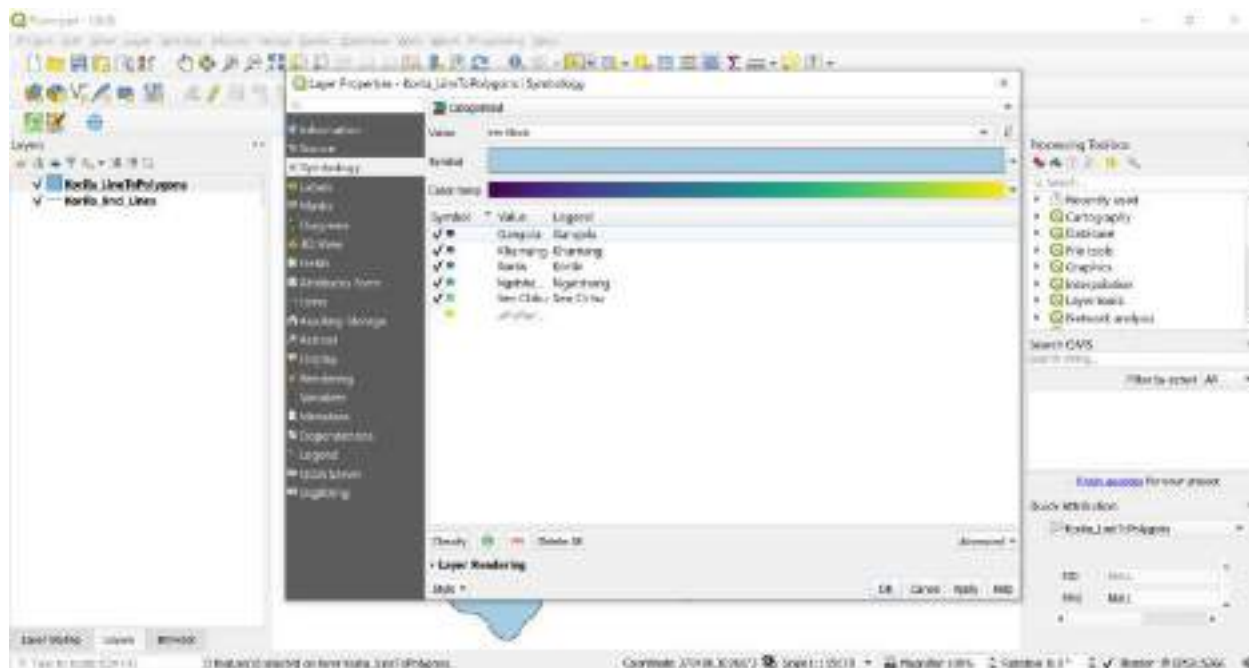


- *Click Symbology > Select Categorized*
- *In the Value: Select Block*
- *Click Color ramp and select appropriate colour*



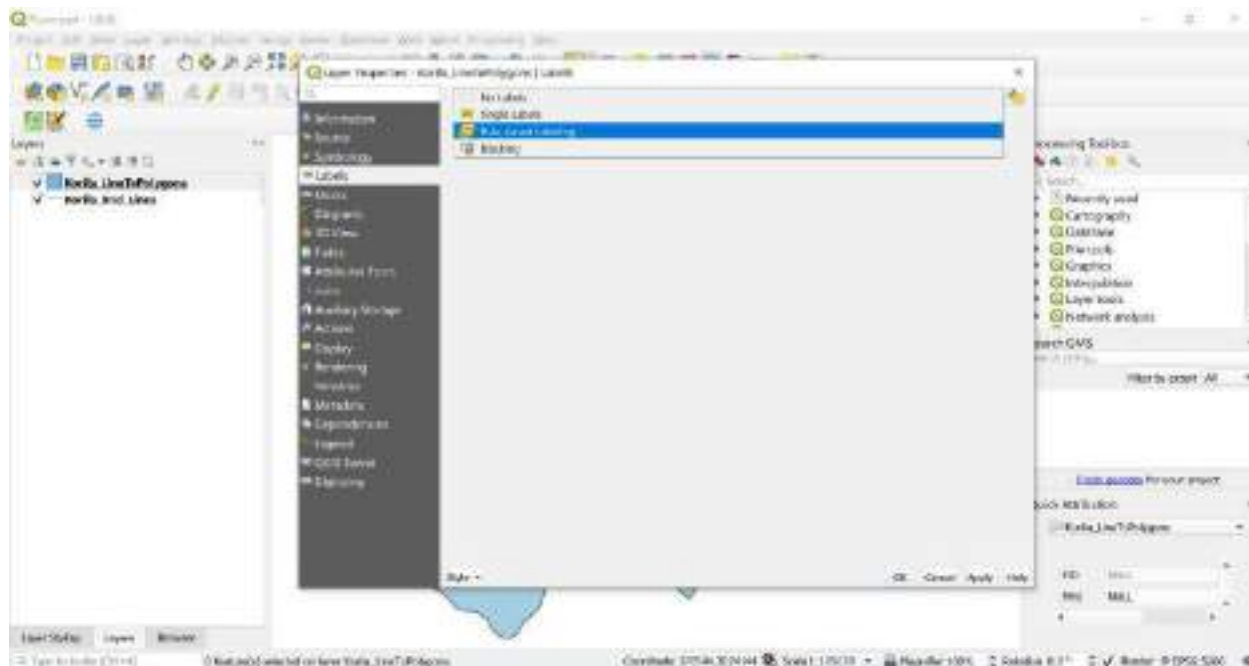
- *Click Classify*
- *Click Apply*
- *Click OK*



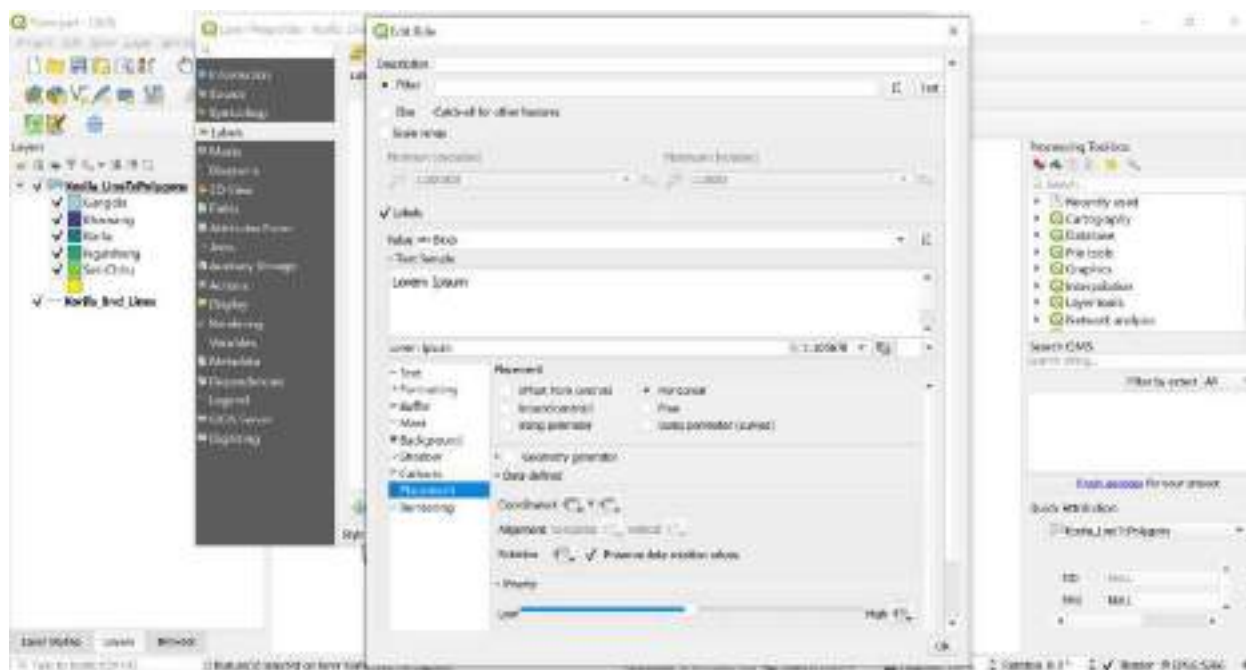


Display the name of Blocks, Compartments and Sub-compartments in Map Viewer

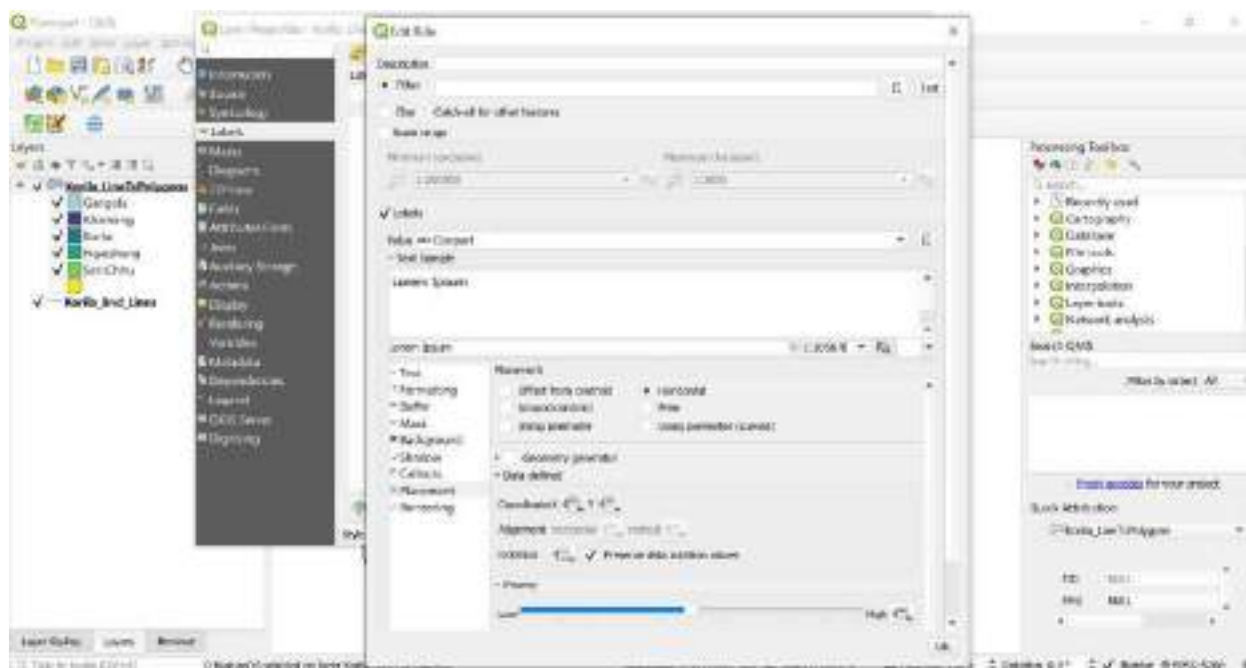
- *Right click on polygon layer > Click Open Attribute Table > Click Properties.*
- *Click Labels > Select Rule-based Labelling*



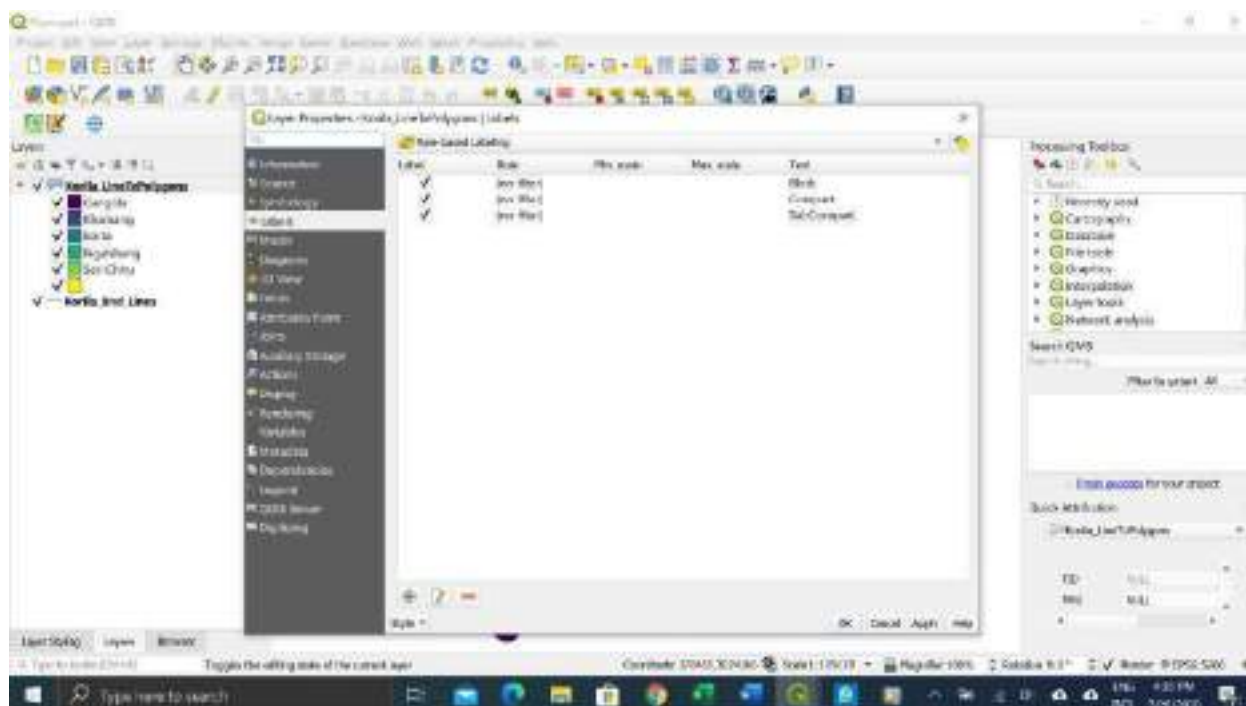
- *Click Add Rule*
- *In the Label Value: Select Blocks*
- *In Placement: Select Horizontal*
- *Click OK*



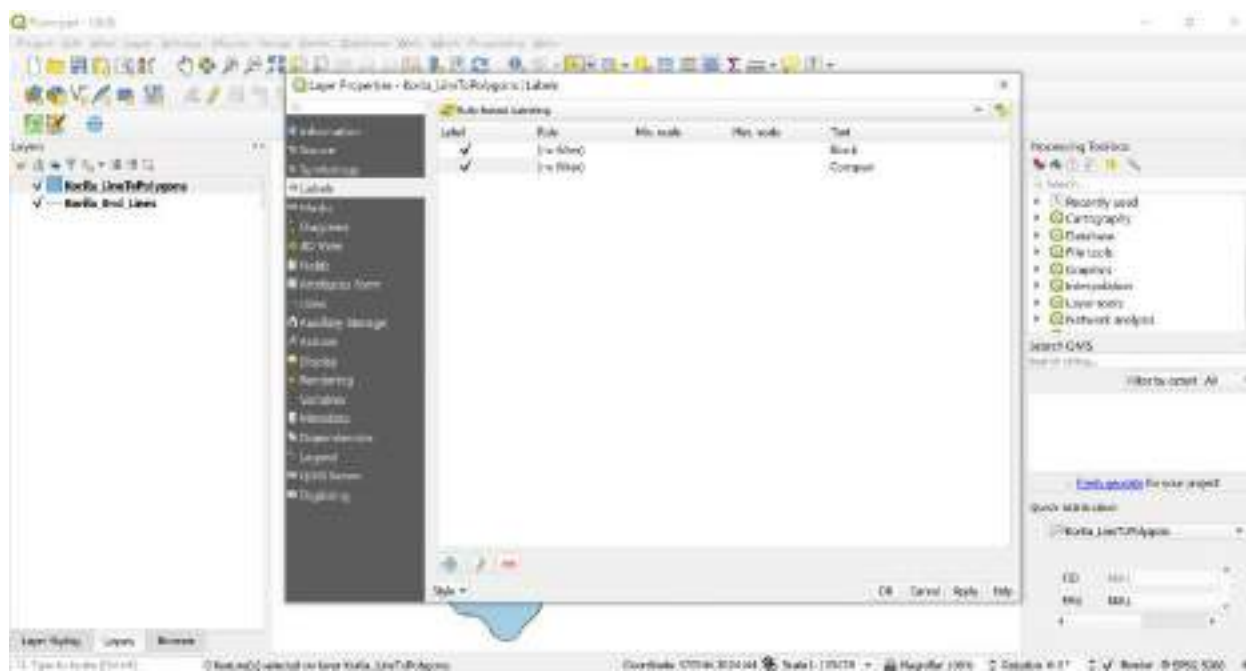
- *To add more rules click Add Rule*
- *In the Label Value: Select Comp*
- *In Placement: Select Horizontal*
- *Click OK*

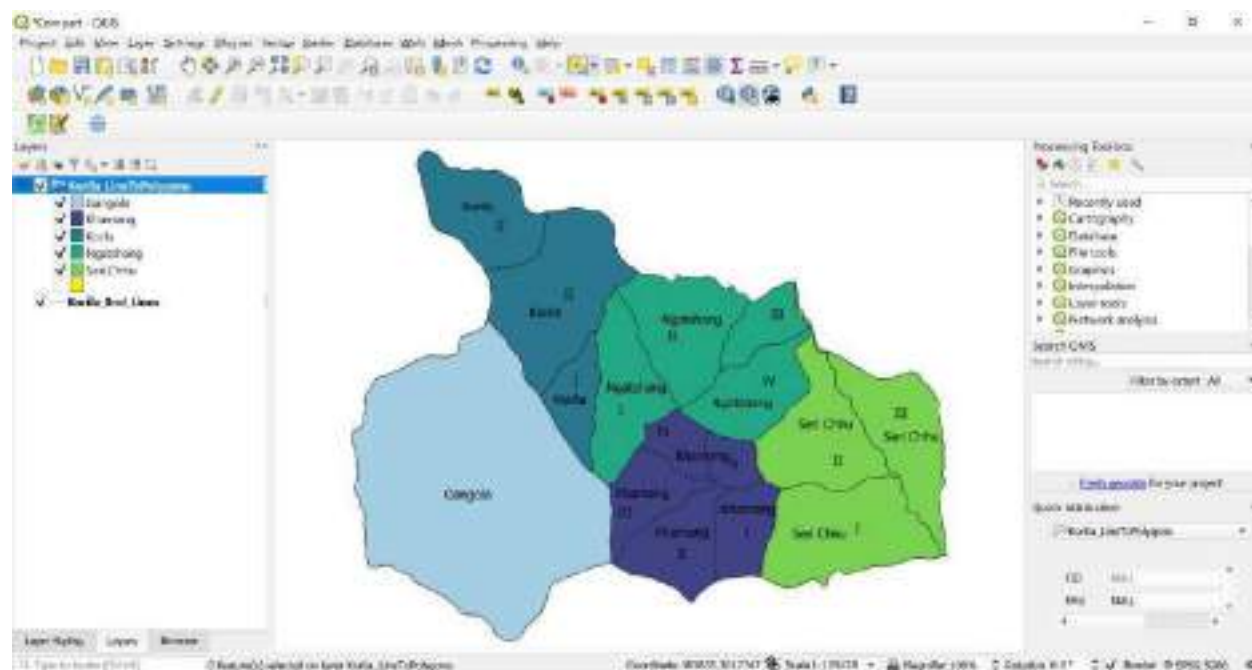


- *To add more rules click Add Rule*
- *In the Label Value: Select SubComp*
- *In Placement: Select Horizontal*
- *Click OK*



➤ In the Layer Properties dialogue box click Apply and OK





## **1.7. Socio-economic Survey and Resources use mapping**

### **1.7.1. Socio-Economic Survey (SES)**

#### **1.7.1.1 Introduction**

This section includes guidelines on socio-economic survey, participatory resource use assessment, stakeholder analysis, establishment of the FMU-level committee and problem analysis and objective setting. These planning steps and processes are essential to ensuring that the FMP effectively incorporates stakeholder needs, interests and priorities.

A socio-economic survey is required in order to collect socio-economic information about the communities who live in and adjacent to an existing or proposed FMU. It provides useful information on local populations and their forest product requirements. Much of this information shall already be available and can be collected by the forest management planner from secondary sources e.g. Dzongkhag or Gewog.

It is essential that local people are actively involved in the planning process; the participatory techniques described in this section shall help to ensure that they are actively involved in the process. Some element of verification of socio-economic information on the ground is useful. This involves visiting local villages and getting reliable idea of settlement patterns and land usage.

#### **1.7.1.2 Objectives**

The objectives of a socio-economic survey are to:

- prepare a socio-economic overview of villages/communities;
- raise awareness of the FMU; to ascertain what is already known and perceived and what information is needed and to inform communities at an early stage about the FMU planning process;
- prepare a complete overview of local use of the forests (including holy sites, *Tsamdro* and *Sokshing*);
- identify possible ways in which the community can fairly benefit from the FMU;
- minimize any negative impacts that might result from the establishment or continued management of an FMU and to pre-empt and avert future conflicts.

#### **1.7.1.3 Outputs**

The outputs of the socio-economic survey are:

- communities informed about the FMU and their involvement in planning; and
- socio-economic survey report containing socio-economic information on stakeholders (especially local stakeholders). The report is included or summarized in the forest management plan. The report shall include a participatory resource use map (showing how the forest is used by local people).

The socio-economic survey contributes to the forest function map by delineating the local/social uses of the forests; therefore, socio-economic survey should be conducted at the same time as forest function mapping.

#### **1.7.1.4 Lead Responsibility**

The Respective DFO shall take the lead role in collaboration with the Local Government.

#### **1.7.1.5 Methodology**

The following steps (Table 1.10) should be adopted to conduct the socio-economic survey in the FMU (Nepal, 2002; Branney, 2002).

*Table 1.10 Socio-economic survey methodology*

Activity	Purpose/objectives	Output
Develop ToR	To define the scope of the survey, identify key tasks and work plan	Agreed ToR
Coordination with Dzongkhag & Gewog	To ensure cooperation from local and government stakeholders To source official data from RNR staff	Agreed by Dzongkhag & Gewog staff. Data made available.
Community meeting	To introduce concept of FMU and planning, to inform villagers of work plan & to elicit initial views on FMU (aim for a minimum of 80% participation)	Minutes of meeting
Timeline map	To track the history & development of the community/village	Community timeline diagram
Social mapping	To gain insight into institutions & strengths of community organization in order to assess organizational capacity	Social map
Participatory resource use mapping	To involve local people in the planning process To map village & forest resources	Participatory resource map
Forest utilization calendar	To identify use of forest resources throughout the year	Forest utilisation calendar
Household interviews	To collect socio-economic information & to gain further insight into interests and perceptions (minimum of 25% of households)	Detailed information for SES report

*a. Terms of reference*

Terms of reference for the SES team should include the following:

- Brief background and rationale
- Objectives
- Anticipated outputs
- Agencies/organisations involved
- Tasks to be undertaken by the team (Box 1.2 Key Task of SES team)
- Timing
- Data requirements
- Team members and experience/qualification



*Box 1.2 Key Task of SES team*

The key tasks of the SES team are to:

- raise awareness and determine information needs regarding the FMU; particularly community involvement in planning
- collect and analyse existing socio-economic data and design a survey based on this secondary data
- prepare, with the communities, a list of where and how they use the forests
- conduct household interviews, including awareness raising about the FMU
- collect detailed information about the local forest use (size, location, products etc.); their future plans for use
- identify all local uses in the field (including holy places and water protection sites mentioned by the communities); GPS can be used for this
- assess the impact of a road construction on the community (as appropriate)
- propose possible roles for the communities in the FMU (e.g. partnerships, FMU-level committee etc.)
- identify the ways in which communities can benefit from the FMU
- prepare a report on the survey.

***b. Community meeting***

The next step is to conduct a community meeting in order to:

- introduce the concept of an FMU
- introduce the planning process
- inform community members of the SES work plan
- elicit preliminary views on the idea of an FMU in their immediate environment including possible impacts of the road if built for log extraction
- aim for minimum of 80% participation

***c. Timing of the activity***

A flexible approach is required to the timing and sequence of meetings. Optimal use of community time must be ensured.

***d. Timeline***

After the community meeting a PRA exercise in the form of a timeline can be done to map the development context of the community. The main objective of doing this activity is to track the history of development in the village.

***e. Social mapping exercise***

A social mapping exercise can be done after the timeline with the same participants in order to get an insight into the institutions and strengths of community organisation in order to assess the organisational capacity of the people and the implications of the FMU for the village and vice-versa if established in the area.

A social mapping exercise is a fairly simple exercise that identifies institutions and community organizations and represents them in a diagram. The diagram should be drawn so that it shows various institutions and

organizations that are within the community and also those which influence or interact with the community. An example of the output of this exercise is shown in Figure 1.5.

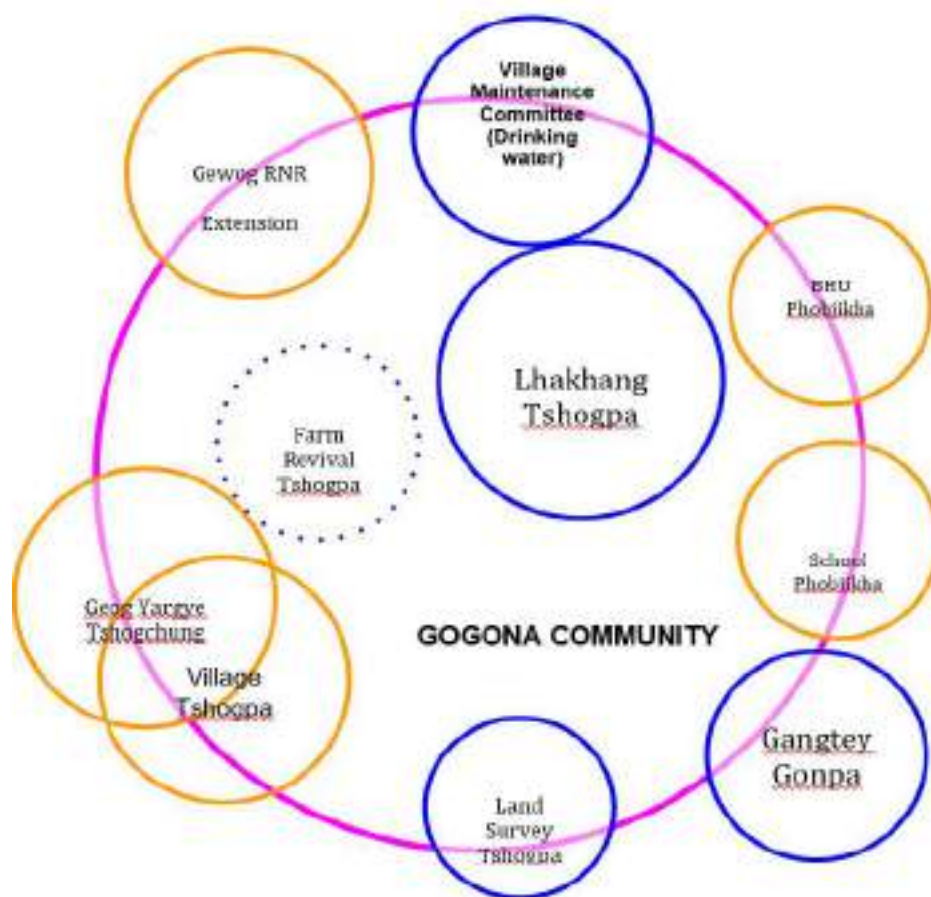


Figure 1.5 Social map for a Community

#### ***f. Participatory resource use mapping***

The purpose of participatory forest use mapping is not to extract information from the participants, but to involve local people in the planning process. Being involved in the planning process shall encourage a sense of ownership and responsibility for the forest management plan amongst local stakeholders, which would not be present if the plan were prepared solely by the planner.

This is a useful point for the forest management planners to explain to groups of local people what is being proposed for the area of the FMU e.g. why it has been selected and how it shall be managed. It shall be useful to explain that planning for the management of the area shall be done through close involvement of local communities (through stakeholder representatives).

#### ***g. Forest utilisation calendar***

A forest resource use calendar can be created in order to illustrate use of forest resources throughout the year. An example of the format is shown in Table 1.11. In the user columns 'X' can be added to represent a user and XX to represent a major user. The location column may need to be extended to accommodate multiple locations.

*Table 1.11 Forest Utilization calendar format*

No	Products	User		Location	Bhutanese Months											
		Male	Female		1	2	3	4	5	6	7	8	9	10	11	12
1.	Firewood															
2.	Fencing poles															
3.	House Construc- tion timber															
4.	Shingles															
5.	Bamboo															
6.	Broom															
7.	Flagpoles															
8.	Incense															
9.	Mushroom															
10.	Others (specify)															

#### ***h. Household interviews***

Individual household interviews can be done in order to collect socio-economic information and to gain further insight into interests and perceptions. The questionnaire that is included in Form 1.3 (or adapted as appropriate) can be used as the basis for this interview. A minimum of 25% of households should be sampled randomly. The information collected can then be collated and summarized following the guidelines on structure and content of the SES report as outlined below. All data should be saved and carefully filed for future reference.

*Form 1.3 Socio-economic survey form*

<b><u>SOCIO-ECONOMIC SURVEY FOR FMU</u></b>	
Name of Enumerator.....	Date of Interview.....
Name of Supervisor.....	Date Checked.....
<b>A. General Information</b>	
Name of respondent.....	Language Spoken.....
Gewog.....	Village.....
Dzongkhag.....	Ethnic group.....

## B. Demography

No	Name of Family member	Relation to Hh head	Sex (Tick box)	Age (Years)	Marital status	Education level (Formal/ Informal) (Completed)	Occupation	Resident for Last 6 m Yes/No
			M	F				
1		H/h head						
2								
3								
4								
5								
6								
7								
8								
9								

## C. ACCESS TO SERVICES

Facility	Time	Unit
----------	------	------

Health		
Walking distance from the respondent's house to the nearest health facility (ORC/BHU/Hospital)		Days
		Hours
		Minutes

Education		
Walking distance from the respondent's house to the nearest school (Community/Primary/Lower Secondary/Higher Secondary)		Days
		Hours
		Minutes

<b>Roads</b>		
Walking distance from respondent's house to nearest motorable road		<i>Days</i>
		<i>Hours</i>
		<i>Minutes</i>

<b>RNR Extension Centres</b>		
Walking distance from the respondent's house to the RNR centre		<i>Days</i>
		<i>Hours</i>
		<i>Minutes</i>

<b>Markets</b>		
Walking distance from the respondent's house to the nearest market		<i>Days</i>
		<i>Hours</i>
		<i>Minutes</i>

**Household Amenities**

**Drinking Water**

Observe and please tick type/source of water source the respondent is using-

a. Piped water in the house	
b. Common tap stand	
c. Protected spring	
d. Spring	
e. Others (specify)	

**Sanitation**

Observe and please tick the type of toilets used-

a. Modern type	
b. Pit type	
c. In the open (jungle)	
d. Others (specify)	

**Observe and tick the type of lighting**

**energy used**

a. electricity	
b. solar	
c. kerosene	
d. candle	
e. pine shavings	
f. Others (specify)	

**Observe and tick cooking energy**

a. Fire wood	
b. Kerosene	
c. LPG	
d. Electricity	
e. Others (specify)	

**D. Landholding**

Land type	Area (in acres)	Owned & operated	Sharecropped (acres)		Fallow (acres)
			Leased in	Leased out	
Dryland					
Tseri					
Orchard					
Kitchen garden					
Pasture					
Tsamdrog					
Sokshing					
Private forest					
Plantation					
Commercial plot					
Others (specify)					

**E. Livestock owned (L=local; I=improved)**

Cows	Bulls	Horse	Mules	Sheep	Pig	Yak	Poultry	Goat	Others?
------	-------	-------	-------	-------	-----	-----	---------	------	---------

**F. Source of Income (in Nu) in the last one year**

L	I	L	I	L	I		L	I	L	I		L	I		

No	Income source	Unit price	Quantity sold	Amount earned	Market sold in
1	Crops Paddy/Rice Wheat				



	Maize Buckwheat Barley Mustard				
2	Processed food ( <i>specify</i> )				
3	Vegetables				
4	Fruits				
5	Livestock				
6	Livestock products				
7	Craftsmanship ( <i>specify</i> ) a. b. c.				
8	On-farm labour Specify type:				
9	Off-farm labour Specify type:				
10	Forestry products (cane, mushroom, wood, etc.)				
11	Wholesale trade				
12	Retail trade				
13	Remittances				
14	Others ( <i>specify</i> )				

**G. Expenditure**

No	Expenditure head	Unit price	Amount spent	Market bought in
1	Food items ( <i>specify</i> ) a. Grain b. Meat c. Fish d. Salt e. Cooking Oil f. Vegetables g. Others....			

2	Clothing			
3	Education			
4	House maintenance/improvement			
5	Livestock purchase/maintenance			
6	Religious ceremonies			
7	Transportation and communication			
8	Recreation and entertainment			
9	Medicines			
10	Personal care and effects			
11	Purchase of durable and non-durable goods			
12	Taxes			
13	Gift and contribution			
14	Farm machinery and tools			
15	Others (specify)			

**Savings**

Amount saved last year	Reason for savings	Place savings kept	Source of spending	Decision on spending by	Spent by

**Credit**

Amount borrowed last year	Amount borrowed from	Reason for borrowings	Borrowing arrangements	Decision on borrowing	Borrowed by

**J. Participation in local political bodies**

Village zomdue			GYT			DYT		
Attend	Discuss	Decide	Attend	Discuss	Decide	Attend	Discuss	Decide

Committee			Others		
Attend	Discuss	Decide	Attend	Discuss	Decide

**K. Food security**

No. of months food shortage last year	Grain borrowed last year (kg)	Other coping mechanisms With food insecurity

**L. Migration**

Relationship of migrant to h/h head	Age	Sex	Year of migration	Reasons for migration	Type of Contribution to family

**M. Products utilised from forest**

Product	Qty used /Year	Collection period (months)	Name of collection site	Remarks on status of stock & reason	Plan to continue collect in future or alternative location?
Construction timber					
Shingles					
Firewood					
Fodder					
Litter					

Leaf mould					
NWFP (e.g. cane, bamboo, burr, mushroom, dye, medicines, edible plants and nuts)					
Grazing (by species)					

### **Road Construction**

What are your views about the road construction that is planned?

Do you think it shall benefit the community? Why?

### **FMU management**

Do you see that creating a FMU in your area would benefit the community? Why?

What role can the community and members play in the management of the Forest Management Unit in future if a FMU is established?

Views on present grazing situation by yaks and cattle of local people?

Views on present grazing situation by yaks and cattle of outsiders (dratshang, other people?)

## **1.7.1.6 Structure and Content of Socio-Economic Survey**

### **a. Introduction**

The socio-economic appraisal covers aspects such as demography, access to social services, employment, literacy, migration, credit and savings, land and livestock holdings, income and expenditure and food grain security. Further, key issues relating to the feasibility of establishing an FMU, namely forest grazing, extent and locations of use of forests can also be addressed in the survey.

Brief guidelines are presented here that indicate a typical structure and contents of the SES report.

**b. Information required**

The information or data required can be included under a number of headings and presented in tables as shown. Details of households can be summarized as in Table 1.12. Study sample.

*Table 1.12. Study sample*

Village	Actual No. of households	No. of households interviewed	Gewog

**c. Area**

Area of potential or actual FMU, estimated operable area, administrative divisions. Number of households by Gewog.

**d. The people**

Ethnic groups, dialects, systems of inheritance e.g. (matrilineal) and residence (e.g. matrilocal). Livelihoods of the people (e.g. subsistence farming, rearing of livestock like cattle, commercial crops).

**e. Development**

Origins of community (estimate of date from timeline), ancestors. Development projects/activities; land use, infrastructure development, health, education and training, hydro etc. Development of institutions in the community (from social mapping exercise).

**f. Demography**

Total number of persons, no. of households, average household size, age class distribution and implications. See Table 1.13.

*Table 1.13. Population/Demographic profile by sex, age and hamlet*

Village	Total No. in Population	Sex		Age group (years)			
		Male	Female	<6	7 to 14	15-64	>64
<b>Total (n=30)</b>							
<b>In % of total</b>							

**g. Migration**

Human migratory trends to gauge the magnitude of populations moving out of the community with possible effects on household labour and other aspects of community life. Proportion of the total population as non-resident. Proportion of M: F migrating. Related cash flow. See Table 1.14.

*Table 1.14. Migrants by age, sex, year of migration and contribution to household*

Age	No. of Persons	Sex		Year of migration				Contribution to household			
		Male	Female	Before 1985	1985-95	1995-2002	Don't know	Cash	Kind	Cash & Kind	No
1 to 6											
7 to 14											
15 above											
Total											
In % of total											

#### *h. Employment*

Common occupations; e.g. farming, as housewives to migrants like army, government and private sector personnel or as gomchens. See Table 1.15.

*Table 1.15. Employment by category and hamlet*

Hamlet	Occupation								
	Farmer	Housewife	Lay monk	Monk	Govt. servant	Army	Private sector	Minor	Student
Total									
In % of total									

#### *i. Access to social services*

Nearest school. Persons who have obtained education ranging from the Primary to High School level. Illiteracy rates. People having had no access to formal or traditional education. minors who have not reached the age for school attendance. See Table 1.16.

*Table 1.16. Literacy by standard and hamlet*

Hamlet	Education					
	Primary (PP-VI)	Junior High (VII-VIII)	High (IX-X)	Monastic	Illiterate	Minor
Total						
In % of Total						

#### *j. Household amenities*

Access to piped water from a protected source, protected and unprotected springs, sanitation facilities. Lighting energy. See Table 1.17.



*Table 1.17. Access to household amenities*

Hamlet	Water Source			Latrine Type	Source of lighting energy			Fuel source
	Common tap stand	Protected Spring	Unprotected Spring	Pit Type	Kerosene	Kerosene & Pine shavings	Kerosene & Electricity	Firewood
No. of households								
In % of total								

### *k. Landholding*

Land ownership and the size of landholdings; Dry land (DL), wetland (WL), kitchen garden (KG) registered pastureland (PL), registered *sokshing*. Lease arrangements. See Table 1.18

*Table 1.18. Land holdings (in acres) by category and hamlet*

Hamlet	DL	DLOO	DLLO	DLFLW	WL	WLLO	WLFLW	KG	PL
<b>Total</b>									
<b>In % of total</b>									

### *l. Livestock*

Livestock development, agricultural and livelihoods system source of income. Cattle, yak, horses, sheep and poultry; owned, breed and used by households. See Table 1.19.

*Table 1.19. Livestock*

	Cows		Bulls		Total	Horse		Sheep	Pigs		Yak	Poultry
Hamlet	Local	Impvd.	Local	Impvd.	Cattle	Local	Impvd.	Sheep	Local	Impvd.		
<b>Total</b>												
<b>In % of total</b>												

### *m. Income*

Exchange of goods and services for cash in the marketplace. Off-farm labour; wage labourers for civil construction works, sawing wood or working on farms etc. NWFPs.

*Table 1.20. Total income (in Nu.) per year by source and hamlet*

Rank No.	Income source				Total	%
1	Religious services					
2	Potatoes					
3	Remittances					
4	Off-farm Labour					
5	Cheese					
6	Animal Products					
7	Porter age					
8	On-farm labour					
<b>Total</b>						
<b>%</b>						

*n. Expenditure*

On food, annual religious ceremonies, transportation and communications, education expenses, rural taxes, personal care and effects, gifts/contributions. See Table 1.21.

*Table 1.21. Total Expenditure (in Nu.) per year by source and hamlet*

Rank No.	Cost head	Hamlet 1	Hamlet 2	Hamlet 3	Etc.	Total	%
1	Food						
2	Religious ceremonies						
3	Clothing						
4	Transportation & Communication						
5	Taxes						
6	Education						
7	Personal care & effects						
8	Gift/Contribution						
9	Recreation						
<b>Total</b>							
<b>%</b>							

*o. Savings and Credit*

Amount, shortfall, source of credit

*Table 1.22. Local credit status by hamlet*

Village	Credit availed in last year			
	Amount loan (Nu.)	Reason for taking loan	Creditor	Terms of Loan
<b>Total</b>				

**p. Food grain security**

Percentage self-sufficiency, households facing food grain insufficiency, coping mechanisms.

*Table 1.23. Grain security by hamlet*

Village	No of months grain shortage					Coping mechanisms
No. of households	0	1 to 3	4 to 6	7 to 9	>9	
<b>Total</b>						
<b>In % of total</b>						

**q. Social Uses of the Forests**

**Introduction**

A core activity in the ToR is to determine the social uses of the forest by residents as an input to the overall Forest Functions Map. To reach this objective participatory group exercises involving village and resource mapping was done with two groups of farmers followed by construction of a Forest Utilisation Calendar.

**Information required**

**Forest Produce**

Construction timber, shingles, firewood, fodder, litter, mushroom, bamboo, Daphne and broom etc. from the forests. See Table 1.24.

*Table 1.24. Forest products – quantity collected, stocks and collection plans*

Forest Produce	Quantity Collected		Situation of Stocks (No. of h/h)			Reason for Situation of Stocks (No. of h/h)			Future Collection Location (No. of h/h)	
	Total	Avg	Same	Less	Don't know	More use	Don't know	No. resp.	Same Place	Don't know
Construction Timber										
Shingles										
Firewood										
Fodder										
Litter										
Mushroom										

Include information from forest utilisation calendar.

**Water**

Sources and availability of drinking water

**Religious sites**

Location and significance of religious sites

## **Animals**

Reports of wildlife sightings

### ***r. Grazing situation***

## **Information required**

Grazing livestock numbers, ownership, distribution, seasonal grazing and migration patterns. Numbers in relation to carrying capacity. Grazing rights, leases, permits etc.

*Community views*

## **Information required**

A summary statement of community views and perceptions on, for example:

- FMU establishment
- participation in FMU management
- road construction

### ***s. Considerations on establishing a FMU***

## **Introduction**

The present local uses of forests by communities and access to such areas should be maintained. If certain areas currently used need to be taken over by the FMU, it is necessary to ensure that mutual assent be secured through a process of dialogue and consultation.

## **Information required**

The alignment of roads should be designed to optimally benefit the FMU and the community; to improve access for logging but also to markets and to ease community collection and transportation of forest produce.

- i. Factors affecting future demand for wood.
- ii. Creation of employment opportunities
- iii. Approaches for control of grazing in afforested areas.

### ***t. Conclusions & Recommendations***

These might include recommendations on for example:

- Consultation among grazing stakeholders to discuss grazing scenarios and use-zonations
- Community rules and regulations on forest use (including grazing)
- Consideration of possible future community forest designation

## **Field truthing**

Field or ground truthing is undertaken in order to verify and map the location of resources etc.

GPS receivers are useful tools for this task.

## **1.7.2. Establishment of FMU-Level Forest Management Committee**

### **1.7.2.1 Objective**

- To agree on the composition and role of the FMU-Level Forest Management Committee

### 1.7.2.2 Outputs

- List of committee members
- Terms of reference (ToR) for FMU-Level Forest Management Committee
- Office bearers

### 1.7.2.3 Lead responsibility

DFO with technical backstopping from FRMD.

### 1.7.2.4 Description of activity

The CFO, DFO should establish FMU Level Forest Management Committee. It is critical to ensure that all stakeholder groups are represented (either directly or indirectly) in the FMU-Level Forest Management Committee. The details of objectives, legal basis, membership, meeting cycles and terms of reference of the FMU-Level Forest Management Committee is detailed in Table 1.25.

*Table 1.25 Composition of FMU Level Forest Management Committee*

FMU-Level Forest Management Committee	
Objective(s)	Ensure effective participation of stakeholders in FMU planning and implementation
Legal basis	Forest Management Code of Bhutan Forest Management Plan
Membership	Members 1. CFO, Divisional Forest Office (Chair) 2. Regional Manager, Authorized Agency 3. Unit Incharge, FMU 4. Production Incharge, Authorized Agency 5. Gup of concerned Gewogs
Meeting cycle	During preparation of FMP: Up to four meetings Thereafter: minimum twice a year (at discretion of chair)

The FMU-level committee members shall ensure their involvement in subsequent planning steps. The ToR for FMU Level Management Committee are:

1. FMP preparation
  - Discuss & agree management objectives
  - Review & endorse the draft FMP
  - Consult with stakeholders & represent their interests during planning
2. Operational planning & implementation
  - Review achievements of previous year, advise & act on any issues identified in FMU annual report
  - Endorse activities, priorities & funding arrangements within the draft OP before submission to FRMD
  - Represent interests of stakeholders during operational planning
  - Hold additional meetings as required in response to specific issues arising from FMP & OP implementation

It is particularly important to ensure that committee members understand that whilst on the committee, their role is to represent the views and interests of identified stakeholder groups.

### **1.7.3. Stakeholder Consultation Meeting**

#### **1.7.3.1 Introduction**

The stakeholder consultation meetings and establishment of FMU-Level Forest Management Committee are essential components of the overall FMU planning process. Effective stakeholder participation is vital to the effectiveness of plan preparation and implementation.

#### **1.7.3.2 Timing of activities**

The stakeholder consultation meetings are undertaken as an integral part of two major planning steps: (i) During forest function mapping for participatory resource assessment (PRA) in order to determine social functions; and (ii) during the environmental assessment process. A single stakeholder consultation meeting must suffice for both of these steps and must be planned accordingly.

#### **1.7.3.3 Objective**

To effectively involve stakeholders in the planning process and decide how their interests can be best represented

#### **1.7.3.4 Output**

Stakeholders are well consulted and their views and interest, which are not contravention to existing policies and legislations, are taken on board during the FMU planning process.

#### **1.7.3.5 Lead responsibility**

Divisional Forest Office

## **1.8. Resource Inventory & Data Processing**

FMU inventory is an underpinning component of SFM which provides the data for planning, monitoring, evaluation, research, growth and yield management in FMUs. It also provides data on many characteristics of land on which the trees are growing. Forest inventories are designed to measure the extent, quantity, composition, and condition of forest resources, (Kangas et al., 2006). Therefore, the FMU inventory may be broadly defined as the systematic collection of data and information on forest for assessment or analysis; it is a systematic collection of data because there are procedures or protocols to follow during data collection to ensure accuracy and precision.

### **1.8.1. Objectives**

The main purpose of FMU inventory is to gather data using which growing stock is assessed and accordingly, prescribe AAC on a sustained yield basis. The AAC is calculated considering the rotation age of the crop or stand, area and the growing stock per unit area.

This information on growing stock is used for determining the AAC on a sustained yield basis. The inventory results provide us information on;

*What resources currently exist?* This information (For example volumes of timber, dimensions and species) normally comes from a static inventory; this consists of pre-harvest inventories, stock surveys and post-harvest inventories and is used to provide a ‘snap-shot’ of the forest resources at a particular point in time.



*How fast do the resources grow and what changes occur in response to management?* This information (For example, rates of growth, mortality and changes in species composition) is collected from dynamic inventory. This is usually done through measuring or collecting data from the sample plots. This type of information is mainly used for long-term planning, calculating sustained yields and monitoring. The Department may establish permanent sample plots, which can be spearheaded by its research institute – Ugyen Wangchuck Institute for Conservation and Environmental Research (UWICER). Some of the important objectives of FMU inventory, but not limited to, are to;

- i. obtain, in an efficient and practical way, sufficiently accurate key information concerning the composition of the forest resources in the FMU in the form of thematic maps, tabular overviews, general descriptions and interpretations. In this respect, only data that is really needed and shall be actually used during the subsequent data processing should be collected;
- ii. include in the forest resources more specifically; resources of timber and fuel wood (dbh 10+ cm), its regeneration potential (dbh<5cm), growing conditions and the quality of the site, non-wood forest produce, and the presence of key wildlife species. In order to monitor and evaluate the impacts of implementation on vegetation, flora and fauna; another inventory is recommended with the same or different design;
- iii. ensure, as a guide for the precision of the obtained results, a final sampling error for the estimate of the overall average gross wood volume of the forest area of +/-10%, at a confidence level of 95%; and
- iv. obtain, during the course of fieldwork, other advanced information, which may assist in the subsequent management plan preparation for the FMU.

These objectives should be considered as guiding and defining parameters for inventory and related procedures. In brief, FMU Inventory results provides, not limited to the following information;

1. Volume per hectare and total volume of timber in the FMU
2. Basal area per hectare and total basal area in the FMU
3. Number of stems or trees per hectare and total stems or trees in the FMU
4. Biomass per hectare and total biomass stock in the FMU
5. Carbon per hectare and total carbon stock in the FMU.
6. Increment and growth, etc.

### **1.8.2. Methodology**

A standardized forest management inventory has been established based on experience of implementing such inventory over several years in Bhutan. The approach is based on a stratified systematic sampling design using fixed-size concentric plots aimed at a wide range of forest resources and this design is also adopted for National Forest Inventory (NFI) of Bhutan at different spatial resolution.

Therefore, this guideline describes a step wise approach for designing and conduct of FMU Inventory. It may also be noted that this guideline may be revised from time to time as needed with technological advancement.

### **1.8.3. Inventory design**

FMU inventory shall adopt systematic sampling design similar to as of NFI but at much finer spatial resolution with single point circular plots. FMU inventory should be designed to achieve estimates at 95% confidence interval and 10% margin of error/ sampling error. The systematic sample uses a fixed grid to assign plots in a regular pattern and its advantages are;

- Maximize the average distance between plots and therefore minimize spatial correlation on observations
- Increase statistical efficiency
- Can be representative in most cases and this is most common in forestry.

#### 1.8.4. Sampling design

The systematic sampling design is used for forest management inventory. In this method, a sample grid is created at a predetermined sampling intervals or plot to plot distance. The sampling for FMU inventory is designed to achieve results at 95% confidence interval at 10% standard error.

##### Number of sample plots

The sampling intensity for each FMU is determined by the forest type of the particular FMU which in turn is determined by the coefficient of variation. Higher the coefficient of variation, larger the same size. The coefficient of variation for typical forest types of Bhutan (for plot area of 0.05 - 0.1 ha) is described in Table 1.26. The use of Land Use and Land Cover data, 2016 or any other update/latest land use and cover product is recommended for stratification of forest types and land use stratification.

Table 1.26: CV% of forest type

Sl No.	Forest Type	CV%
1	Fir	50
2	Spruce	70
3	Blue Pine	105
4	Mixed Coniferous forest	70
5	Combined conifers	80
6	Oak (Quercus semecarpifolia)	65
7	Mixed broadleaf	85
8	Combined broadleaf	85
9	Combined all	85

The sample size is the function of coefficient of variation (Table 1.26) and percentage sampling error (10%) and level of confidence. The commonly used formula is shown in equation 8.

$$n = \frac{t^2 \times CV\%^2}{SE^2} \quad (8)$$

Where,

n is number of sample plots or it is also called sample size;

t is t value for 95% confidence interval from t-distribution table;

CV% is coefficient of variation; and

SE is standard error or desired margin of error

**The coefficient of variation (CV)** is a statistical measure of the dispersion of data points in a data series around the mean expressed in percentage. The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from one another. It shows the extent of variability of data in a sample in relation to the mean of the population. The coefficient of variation is determined by Equation (9).

$$CV\% = \frac{s}{\bar{x}} \times 100 \quad (9)$$

Where,

CV% of coefficient of variation in percentage

S is sample standard deviation

$\bar{x}$  is sample mean

For a sample with a mean of  $\bar{x} = 20$  and a standard deviation of  $s = 8$ , we would estimate the coefficient of variation as  $CV\% = 0.40$  or 40 percent. This coefficient of variation can be used for determining the sample size for your inventory area.

The sample mean and standard deviation can be generated for basal area, tree count, tree height and tree volume. However, it is recommended to use the basal area to generate the sample mean and standard deviation to estimate CV%.

### Sample size Calculation

Let us consider the example of Selela FMU (SFMU) and estimate the sample size

**Step 1:** Define the total FMU area

e.g Selela FMU, Area = 9157 ha

**Step 2:** Stratify the FMU area into different forest types using the latest available land use land cover/ forest type data. For example, SFMU has four forest types of **Blue Pine, Broadleaf, Fir and Mixed Conifer forest** (Table 1.27 and Figure 1.6) (LULC, 2017).

Table 1.27: Forest Type of Selela FMU

Sl. No.	Forest Type	Area	Coefficient of variation (cv%)
1	Blue pine	2312.67	105
2	Broadleaf	370.52	85
3	Fir	1076.59	50
4	Mixed conifer	4732.14	85
	Grand Total	8491.92	

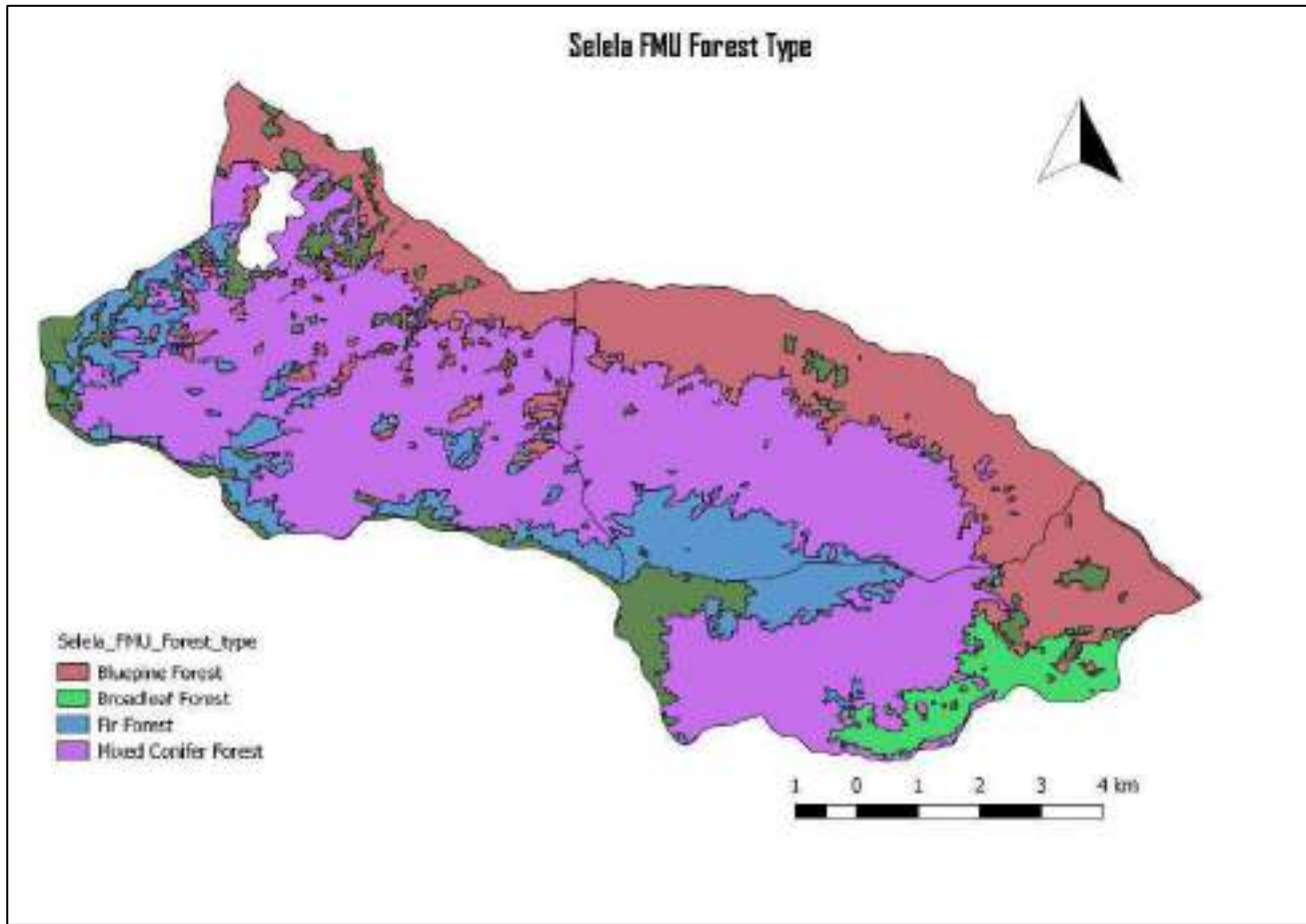


Figure 1.6: Forest Type Map of Selela FMU

**Step 3:** Apply the CV% of each forest type to determine the weighted area by CV% of the forest type. This is estimated by the equation (10) and (11) and described in Table 1.28.

$$\text{Weighted Area by CV\%} = A_1CV_1 + A_2CV_2 + \dots + A_nCV_n \quad (10)$$

$$\text{Weighted CV\%} = \frac{A_1CV_1 + A_2CV_2 + \dots + A_nCV_n}{A_1 + A_2 + \dots + A_n} \quad (11)$$

Where,

$A_1, A_2, \dots, A_n$  is area of a particular forest type in ha; and

$CV_1, CV_2, \dots, CV_n$  is CV% of corresponding forest type

The weighted area by CV% for Selela is therefore calculated as follow:

Table 1.28: Weight CV% for Selela FMU

Sl. No	Forest Type	CV%	Area (ha)	Weighted area
1	Blue pine forests	105	2312.67	2428.3035
2	Broadleaf Forest	85	370.52	314.942
3	Fir forest	50	1076.59	538.295
4	Mixed Conifer forests	85	4732.14	4022.319
	Sum		8491.92	7303.8595

Therefore,

$$\text{Weighted CV\%} = \frac{7303.8595}{8491.92} \times 100$$

$$= 86\%$$

**Step 4:** Applying the formula in *Equation* (8) above, the number of plots or sample size is calculated at confidence interval of 95% with corresponding t-value of 1.96 (rounded to 2), CV% of 86 (as determined in step 3) and sampling error (used a synonymous with margin of error (MoE) and Standard Error) of 10%.

Therefore, number of plots for SFMU is determined using equation (8) as follows;

$$n = \frac{2^2 \times 86^2}{10^2}$$

$$= 295.9 \text{ plots} \approx 296 \text{ plots}$$

**Step 5:** Allocate number of sample plots to each stratum and validate the total number of plots for different strata using equation 5 and 6 (Table 4).

$$\text{Weighted CV\% by strata} = \frac{\text{Weighted area of strata}}{\text{Total weighted area}} \quad (12)$$

$$\text{Plot by strata} = \text{Total number of plot} \times \text{Weighted CV\% by strata} \quad (13)$$

Table 1.29: Number of plots by strata in Selela FMU

Sl. No	Forest Types	CV%	Area (ha)	Weighted area	weighted CV by strata	No. of plots by strata
1	Broadleaf forest	85	370.52	314.942	0.043119942	12.75942767
2	Fir forest	50	1076.59	538.295	0.073700076	21.80825714
3	Blue pine forests	105	2312.67	2428.3035	0.332468539	98.37926627
4	Mixed Conifer	85	4732.14	4022.319	0.550711442	162.9585395
	Total		8491.92	7303.8595		295.9054906 $\approx$ 296

**Step 6:** Generate sampling grid area and determine the plot to plot distance using equation (14) and (15). The sampling grid is generated using the formula;

$$\text{Grid area} = \frac{\text{FMU forest area}}{\text{Number of plots}} \quad (14)$$

$$\text{Plot to plot distance} = \sqrt{\text{Grid area}} \quad (15)$$

For example, the grid area for SFMU is

$$\text{Grid Area} = \frac{8491.92}{296}$$

= 28.6889.189 ha, which is equivalent to 286889.189 m<sup>2</sup>

And the *Plot to plot distance* =  $\sqrt{286889.189 \text{ m}^2}$

= 535.62 meters.

But for the practical purpose, it is rounded to lower 50<sup>th</sup> value. Therefore, the final plot to plot distance is 500 m.

**Note:** The plot to plot distance is rounded to lower 50<sup>th</sup> value using the function = floor (estimated plot to plot distance, 50) in excel. In this case, = floor (535.62) = 500 m.

**Step 7:** Determine the new grid area based on plot to plot distance estimated in step 6 (Equation (16)) in ha (e.g. SFMU)

$$\text{Grid area} = \frac{(\text{plot to plot distance})^2}{10000} \quad (16)$$

$$\text{Grid area} = \frac{500^2}{10000}$$

= 25 ha

**Step 8.** Determine the final number of plots with new grid area estimated in step using 7 equation (17).

$$\text{No. of plots} = \frac{\text{FMU area (area of forest under FMU)}}{\text{Grid Area}} \quad (17)$$



For a) total FMU area

$$\text{No. of plots} = \frac{9157}{1625}$$

= 366 (rounded to nearest whole number)

b) For forest area only

$$\text{No. of plots} = \frac{8491.92}{25} = 340$$

**Step 9:** Calculate no of plots by strata as per the no. of plots calculated in step 8 using equation

$$\text{Plot by strata} = \text{Total number of plot} \times \text{Weighted CV\% by strata}$$

Sl. No	Forest Types	CV %	Area (ha)	Weighted area	Weighted CV by strata	No. of plots by strata
1	Broadleaf forest	85	370.52	314.942	0.04311994	15
2	Fir forest	50	1076.59	538.295	0.07370008	25
3	Blue pine forests	105	2312.67	2428.3035	0.33246854	113
4	Mixed Conifer	85	4732.14	4022.319	0.55071144	187
	Total		8491.92	7303.8595		340

### Generate Sampling Grid

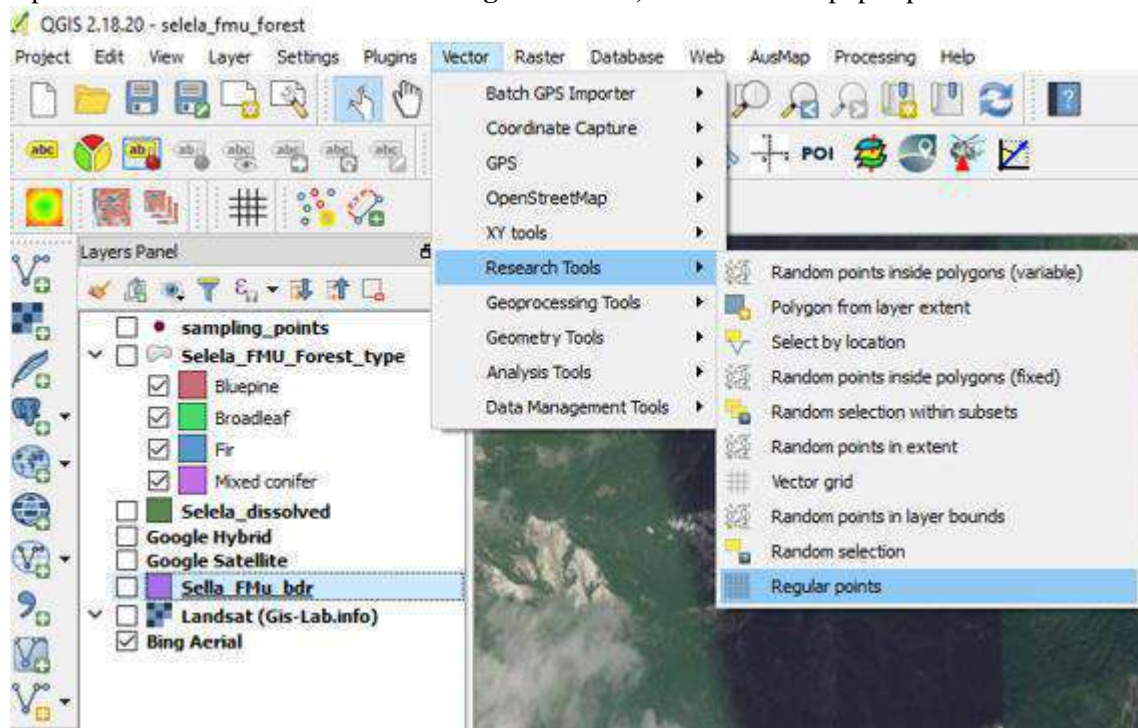
The regular sampling grid can be generated in ArcGIS, QGIS and any other GIS software. To generate the grid, you need to have physical boundary of the FMU either in the .kml file or shape file, which shall be used for clipping the area such that only grid intersection falling inside the FMU boundary is selected for further assessment.

**Note:** In many cases, you shall need to confirm the coordinate system of the FMU boundary. If it is in DrukRef, it has to be converted into WGS coordinate system. For each grid point, we then generate the northing and easting or coordinates for each point in degree minute second or decimal degrees as may be needed. If you are using QGIS, it is strongly recommended to use WGS coordinate system and coordinate in decimal degrees.

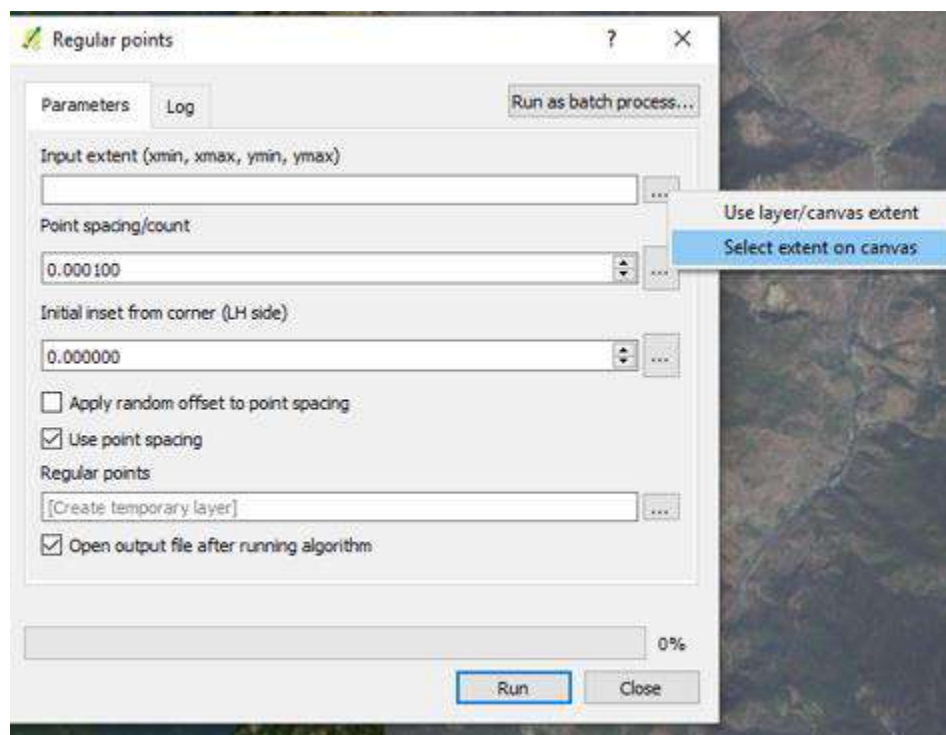
Another point to be noted here is that using the plot to plot distance (sampling grid), which in this example is 500 m, the sampling points or sample points shall be generated. Often the sampling points generated from GIS may not be exactly same as generated using equation 9 above. This is because in GIS we use regular plot distance (500 m) but the actual boundary of the FMU is irregular, hence the slight variation between calculated plot number vis-à-vis the one generated from GIS. However, this is not a huge cause of concern, just ignore it.

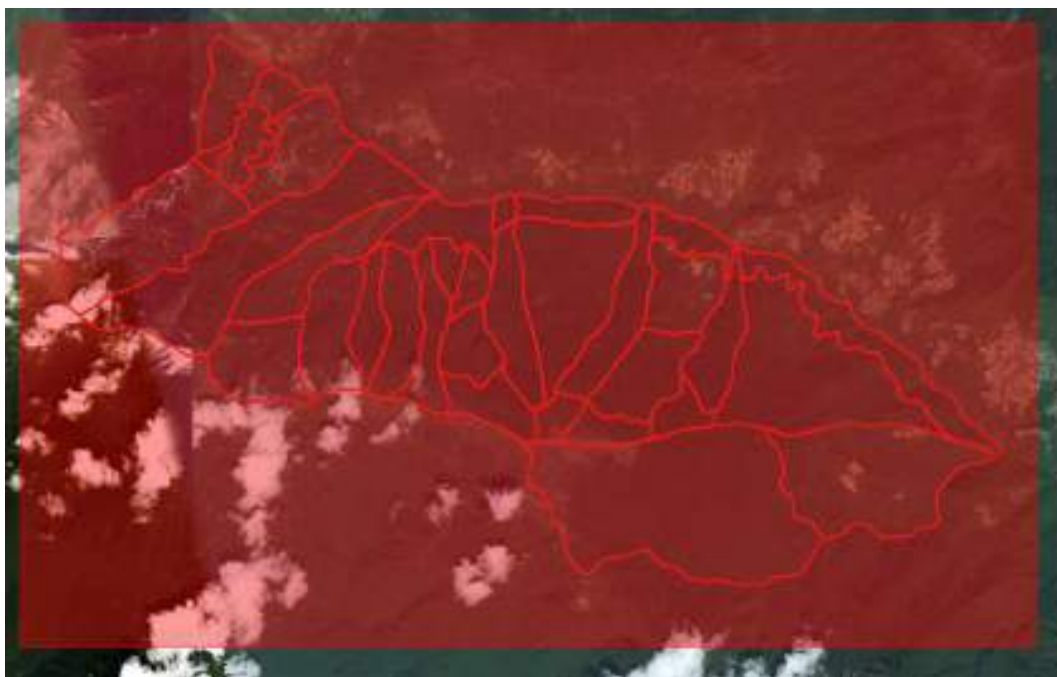
In QGIS, you can generate the systematic sampling points following the following step;

1. Load your forest boundary (FMU boundary in this case) shape file or .kml file, which is a vector layer
2. Open **Vector** → **Research Tools** → **Regular Points**, a new window pops up.

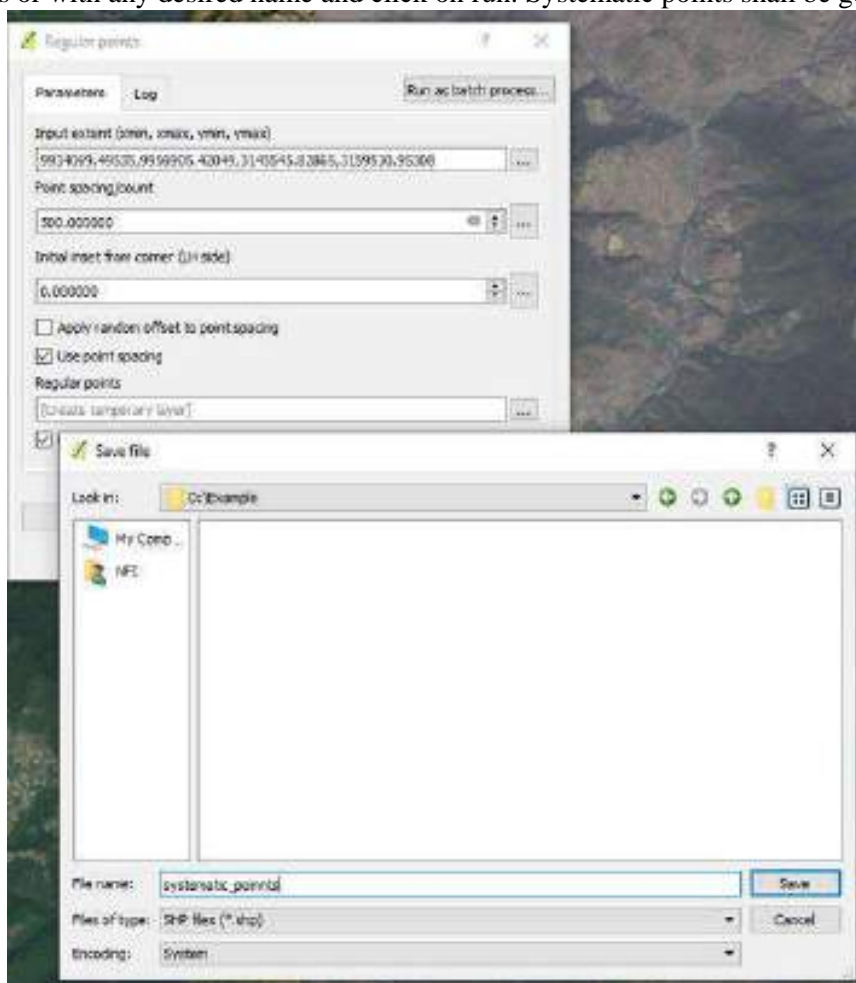


3. In the Input Extent, Select Extent on Canvas and select the extent of canvas by dragging the mouse covering whole FMU boundary



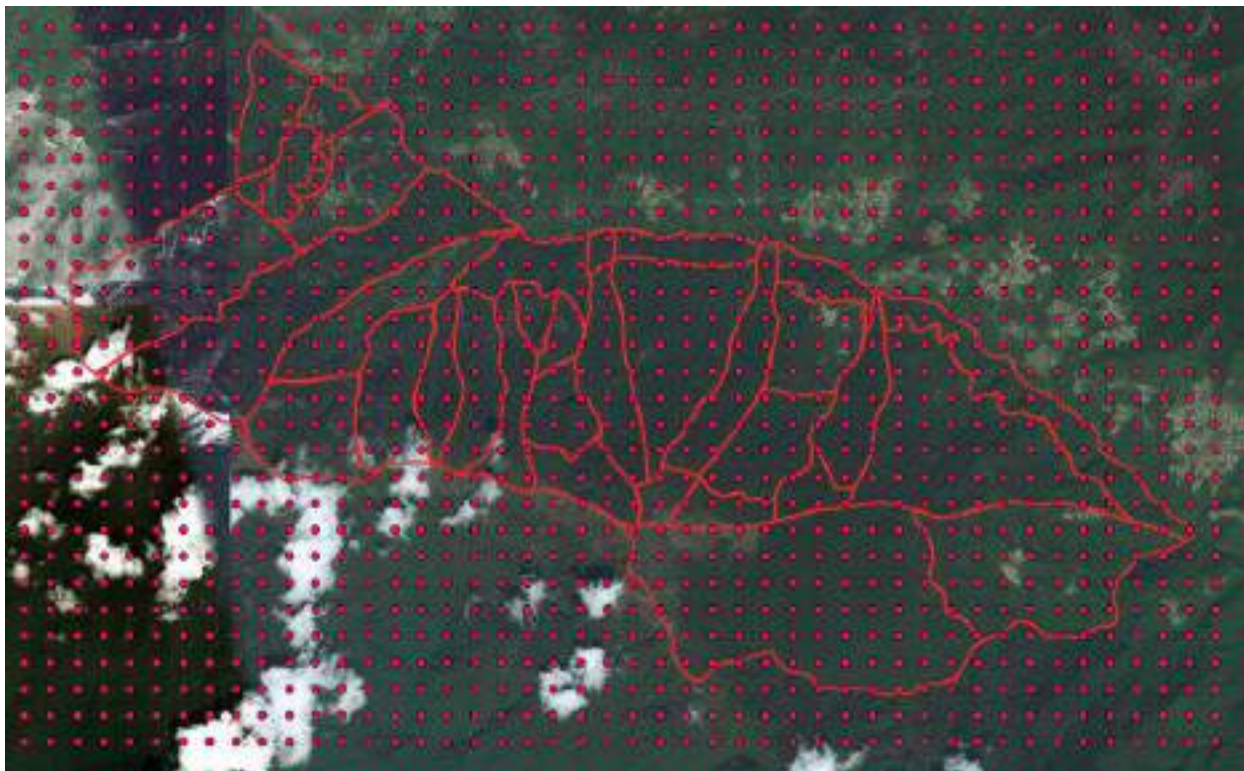


4. In the point spacing/count, type the plot to plot distance (e.g. 500 in SFMU) and save the file as systematic\_points or with any desired name and click on run. Systematic points shall be generated

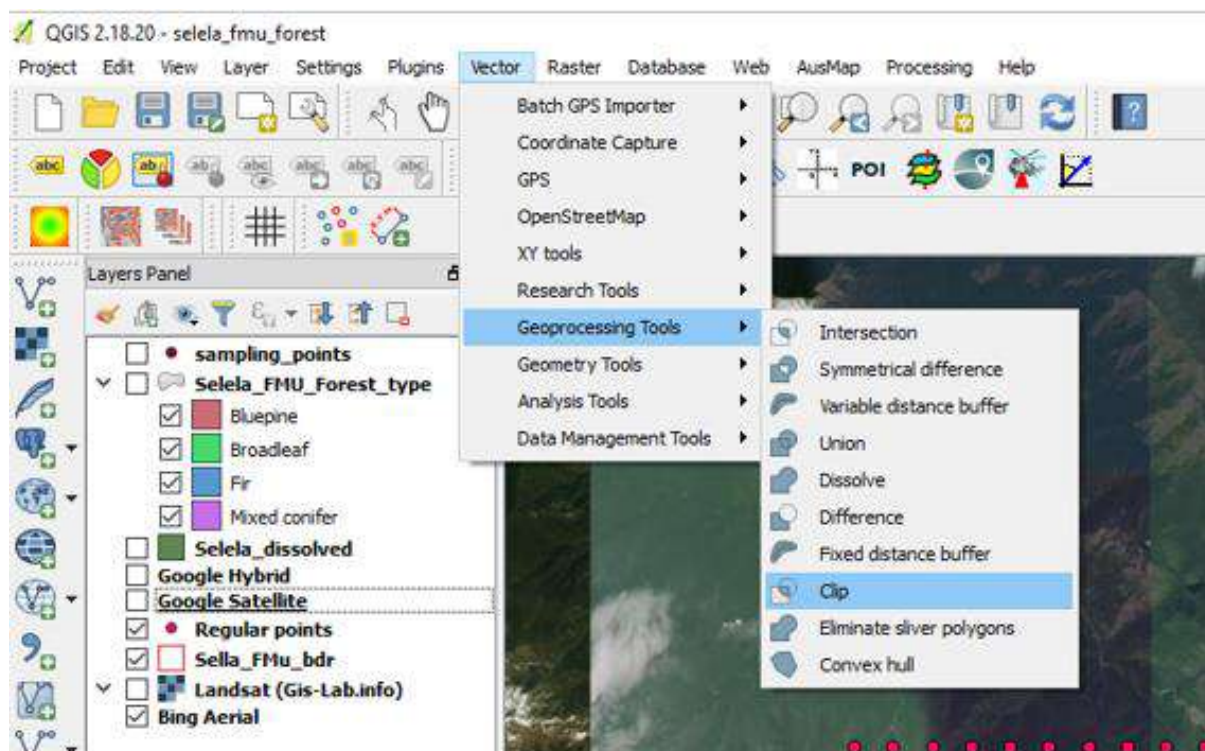




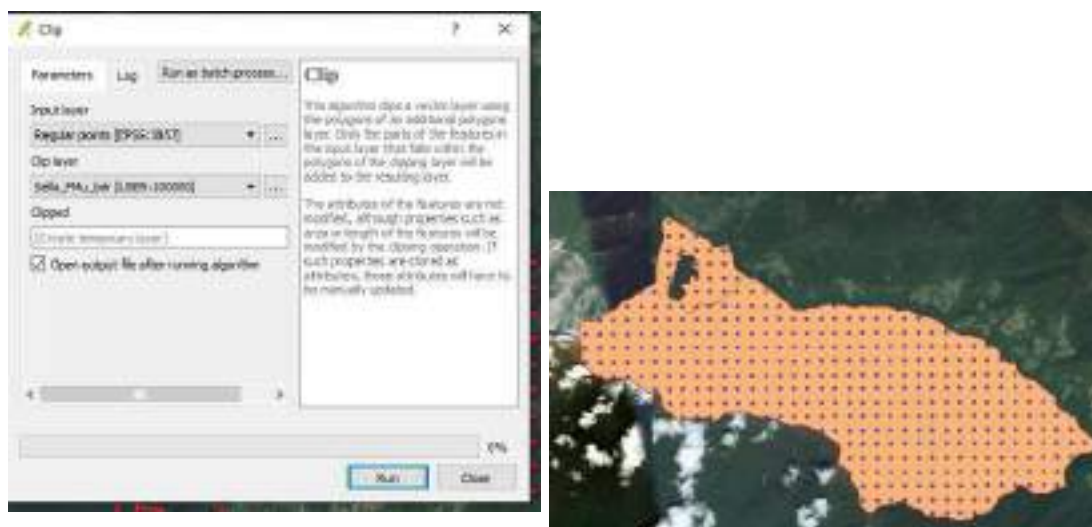
5. Systematic sample points shall be generated



6. Since we only want points falling inside the FMU boundary, we need to clip the points using clip function in QGIS. Open **Vector** -> **Geoprocessing Tools** -> **Clip**



7. Select 'systematic\_points' as input layer and FMU boundary as clip layer. Name the file as desired and save and run the algorithm



8. Go to the Attribute table for the sampling\_point...FMU
9. Enable the edit mode.
10. Open the Field calculator and name the new column Plot\_ID
11. Set the **Output field type to :Text (string)** or as desired
12. Similarly generate coordinate for each sampling points
13. Export the sampling point as GPS exchange format for loading into GPS for locating the plots in the field

Note: In many cases, you shall need to confirm the coordinate system of the FMU boundary. If is in DrukReff, it has to be converted into WGS coordinate system. For each grid point, we then generate the northing and easting or coordinates for each point in degree minute second or decimal degrees as may be needed. If you are using QGIS, it is strongly recommended to use WGS coordinate system and coordinate in decimal degrees.

### 1.8.5. Plot design

For the purpose of FMU inventory, circular<sup>2</sup> plot of 12.62 m radius is used for collecting inventory data and another circular plot of 3.57 m radius nested inside the larger plots is used for collection of regeneration data (Figure 1.7). The concentric circular plot is not only easy to establish, but also very sensitive to measurement and cost (Henttonen & Kangas, 2015). The area of the plot is 0.05 ha for all inventory data except regeneration data (plot area is 0.004 ha).

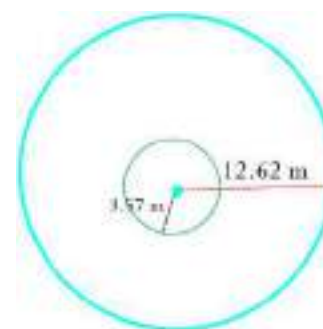


Figure 1.7: Plot Design

<sup>2</sup> The circular plot is adopted as it is easier to establish in the field compare to rectangular or square plot.

### 1.8.6. Data Collection

Measurements and observations in the field are made on individual trees (and shrubs) as well as on the whole plot and forest ecosystem using the forms. Common tree parameters collected are diameter, height, forest condition, tree condition (live or dead) and taxonomic species. The data collection protocols such as measurement of diameter and height, etc., and forms to be used for collecting data too are defined in this section. The successful completion of the data collection and/or implementation of field inventory involves following steps;

#### Planning for inventory

It is essential that field inventory is planned in advance by FRMD and the concerned field offices to ensure that the field works are conducted on timely manner and execution of the work is completed in one season. There should be an adequate logistical arrangement for field work and the field crews should get themselves familiarized on the inventory maps and FMU area.

#### Timing of the Activity

FMU inventories should be scheduled for completion as close to the time of writing the management plan as possible; ideally, no more than six months in advance or when the management plan is in the final year of implementation.

#### Type and data collection methods

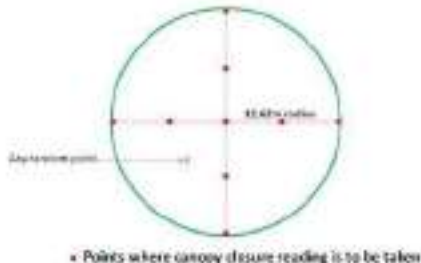
The data can be collected in paper forms and/or digital forms on android based applications. The detailed guidelines for data collection are as described and specified below. The inventory crew shall navigate to and locate the plot using GPS and establish the plot. After that the crew shall complete the forms by collecting and recording the data for data forms 1 through 7. These forms and data collection parameters shall remain dynamic and change from time to time depending on needs.

#### 1. Collecting and recording plot description data (F1/7)

SN	Data Item	Definition/Description	Instructions
1	District Name	Name of the District in which FMU is located. e.g KKFMU001 is located in Trashigang or Selela FMU is located in Haa.	1. Select the District Name from the dropdown list for electronic form or type manually if paper form is used.
2	FMU Name	Refers to the name of the FMU. The FMUs in respective districts shall appear as soon as district is selected.	1. Select the name of the FMU from the dropdown list for electronic form or type manually for paper forms
3	Plot No.	This is the unique identification number given to Inventory Plots in the FMU	1. Select correct Plot No from the drop-down list on electronic field form or record the correct Plot No, if the paper field form is used. <b>Note:</b> Paper Field Forms are to be used only if the does not function in the field.
4	Region	Refers to region under which the FMU falls. 20 dzongkhags are placed under 3 different regions.	1. The region field shall automatically populate once the dzongkhag is selected.
5	Expected coordinate	Refers to the geo-coordinates generated by sampling design of plot location	1. The design or expected coordinates shall be hidden. Crew shall swipe it and move on to next parameter.



6	Coordinate/Location	Refers to the geo-coordinates of plot location.	1. Click on ‘Start the GPS’ in the data logger (android tablet) and coordinates shall be generated automatically. If paper forms are use, use GPS to obtain coordinates.
7	Crew Leader	Refers to name of the Inventory Team Leader	1. Type the name of the person entering the data or team leader
8	Date	Refers to date of day on which data is collected	1. Record the date by clicking on calendar icon next to it on android tablet.
9	Time	Refers to time of day when data for Plot is collected	1. Record the time by clicking on time icon next to it on android tablet.
10	Altitude	Refers to the elevation from mean sea level at which the plot is located. It is measured in meter.	1. Use the GPS to obtain altitude reading. Record altitude in meter, as it appears on GPS.
11	Land use	Refers to class of land cover and land use. For the purpose of FMU inventory following six categories are used, as defined in IPCC GPG for LU-LUCF; Forest land Cropland Grassland Wetland Settlement Other land	1. Use the technical definition provided in Table 1.30 for identifying the Land cover class. 2. Then record appropriate land cover class accordingly in the data dictionary or electronic field forms.  Land Cover Classification Code as provided in the Table 1.30 <b>Error! Reference source not found.</b> may be used, if paper field forms have to be used.
12	Forest type	Refers to Forest type as classified in the Flora of Bhutan. The characteristic features of different forest types are provided in Table 1.31.	1. Refer Table 1.31 to classify the forest type. 2. Select the appropriate forest type from the drop-down list in case of electronic field form and in case of paper field forms, record the Forest type Code as provided in Table 1.31.
13	Stand height	Refers to height of the forest stand and for FMU inventory it would mean an arithmetic mean(average) of the height of five tallest trees in the plot	1. Identify five tallest trees having DBH above 10 cm located within 12.62 m radius plot. 2. Measure the heights of the identified trees using Hypsometer or clinometers. 3. Start from North and move in clockwise direction to measure heights all five identified trees located within the plot. 4. Once the measurement of height is completed for all five trees, add the height and divide the sum by 5. The result is the <i>stand height</i> . 5. Record the result to the nearest one decimal place.

14	Canopy Closure	<p>Refers to the cover percent of tree canopy.</p>  <p>Points where canopy closure reading is to be taken</p> <p><i>Points of measurement on circular plot</i></p>	<ol style="list-style-type: none"> <li>1. Divide the plot into four quarters using or with imaginary lines running through North-South intersecting with East-West line.</li> <li>2. Using the Crown Densitometer, estimate the canopy cover percent from the following ten positions: <ul style="list-style-type: none"> <li>-Plot centre,</li> <li>-Four mid-points of the lines joining Plot Center (PC) and four directions (North, East, South and West)</li> <li>-Four points on the edges of the plot boundary (Northern, Southern, Eastern and Western edges)</li> <li>-and one from any random point within the plot.</li> </ul> In total, take 10 points readings for canopy per cent calculation. </li> <li>3. Record the canopy closure in percentage. <p><b>Note:</b> Use of Crown Densitometer &amp; calculation is given separately.</p> </li> </ol>
15	Accessibility	<p>Refers to if the Inventory Plot was accessible or not.</p>	<ol style="list-style-type: none"> <li>1. Select 'Yes' if the Plot was accessible, 'No' if it was not accessible. Upon clicking 'Yes' subsequent data parameter fields shall open. But if recorded as 'No' subsequent data parameter fields shall remain hidden on electronic form.</li> </ol>
16	Aspect	<p>Refers to the direction of the slope and is classified as:</p> <p><b>Northern:</b> When the slope is facing North</p> <p><b>North-Eastern:</b> When the slope is facing North East</p> <p><b>Eastern:</b> When the slope is facing East</p> <p><b>South-eastern:</b> When the slope is facing South-East</p> <p><b>Southern:</b> When the slope is facing South</p> <p><b>South-western:</b> When the slope is facing South -West</p> <p><b>North-western:</b> When the slope is facing North West</p> <p><b>No aspect:</b> When the plot falls on a flat area</p>	<ol style="list-style-type: none"> <li>1. Use a compass to determine the direction to which the slope is facing.</li> <li>2. Record appropriate aspect by selecting from the drop-down list on the data dictionary in the electronic field form and tick appropriate aspect from check list in the paper field form.</li> </ol>
17	Slope up	<p>Slope Up describes the gradient, inclination of the up-hill slope from the Plot Center (PC).</p>	<ol style="list-style-type: none"> <li>1. For measuring the Slope up, walk one of the crew members towards the steepest part of the up-hill side and position the member on the edge of the 12.62 m plot.</li> </ol>

		Note: Slope reading for our purpose shall be done in degrees.	2. Take a clinometer reading to his eye height from the PC. 3. Record the reading accordingly.
18	Slope down	Slope down describes the gradient, inclination of the down-hill slope from the PC.	1. For measuring the Slope down, walk one of the crew members towards the steepest part of the down-hill side and position the member on the edge of the 12.62 m plot. 2. Take a clinometer reading to his eye height from the PC. 3. Record the reading accordingly
<b>Pest and diseases</b>			
19	Common mistletoe	Refers to presence or absence of evidence of Common mistletoe	4. Observe ocularly within plot and around 25 m from the PC and record “Yes” is evidence of Common mistletoe is observed, otherwise “No”.
20	Dwarf Mistletoe	Mistletoe is an obligate hemiparasitic plant that grows attached to and penetrating within branches of trees. Can be identified on trees by the presence of “witches’ broom”	1. If mistletoes are observed on the plot itself or within 25 m from the PC, record as “Yes, mistletoe”, otherwise as “No”
21	Bark Beetle	Refers to occurrence of Bark Beetle infection in the forest stand. The visible symptoms of bark beetle infections are: Discoloration of needles from green to yellow and eventually from red to brown Tiny holes in the bark of the infected trees	1. If you observe the symptoms of Bark Beetle infection in the area, record as “Yes”, else “No”.
22	Dieback Fir	Fir dieback is a condition observed in Fir, where the following symptoms are observed: Top-dying/shedding of needles Thinning crown	1. If fir dieback is observed on the plot itself or within 25 m from the PC, record as “Yes”, otherwise “No”.
<b>Forest health, disturbances and NWFP</b>			
23	Understorey cover percent	Refers to the area of plot (in percentage) covered by dominant understorey type.	1. Observe the understorey cover within the plot and make ocularly professional calculation. 2. Record the cover percent of the dominant understorey type in percentage.
24	Main Understorey type	Refers to the dominant understorey type growing within the plot. The understorey type is categorized as: Moss Grass Herbs Bamboos Shrubs Others	1. Observe the understorey type within the plot. 3. Record the appropriate undergrowth type from the drop-down list for electronic form and tick appropriately for paper forms

25	Bamboo cover percent	Refers to presence or absence of ever-green perennial flowering plants of grass family Poaceae. It is categorized as; None – absence of bamboo Cover_1-20 % Cover_21-40% Cover_41-60% Cover_61-80% Cover_81-100%	1. Observe ocularly for presence or absence of bamboo within the plot and 12.62 m around the PC. 2. If bamboos are present within the 12.62 m radius plot, record as “Yes” and then choose appropriate category from the drop down list, otherwise “No”.
26	Bamboo type	Refers to type of bamboo – either Spreading or Clump.	1. Select from the dropdown list appropriately and record on electronic form. 2. Write correct bamboo type, if the paper form is used.
27	Scientific Name	Refers to scientific or botanical name which conforms to the <i>International Code of Botanical Nomenclature (ICBN)</i>	1. Observe within the plot and record the botanical name of the bamboo. 2. The botanical names of the bamboos found in Bhutan are provided as drop-down list in the electronic field form. 3. If paper field form is used, record appropriately from the list of Bamboo provided.
28	Bamboo dbh	Refers to the diameter at breast height of the bamboo in the plot and choose from the following category; <2 cm 2 cm – 4 cm >4 cm	1. Measure the bamboo dbh and record by selecting the appropriate category from the dropdown list.
29	Cane Cover Percent	Refers to percent area of 12.62 m radius plot covered by cane.	1. Observe ocularly within plot and make expert judgement of percent area of plot covered by Cane. 2. Record the observation in percentage.
30	Cane dbh	Refers to the diameter at breast height of the bamboo in the plot and categorized as; < 2 cm > 2 cm	1. Measure the diameter of breast height for Cane present in the plot and record accordingly in centimeter (cm) to nearest one decimal place.
31	Daphne Cover percent	Refers to percent area of the 12.62 m radius plot covered by Daphne, categorized as; None – absence of Daphne Cover_1-20 % Cover_21-40% Cover_41-60% Cover_61-80% Cover_81-100%	1. Observe ocularly for presence or absence of daphne within the plot and 12.62 m around the PC. 2. If daphne is present, then choose appropriate category from the dropdown list, otherwise.

32	Snag	Refers to dead standing tree within the 12.62 m radius plot. Such trees shall not have any living part at or above the DBH.	1. Look for snag within the plot, record “Yes” if snag is present in the plot, otherwise “No”.
33	Snag count	Refers to the number of snag present in the plot.	1. Count the number of snag and record the count of snag accordingly in electronic form or record on paper form.
34	Fallen trees	Refers to the number of dead fallen trees (of more than 1.37 m length and diameter of more than 10 cm at the midpoint) within the 12.62 m radius plot	1. Look for fallen trees within the plot. 2. Record “Yes”, if it is present, otherwise “No”
35	Fallen trees count	Refers to total number/count of fallen trees found in the plot.	1. Count the number of fallen trees and record and record accordingly on electronic form or paper form.
36	Forest Fire	Refers to presence or absence of evidence of forest fire	1. Observe within plot and 12.62 m around the PC for evidence of forest fire. 2. Record “Yes” if evidence is present, otherwise “No”.
37	Intensity of forest fire	Refers to the severity of forest fire damage and shall be classified in one of the following categories: <b>Heavy:</b> Where more than 50% of the area/crop is affected by fire <b>Moderate:</b> Where 10-50% of the area/crop is affected by fire <b>Light:</b> Where less than 10% of the area/crop is affected by fire <b>No Fire:</b> Self explanatory	1. Observe the area ocularly within the plot and assess the severity of damage as per description of each category 2. Then record the category accordingly from the drop-down list in the electronic form or tick appropriately for the paper form.
38	Type of forest fire	Refers to type of forest fire and is classified as one of the following categories: <b>Underground fire:</b> fire spreading under the surface through roots or any other underground means <b>Surface fire:</b> Fire spreading through ground cover, vegetation and litters without reaching the tree canopies <b>Crown fire:</b> Fire spreading through the canopies of woody vegetation <b>Not Sure/not known:</b> If the nature of forest fire cannot be ascertained <b>Not applicable:</b> When no fire incidence is evident	1. Classify the type of forest fire that had affected the area, as per definition provided 2. Then record the appropriate category from the drop-down list in the electronic form or tick appropriately for paper forms.
39	Grazing	Refers to presence or absence of evidence of grazing.	1. Observe ocularly for evidence of presence or absence of grazing within the plot and 12.62 m around the PC. 2. Then record as;

			<p>a. <b>Yes:</b> When there are signs of grazing, presence of livestock or sighting of cattle or dung etc.</p> <p>b. <b>No:</b> When there is no evidence of grazing.</p> <p>c. <b>Not sure:</b> When you are not sure</p>
40	Intensity of grazing	Refers to the severity of grazing and shall be classified as: Low Moderate Severe No grazing	<p>1. Observe ocularly for evidence of severity of grazing within the plot and 12.62 m around the PC.</p> <p>2. Then make expert judgement and record the extent of grazing class from the drop-down list for electronic form or tick appropriately on the paper form.</p>
41	Timber extraction	Refers to evidence of timber being extracted from the plot.	<p>1. Observe for evidence of timber extraction within the plot and 12.62 m around PC.</p> <p>2. Record as “Yes” if there is evidence of extraction, otherwise “No”.</p>
42	Type of Timber Extraction	Refers to type of timber extraction in the plot and shall be categorized in one of the following: Clear felling: Felling of all trees in the area Selective felling: Felling of trees selectively/few trees felled Group felling: Felling of trees in group/patch Others No felling	<p>1. Observe and record the observation by selecting the type of timber extraction appropriately from drop-down list for electronic form or tick appropriate type of timber extraction on the paper form</p>
43	Mining	Refers to evidence of presence or absence of mining in the plot	<p>1. Observe ocularly in the plot for evidence of presence or absence of mining in the plot and 12.62 m around the PC.</p> <p>2. Record “Yes” if there is presence of mining, otherwise “No”.</p>
44	Type of Mining	Refers to type of mining and shall be categorized as: 1. Yes, Surface collection 2. Yes, quarry 3. None 4. Don’t know	<p>1. Observe ocularly within plot and 50 m around the PC; and record your observation as; a. Yes, surface collection b. Yes, quarry c. Don’t know</p>
45	Transmission lines	Refers to the transmission wires running over-head and/or existence of transmission poles.	<p>1. If the transmission line runs over the plot or presence of electric poles within plot or boundary, then it shall be recorded as “Yes”, otherwise “No”.</p>
46	Garbage	Refers to presence or absence of garbage and shall be categorized as: Food wrappers PET bottles	<p>1. Observe within the plot for evidence of any garbage/wastes.</p>



		Construction wastes: All of above None	2. Record the observation under any one of the relevant categories by selecting from the drop-down list for electronic form or tick appropriately on the paper form
<b>Litter, Humus and Fuel bed</b>			
47	Litter Depth Value	Refers to the depth of litter on the forest floor, measured in centimeters. Litter can be defined as the surface layer of the forest floor consisting of freshly fallen leaves, needles, twigs, stems, bark, and fruits. The decomposition would have just begun in this layer.	1. Measure the Litter depth at three random points in the plot, using a measuring scale. 2. Record the average value to the nearest decimal in centimeters.
47	Humus Depth Value	Humus is the layer just below the litter and comprises of highly decomposed organic matter. There shall be no discernible plant parts.	1. Measure the Humus depth at three random points in the plot, using a measuring scale. 2. Record the average value to the nearest decimal in centimeters.
42.	Fuelbed Depth Value	The accumulated mass of dead, woody material on the surface of the forest floor. It begins at the top of the duff/humus layer, and includes litter, fine and coarse wood debris and dead woody shrubs.	1. Measure the fuel depth at three random points in the plot. 2. Record the average value to the nearest decimal in centimeters.
43.	Litter Cover percent	Refers to the coverage of the litter measured as a percentage of the total area of the plot.	3. Record the cover percent of litter in the 12.62 m radius plot.
44.	Bare soil cover percent	The extent of plot area that is not covered by litter and is indicated as the percentage of total area.	4. Record the bare soil cover percent in the 12.62 m radius plot.
<b>Soil</b>			
45.	Stoniness	Refers to cover percent of stones in the 12.62 m radius plot area. The stoniness of the plot area may be classified as: None Rare, <10 percent Few, 10-20 percent Common, 20-30 percent Many, 30-60 percent Abundant, >60 percent	1. Walk around the plot and assess the area for stoniness. 2. Record your observations by selecting the most appropriate category from the drop-down list on the electronic form or tick appropriately on paper form
46.	Soil drainage	The drainage capacity of the soil is observed and classified as under: <b>Poorly drained:</b> Water removed slowly; soil remains wet with water table near the surface for considerable part of the time.	1. Observe ocularly in the plot. 3. Select and record the most appropriate soil drainage category based on the definition provide.

		<p><b>Imperfectly drained:</b> Water removed slowly; soil remains wet for significant part of the year; mottles present within 75 cm of the soil.</p> <p><b>Moderately drained:</b> Water removed somewhat slowly and soil remains wet for small part of the time. Mottles observed below 75 cm.</p> <p><b>Well drained:</b> Water removed rapidly. No mottles</p>	
47.	Top soil moisture	Refers to the moisture content of the top soil at the time of data collection and classified as: Dry Slightly moist Moist Wet Water-logged.	1. Select and record the most appropriate category of top soil moisture from the drop-down list on electronic form or tick appropriately on the paper form.
48.	Top soil colour	Refers to the colour of the soil and classified as: Dark Reddish Yellowish Others	1. Select and record the most appropriate top soil color from the drop-down list on electronic form or tick appropriately on paper form. 2.
49	Top soil texture	Refers to assessment of the soil texture, which shall be classified as: Sand Sandy loam Loam Silty Loam Silt Clay loam Clay Refer the Table 1.32.	1. Feel the soil particles and assess the texture as instructed in the field guide provided in Table 1.32. 2. Record your observation.
<b>Water Bodies</b>			
50	Stream	Stream refers to any flow of water in a channel or bed, as a brook, rivulet or small river.	1. If there is a stream within the plot or 25 m around the plot, record as “Yes”, otherwise “No”.
51	River	A large natural stream of water following in a channel to a sea, a lake or to another river.	2. If there is a river within the plot or 25 m around the plot, record as “Yes”, otherwise “No”.
52	Wetland/Marshy area	Refers to any inundated /waterlogged area or areas with ponds.	3. If the plot area or area within 25 m radius from the PC, shows waterlogged/swampy conditions, then record as “Yes” else “No”
53	Lakes	A <b>lake</b> is a body of relatively still fresh or salt water of considerable size, localized in a <u>basin</u> , which is surrounded by land apart from a river, stream, or other form of moving water that serves to feed or drain lake.	1. If there is lake (irrespective of the category) within the plot or within 25 m radius from the PC, record as “Yes” else “No”.

		(Source: <a href="http://en.wikipedia.org/wiki/Lake">en.wikipedia.org/wiki/Lake</a> ). Lakes can be Alpine lake, Sub-alpine lakes, Glacier lakes, Supra Glacial lake, Supra snow lake or Tsho.	
54	Remarks	Any other additional information that crew might want to give.	1. Crew can provide an additional information relevant to the cluster plot, if any.

Table 1.30 Land Use and Land Class (source: IPCC GPG for LULUCF, 2000)

**Forest land:** This category includes all land with **woody vegetation** consistent with thresholds used to **define forest land** in the national GHG inventory, sub-divided into managed and unmanaged, and also by ecosystem type as specified in the IPCC Guidelines<sup>3</sup>. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.

**Cropland:** This category includes **arable and tillage land, and agro-forestry systems** where vegetation falls below the thresholds used for the forest land category, consistent with the selection of national definitions.

**Grassland:** This category includes **rangelands and pasture land** that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and are not expected to exceed, without human intervention, the threshold used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastoral systems, subdivided into managed and unmanaged consistent with national definitions.

**Wetlands:** This category includes land that is **covered or saturated by water** for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. The category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

**Settlements:** This category includes all **developed land, including transportation infrastructure and human settlements of any size**, unless they are already included under other categories. This should be consistent with the selection of national definitions.

**Other land:** This category includes **bare soil, rock, ice, and all unmanaged land areas** that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.

Table 1.31 Forest Types of Bhutan

Sl. No	Forest Type	Code	Characteristics	Characteristic species
1	Subtropical Forest	STFr	<ul style="list-style-type: none"> <li>Contain many tropical genera and species, forming dense jungle</li> <li>Scattered Sal trees in Sarbang areas</li> <li><b>Altitudinal range: 200-1000 m (-1200m)</b></li> </ul>	<i>Acraocarpus fraxinifolius</i> , <i>Ailanthus grandis</i> , <i>Bombax ceiba</i> , <i>Crateva regillosa</i> , <i>Dellinia pentgyna</i> , <i>Duanbanga grandiflora</i> . <i>Gmelina arborea</i> , <i>Leea asiatica</i> , <i>Musa</i> , <i>Pnadanus</i> , <i>Pterospermum acerifolium</i> , <i>Shorea robusta</i> , <i>Tetrameles nudiflora</i> , <i>Thunbergia</i>
2	Warm Broad-leaved Forest	WBFr	<ul style="list-style-type: none"> <li>Type of Subtropical forest, but occurs at higher altitude with lower rainfall</li> <li>Contains mixture of Evergreen and deciduous broad-leaved species</li> <li>Many of the tropical genera e.g. <i>Duabanga</i>, <i>Pterospermum</i> and <i>Tetrameles</i> are absent</li> <li><b>Altitudinal range: 1000-2000m(-2300m)</b></li> </ul>	<i>Alangium chinensis</i> , <i>Altingia excels</i> , <i>Bischofia javanica</i> <i>Calicarpa arborea</i> , <i>Castanopsis indica</i> , <i>Cordia oblique</i> , <i>Dendrocalamus hookeri</i> <i>Dichroa febrifuga</i> , <i>Engelhardtia spicata</i> , <i>Eouidia fraxinifolia</i> , <i>Macaranga pustulata</i> , <i>Maesa spp.</i> , <i>Mussaenda roxburghii</i> , <i>Pouzolzia sanguine</i> , <i>Raphidophora eximea</i> , <i>Schima wallichii</i> , <i>Wandlandia puberula</i>
3	Chirpine Forest	CPFr	<ul style="list-style-type: none"> <li>Low-altitude xerophytic forest occurring in the deeper dry valleys of Bhutan</li> <li>Almost no other tree species occur in such forest other than <i>Chirpine</i></li> <li><b>Altitudinal range: 900-1800 m(-2000m)</b></li> </ul>	<i>Buddleja asiatica</i> , <i>B. bhutanica</i> , <i>Cycas pectinata</i> , <i>Cymbopogon flexuosus</i> , <i>Euphobia royleana</i> , <i>Ficus obligodon</i> , <i>Grewia sapida</i> <i>Indigofera dosua</i> , <i>Rhus paniculata</i> , <i>Zizyphus incurve</i>
4	Cool Broad-leaved Forest	CBFr	<ul style="list-style-type: none"> <li>Found on moist exposed slopes</li> <li>Mixed forest in which oaks are LESS COMMON and other trees, both deciduous and evergreen, e.g. <i>Lauraceae</i>, <i>Exbucklandia</i> etc., are more abundant together with dense shrubs, climbers and epiphytes</li> </ul>	<i>Acer campbelli</i> , <i>A. sterculiaceum</i> , <i>Betula alonoides</i> , <i>Brassiopsis alpine</i> , <i>Chirita lachensis</i> , <i>Corylopsis himalayana</i> , <i>Elatostema monandrum</i> , <i>E. obtusum</i> , <i>Exbucklandia populnea</i> , <i>Ilex fragilis</i> , <i>Lecanthus peduncularis</i> , <i>Lindera neesiana</i> , <i>L.</i>

			<ul style="list-style-type: none"> <li>• <b>Altitudinal range: 2000-2900m</b></li> </ul>	<i>pulcherrima</i> , <i>Persea clarkeana</i> , <i>Pilea bracteosa</i> , <i>Rosa moschata</i> , <i>Rubus lineatus</i> , <i>Schisandra grandiflora</i> , <i>Symplocos dryiphila</i>
5	Evergreen Oak Forest	EOFr	<ul style="list-style-type: none"> <li>• Characteristic feature of some parts of Central Bhutan (for e.g. Trongsa and hills above Mongar)</li> <li>• Composition varies according to altitude and rainfall</li> <li>• At lower levels, <i>Castanopsis hystrix</i> and <i>C. tribuloides</i> are often dominant, higher up <i>Quercus lamellose</i> becomes commoner</li> <li>• With increasing dryness, more xerophytic <i>Quercus</i> species, e.g. <i>Q. lanata</i>, <i>Q. griffithii</i> and <i>Q. semicarpifolia</i> and <i>Pinus wallichiana</i> are seen</li> <li>• Not much shrub layer, whilst shady humid floors are dominated by small herbs</li> <li>• <b>Altitudinal range: (1800-2000-2600m)</b></li> </ul>	<i>Acer campbelli</i> , <i>Castanopsis hystrix</i> , <i>C. tribuloides</i> , <i>Elatostema hookerianum</i> , <i>E. sessile</i> , <i>Galeola lindleyana</i> , <i>Juglans regia</i> , <i>Pilea symmeria</i> , <i>Quercus lamellose</i> , <i>Skimmia arborescens</i> , <i>Symplocos lucida</i>
6	Blue Pine Forest	BPFr	<ul style="list-style-type: none"> <li>• Temperate equivalent of Chirpine forest and occupies the dry valleys of Bhutan</li> <li>• Bluepine dominant with <i>Quercus species</i> in some places</li> <li>• Xerophytic shrubs occurs and herbs mostly appear during the monsoon season</li> <li>• <b>Altitudinal range: 2100-3000(-3200) m</b></li> </ul>	<i>Berberis asiatica</i> , <i>Berchemia edgeworthii</i> , <i>Cotoneaster griffithii</i> , <i>Eleagnus parviflora</i> , <i>Euonymus grandiflorus</i> , <i>Indigofera heterantha</i> , <i>Jasminium humile</i> , <i>Prinsepia utilis</i> , <i>Lyonia ovalifolia</i> , <i>Quercus griffithii</i> , <i>Q. semicarpifolia</i> , <i>Rhododendron arboretum</i> , <i>Rosa sericea</i> , <i>Spirea canescens</i> , <i>Zanthoxylum armatum</i>

7	Spruce Forest	SPFr	<ul style="list-style-type: none"> <li>Spruce forest with Hemlock and Fir forests occupy the montane cloud-forest zone of Bhutan</li> <li>Often mixed with each other but separate forests can frequently be recognized</li> <li>Spruce are found at lower altitude than Hemlock and Fir</li> <li><b>Altitudinal range: 2700-3100(-3200) m</b></li> </ul>	<i>Acer cappadocicum</i> , <i>A. pectinatum</i> , <i>Berberis praecipua</i> , <i>Enkianthus deflexus</i> , <i>Larix griffithiana</i> , <i>Lindera heterophylla</i> , <i>Osmanthus suavis</i> , <i>Picea brachytyla</i> , <i>P. spinolosa</i> , <i>Salix daltiniana</i> , <i>Salvia campanulata</i> , <i>Taxus baccata</i>
8	Hemlock Forest	HMFr	<ul style="list-style-type: none"> <li>Appears at higher altitude than Spruce where <i>Tsuga dumosa</i> is dominant species mixed with Spruce and Fir</li> <li>Shrubby and arborescent rhododendrons are frequent with dense growth of ferns, lichens and bryophytes</li> <li><b>Altitudinal range: 2800-3100m</b></li> </ul>	<i>Arundinaria griffithiana</i> , <i>Betula utilis</i> , <i>Buddleja colvilei</i> , <i>Daphne bholua</i> , <i>Gaultheria fragmentissima</i> , <i>Larix griffithiana</i> , <i>Litsea sericea</i> , <i>Maddenia himalaica</i> , <i>Magnolia globosa</i> , <i>Panax pseudo-ginseng</i> , <i>Rhododendron falconeri</i> , <i>R. hodgsonis</i> , <i>R. keysii</i> , <i>Rubus calophyllus</i> , <i>R. pentagonus</i> , <i>Sorbus thibetica</i> , <i>Tsuga dumosa</i> , <i>Viburnum mullaha</i>
9	Fir Forest	FIFr	<ul style="list-style-type: none"> <li>Occurs in the highest ridges of Bhutan below tree line, where huge tracts are covered by no other tree species than Fir (<i>Abies densa</i>) and some Hemlock and Birch in places.</li> <li>Luxuriant undergrowth of Rhododendrons and other shrubs with many small herbs on mossy ground layer are found.</li> <li>As tree lines are approached, the firs become stunted and are mixed with Junipers and smaller Rhododendron species</li> <li><b>Altitudinal range: 3300-3800m</b></li> </ul>	<i>Abies densa</i> , <i>Arundinaria maling</i> , <i>Betula utilis</i> , <i>Bryicarpum himalaicum</i> , <i>Daphne bholua</i> , <i>Juniperus pseudosabina</i> , <i>Maddenia himalaica</i> , <i>Primula denticulate</i> , <i>Prunus rufa</i> , <i>Rheum acuminatum</i> , <i>Rhododendron cinnabarinum</i> , <i>R. hodgsonii</i> , <i>Ribes tikare</i> , <i>Rubus fragarioides</i> , <i>Skimmia laureola</i> , <i>Sorbus foliolosa</i> , <i>Viburnum nervosum</i>
10	Juniper-Rhododendron Scrub	JUSc	<ul style="list-style-type: none"> <li>Moist scrub vegetation occurring above treeline throughout Northern and Central Bhutan</li> <li>Consists of scattered shrubs of <i>Junipers</i>, <i>Rhododendron</i> and <i>Potentilla arbuscula</i> but with rich herb layer appearing during the monsoon</li> </ul>	<i>Gaultheria trichophylla</i> , <i>Juniperus recurva</i> , <i>J. squamata</i> , <i>Morina nepalensis</i> , <i>Pedicularis megalantha</i> , <i>Phlomis tibetica</i> , <i>Potentilla arbuscula</i> , <i>Primula sikkimensis</i> , <i>Rhododendron lepidotum</i> , <i>Thalictrum chelidonii</i> , <i>Trollius purnilus</i>



			<ul style="list-style-type: none"> <li>Damp grassy meadow commonly found in this zone</li> <li><b>Altitudinal range: 3700-4200m</b></li> </ul>	
11	Dry Alpine Scrub	DASc	<ul style="list-style-type: none"> <li>More xerophytic vegetation found</li> <li>Higher altitude than Juniper-Rhododendron Scrub</li> <li><b>Altitudinal range: 4000-4600m</b></li> </ul>	<i>Aconitum orochryseum</i> , <i>Astragalus acaulis</i> , <i>Chesneya nubigena</i> , <i>Cremanthodium thomsonii</i> , <i>Ephedra gerardiana</i> , <i>Mecynopsis calderiana</i> , <i>Rheum nobile</i> , <i>Rhododendron anthopogon</i> , <i>Salix lindleyana</i> , <i>Saussurea gossypiphora</i> , <i>S. obvallata</i> , <i>Saxifraga moorcroftiana</i> , <i>Tanacetum gossypinum</i> , <i>Thermopsis barbata</i>

Table 1.32 Rough guide for identifying soil texture in the field

Soil Texture	Feel to fingers and visual	Ball formation		Stickiness	Ribbon formation
		When dry	When moist		
Sand	Very gritty and individual grains visible, free flowing when dry	Does not form ball (falls apart when pressure is released)	Does not form ball (Ball crumbles when lightly touched)	Does not stain fingers	No ribbon formation
Sandy Loam	Moderately gritty (sand characteristic predominate)	Forms a ball which falls apart when lightly touched	Forms ball but easily broken	Stains the fingers	No ribbon formation
Loam	Neither very gritty nor very smooth	Forms ball but easily broken	Forms firm ball	Stains the fingers	No ribbon formation
Silt Loam	Smooth or slick "buttery" feel".	Forms ball but easily broken and has soft flour like feel	Forms firm ball	Stains the fingers	Slight tendency to ribbon with flaky surface
Silt	smooth feel	Forms firm ball	Forms firm ball		Slight tendency to ribbon with flaky surface
Clay Loam	Slightly gritty feel	Moderately hard ball	Forms firm ball which can be handled freely	Stains fingers	Ribbons on squeezing but ribbon breaks easily

Clay	Very smooth	Forms ball without breaking	Forms firm ball which can be handled freely and cannot be crushed with fingers when dry	Stains fingers	Squeezes out at right moisture into long ribbons
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## 2. Collecting and recording regeneration data (F2/7)

Regeneration data shall be collected only from the circular subplot with 3.57 m radius which shall be laid around the Plot Center (PC). All tree species with diameter at breast height (DBH) less than 5 cm and located within 3.57cm subplot shall be enumerated and recorded in the regeneration data form.

SN	Parameters	Description/ Definition	Instructions or how to fill in Data Dictionary
1.	Plot No	This is the unique identification number given to Plot. Eg. KKFMU001	1. Select correct Plot No from the drop-down list on electronic field form or record the correct Plot No, if the paper field form is used. <b>Note:</b> Paper Field Forms are to be used only if the android Tablet does not function in the field.
2	Date	Refers to date on which data was collected	1. Record the date by clicking on calendar icon next to it on android tablet. 2. If paper form is used, record the date accordingly.
4	Time	Refers to time of data collection which is auto-generated by the data logger/android tablet.	1. Record the date by clicking on time icon next to it on android tablet. 2. If paper form is used, record the date accordingly.
5	Species /Scientific Name	Refers to scientific or botanical name which conforms to the <i>International Code of Botanical Nomenclature (ICBN)</i>	1. Choose appropriate botanical name as it appears against it as drop-down list.
6	Common Name/Local Name	"Common name" refers to the commonly used name of that tree species in English or local dialect. "Local name" means name of tree in local dialect. For NFI, the local names in following dialects shall be used; Dzongkha (Dz), Tshanglha Kha (Ts), Lhotsham kha (Lh), Bumthangp (Bum), Khengkha (Kh), Trongsap (Tr) and Kurtoep (Kr).	1. The Crew may note either the common name or the local name, or both, of the tree. 2. In case of local name, Crew must specify dialect in which the local name has been given. (For <i>Quercus griffithii</i> , it is <b>Bae-nangshing</b> in <b>Tshanglha Kha</b> , therefore, local name must be written as <b>Bae-nangshing (Ts)</b> , Ts indicates it is in <b>Tshanglha Kha</b> )
7	Number of established	Established seedlings are plants having height more than 2 m.	1. Count the number of plants having DBH less than 5 cm and of height more than 2 m

	regenerations.		within 3.57 m sub-plot and record the number.
8	Number of un-established regeneration	Un-established regeneration refers to plants which are less than 2 m height and are more than one year old.	1. Count the number of plants having DBH less than 5 cm and of height less than 2 m within 3.57 m sub-plot and record the number.
9	Number of recruits	Recruits are very small plants having 2-4 leaves but are current years seedling	1. Count the number of recruits and record the number
10	Remarks		1. The Crew leader or the data recorder may add any additional information that may help in assessing regeneration status in the plot

**NOTE:** If the plants cannot be identified by either Scientific name or local name or common name, then the plant shall be recorded as "UNKNOWN 1,2,3,4....." for that plot. A picture of the plant may be taken and, in the bracket, record the photograph number (e.g. UNKNOWN 1(DSC423)).

## 2. Tree Data (F3/7)

Tree is a woody perennial with a single main stem, or, in the case of coppice, with several stems, having a more or less definite crown (FAO 2005). Any woody perennial that meet the above definition of tree and has DBH of above 10 cm (both live and dead); and falls within 12.62 m are considered tree, for which data should be collected.

SN	Parameters	Description/ Definition	Instructions or how to fill in Data Dictionary
1	Plot No	This is the unique identification number given to Plot. Eg. KKFMU001	<ol style="list-style-type: none"> <li>1. Select correct Plot No. from the drop-down list on electronic field form or record the correct Plot No, if the paper field form is used.</li> </ol> <p><b>Note:</b> Paper Forms are to be used only if the android Tablet does not function in the field.</p>
2	Scientific Name	Refers to scientific or botanical name which conforms to the <i>International Code of Botanical Nomenclature (ICBN)</i>	<ol style="list-style-type: none"> <li>1. Choose appropriate Botanical Name as it appears against it as drop-down list on electronic form.</li> <li>2. If the name of the plant is not in the list, then provision for typing the botanical name is also provided.</li> <li>3. If Paper forms have been used, record accordingly.</li> </ol>
3	Common Name/Local Name	"Common name" herein is referred to the commonly used name of a tree in English.	<ol style="list-style-type: none"> <li>1. The Crew may note either the common name or the local name of the plant.</li> </ol>

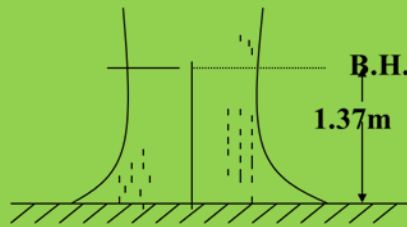
		<p>"Local name" means name of tree in local dialect.</p> <p>For NFI, the Local Names in following dialects shall be used; Dzongkha (Dz), Tshanglha kha (Ts), Lhotsham kha (Lh), Bumthangp (Bum), Khengkha (Kh), Mangdep kha (Mg) and Kurtoep kha (Kr).</p>	<p>2. In case of local name, specify dialect in which the local name has been given.</p> <p>(For <i>Quercus griffithii</i>, it is <b>Baenangshing</b> in <b>Tshanglhakha</b>, therefore, local name must be written as <b>Baenangshing</b> (Ts), Ts indicates it is in <b>Tshanglha kha</b>)</p>
4	DBH	<p>Refers to Diameter measured at Breast Height. It is defined as a method of dendrometric measurements wherein the Diameter is measured at Breast Height which is 1.37 m height from the ground.</p>	<p>1. Measure the DBH and record accordingly.</p> <p>2. Record DBH in centimeter (cm) to one decimal place.</p> <p>Note: Standard Rules for measuring DBH is given in</p> <p>Box 1.3 Standard rules for measuring Tree DBH.</p>
5	Total Height	<p>Refers to the height of a tree which is the length of tree from Ground till tip of the tallest crown or tallest part of the crown.</p>	<p>1. Measure the height of tree using Hypsometer.</p> <p>2. Measure the height by standing on uphill side of the tree on a slope.</p> <p>3. Record the height in meters (m) to once decimal place.</p>
6	Bole Height	<p>The distance between ground level and crown point (<i>the position of the first crown forming living or dead branch</i>) is defined as Bole Height.</p> <p>However, for the purpose of NFI, the Bole height shall be referred to the distance between ground or base of tree to the point on the bole having approximately 10 cm diameter.</p>	<p>1. Measure the bole height using hypsometer.</p> <p>2. Record the bole height in meter to one decimal place.</p> <p>3. <b>Note:</b> The measurement should be taken by standing on uphill side of the tree on a slope.</p>
7	Crown Length	<p>The vertical measurement of crown from the tip of the crown to the point, half way between lowest green branch forming green crown all around and the lowest green branch on the bole is Crown Length.</p>	<p>1. Measure the crown length of tree using Hypsometer.</p> <p>2. Record the crown length in meter to one decimal place.</p> <p><b>Note:</b> The measurement should be taken by standing on uphill side of the tree on a slope.</p>
8	Crown Position	<p>This refers to the position of crown of a tree in relation to the adjacent trees. It is categorized as;</p> <p>a. <b>Dominant Trees:</b> Trees which form the upper most leaf canopy</p>	<p>1. Observe ocularly and select the appropriate category of crown position of tree from the drop-down list on electronic form or tick appropriately on paper form.</p>

		<p>and have their leading shoots free. These trees are called best trees.</p> <p>b. <b>Dominated Trees:</b> Trees which do not form part of the upper most leaf canopy but leading shoots of which are definitely not over-topped by neighboring trees. Their height is about 3/4 of the tallest tree which falls within the plot.</p> <p>c. <b>Suppressed Trees:</b> Trees which reach only about 1/2 to 5/8 of the height of the best trees, with their shoots over-topped by the neighboring trees.</p> <p>d. <b>Solitary Trees:</b> Trees which stand scattered or stand individually.</p> <p>e. <b>Not Applicable:</b> This option is to be selected when the tree is dead &amp; has no crown.</p>	
9	Condition of Tree	<p>Refers to state of the tree. The condition of the tree shall be categorized as:</p> <ol style="list-style-type: none"> <li>1. <b>Healthy:</b> Tree is free of disease or abnormality and damage.</li> <li>2. <b>Diseased:</b> Tree is infected with pests and diseases.</li> <li>3. <b>Abnormal and Damaged:</b> Tree is moribund, damaged or hollowed, etc.</li> <li>4. <b>Dead:</b> Tree has utility less than 70%.</li> </ol>	<ol style="list-style-type: none"> <li>1. Observe and record the condition of tree by choosing the appropriate category from the drop-down option on the electronic form or tick appropriate category on paper form. .</li> </ol>
10	Bark Thickness	<p>Refers to thickness or amount of bark around a tree from outer surface till cambium/wood of a tree.</p>	<ol style="list-style-type: none"> <li>1. Measure the Bark thickness using Bark gauge.</li> <li>2. Measure the bark thickness at DBH.</li> <li>3. Press Bark gauge against bark until wood is reached and read the scale to determine bark thickness.</li> <li>4. Record the bark thickness in centimeter to one decimal place.</li> </ol>
11	Remarks	<p>Any useful remarks related to this particular tree</p>	<ol style="list-style-type: none"> <li>1. Crews may or may not provide remarks.</li> </ol>

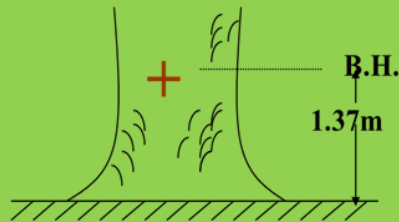
### STANDARD RULES FOR MEASURING DIAMETER AT BREAST HEIGHT (DBH)

Diameter at Breast Height (DBH) is the diameter of a tree measured at 1.37m above ground. The DBH over bark and under bark are abbreviated as DBH (O.B) and DBH (U.B) respectively. A few but very important rules one must follow while measuring DBH are;

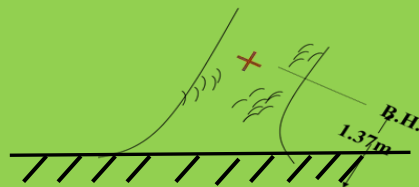
1. Loose bark/ creepers/mosses if found on the tree especially near breast height shall be removed before measuring the diameter.
2. Mark BH by means of measuring stick or white paint or a soft nail (e.g. aluminum) driven into the bark or a scribe mark.



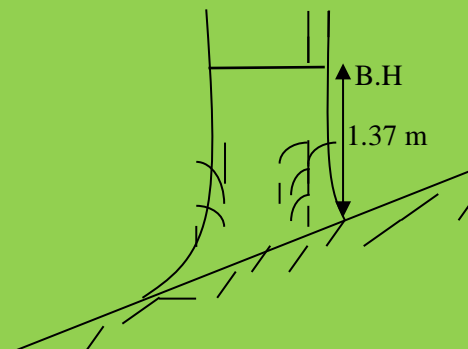
3. On a Flat ground and if the tree is straight, the DBH is taken as depicted in figure below;



4. If the ground is flat and the tree is leaning, then measure DBH parallel to the tree stem and not vertically, on the side of the lean as shown below.

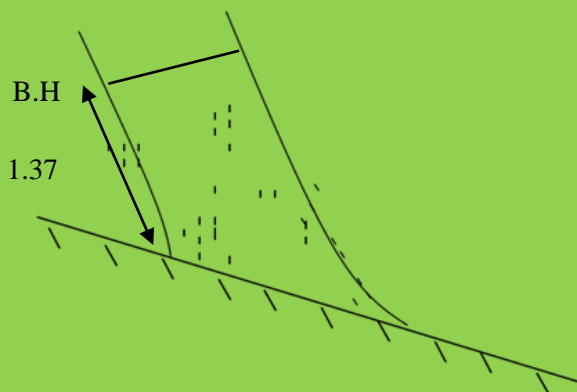


5. On a **sloping** ground with **straight tree**, the DBH is measured from the up- hill side as shown below.

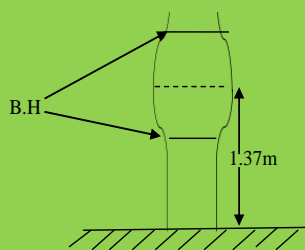




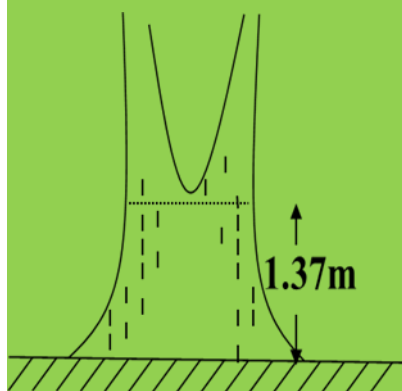
6. On a sloping ground with tree leaning against the direction of slope, measure DBH parallel the tree stem and not vertically, on the side of the lean as shown below.
7. On sloping ground with tree leaning towards uphill slope, measure DBH parallel to the tree stem and not vertically, on the side of the lean as shown below.



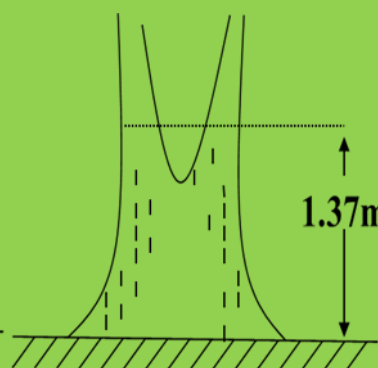
8. If the tree stem is abnormal at Breast Height level, DBH is measured not exactly at 1.37 m but measurement mark is slightly shifted up or down (*as little as possible*) to a more normal position of the stem as shown below.



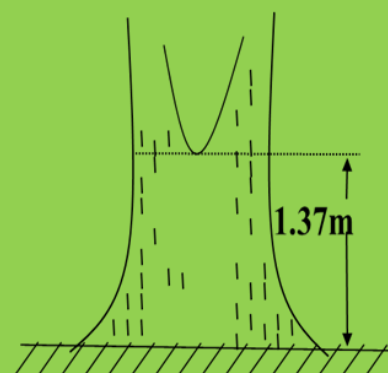
9. If the stem is Forked, then



Count as One Trees

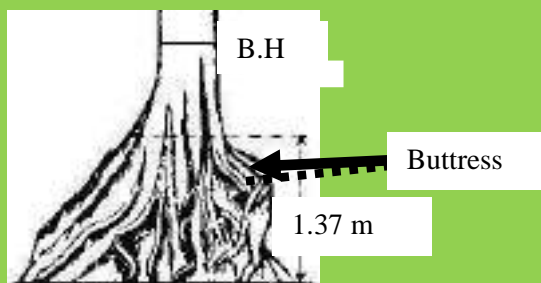


Count as Two Trees



Count as One or Two Trees depending on place of measure-

10. Tree stem has buttress at breast height level, then DBH is measured at the lowest point above which the abnormal formation is not likely to extend.



#### 4. Sapling Data (F4/7)

All tree species having DBH above 5 cm but less than 10 cm shall be identified as Sapling. Sapling data shall be collected within 12.62 m radius plot

SN	Data Items	Description/Definition	Instructions
1	Plot No	This is the unique identification number given to Plot. Eg. KKFMU001	<ol style="list-style-type: none"> <li>1. Select correct Plot No from the drop-down list on electronic field form or record the correct Plot No, if the paper field form is used.</li> </ol> <p><b>Note:</b> If Paper Field Forms are to be used only if the android Tablet does not function in the field.</p>
4	Scientific Name	Refers to scientific or botanical name which conforms to the <i>International Code of Botanical Nomenclature (ICBN)</i> .	<ol style="list-style-type: none"> <li>1. Choose appropriate Botanical Name as it appears against it as drop-down list on electronic form.</li> <li>2. If the name of the plant is not in the list, then provision for typing the botanical name is also provided.</li> <li>3. If Paper forms have been used, record accordingly.</li> </ol>
5	Common Name/Local Name	<p>“Common name” herein is referred to the commonly used name of a tree in English.</p> <p>"Local name" means name of tree in local dialect.</p> <p>For NFI, the Local Names in following dialects shall be used; Dzongkha (Dz), Tshanglha kha (Ts), Lhotsham (Lh), Bumthangp (Bum), Khengkha (Kh), Trongsap (Tr) and Kurtoep (Kr).</p>	<ol style="list-style-type: none"> <li>1. The Crew may note either the common name or the local name of the plant.</li> <li>2. In case of local name, Crew must must specify dialect in which the local name has been given.</li> </ol> <p>(For <i>Quercus griffithii</i>, it is <b>Baenangshing</b> in <b>Tshanglha kha</b>, therefore, local name must be written as <b>Baenangshing (Ts)</b>, Ts indicates it is in <b>Tshanglha kha</b>).</p>
6	Number of individuals	Refers to the number of saplings of that particular species found within a plot.	<ol style="list-style-type: none"> <li>1. Count the number of saplings of one species and record the observation.</li> </ol> <p><b>Note:</b> If there are more than one species, open same electronic field form (electronic form) and fill it up as being done for first species.</p> <ol style="list-style-type: none"> <li>2. For paper field forms, write the species name and record the number accordingly.</li> </ol>
7	Average dbh	Refers to average dbh of sapling of a particular species	<ol style="list-style-type: none"> <li>1. Obtain average dbh of sapling and record in cm to nearest one decimal place.</li> </ol>
8	Average height	Refers to the average height of sapling in meters	<ol style="list-style-type: none"> <li>1. Record the average height of the sapling in meters</li> </ol>
9	Cover percent	Refers to the percentage of the plot area that is covered by sapling.	<ol style="list-style-type: none"> <li>1. Ocularly estimate as to the extent of coverage of sapling within 12.62 m plot and record it in terms of percentage.</li> </ol>
10	Remarks	Any useful remarks related to the sapling	<ol style="list-style-type: none"> <li>1. Crews may or may not provide remarks.</li> </ol>

## 5. Wildlife Data

The FMU inventory shall also collect some information on wildlife. Wildlife field forms shall collect data on Mammals, Birds and Reptiles separately as described.

### Mammal data (F5/7)

SN	Data Item	Definition/Description	Instruction
1	Plot No.	This is the unique identification number given to Plot No. Eg. KKFMU001	<ol style="list-style-type: none"> <li>1. Select correct Plot No from the drop-down list on electronic field form or record the correct Plot No, if the paper field form is used.</li> </ol> <p><b>Note:</b> If Paper Field Forms are to be used only if the android Tablet does not function in the field.</p>
2	Mammal species	Refers to identity of the particular mammal that has been sighted or identified. The list of mammals shall be provided in Table 1.33.	<ol style="list-style-type: none"> <li>1. Select from the drop-down list and record the mammal sighted or identified from the evidence on electronic field form or write down on the paper field form.</li> <li>2. Select “None” if no mammal is observed.</li> </ol>
3	Mammal evidence	Refers to the type of evidence using which mammal is identified. The categories are: <ol style="list-style-type: none"> <li>1. Direct sighting</li> <li>2. Sound/calls</li> <li>3. Dung/Pellets/Scats</li> <li>4. Skeleton/Cadaver</li> <li>5. Horns/Antlers</li> <li>6. Footprints/pugmarks</li> <li>7. Tracks/Paths</li> <li>8. Burrow/Den</li> <li>9. Browsing</li> <li>10. Debarking</li> <li>11. Fraying</li> <li>12. Digging</li> <li>13. Not relevant</li> </ol>	<ol style="list-style-type: none"> <li>1. Select the appropriate evidence type and record.</li> <li>2. <b>Not relevant</b> should be selected when there are no mammals sighted or observed in the 25 m radius.</li> </ol>
4	Species name	Refers to the mammal species sighted or observed but not listed in above list. Can be local or common name	<ol style="list-style-type: none"> <li>1. If the mammal is sighted but not listed in the above list or not known, write the common or local name.</li> </ol>
5	Remarks	Refers to any other relevant information to be added by the crew.	<ol style="list-style-type: none"> <li>1. The Crew Leader or the data recorder may add any additional information on mammal</li> </ol>

Table 1.33 List of mammals

Sl. No	Scientific Name	Common Name
1	<i>Hipposideros Pomona</i>	Andersen's Leaf-nosed Bat
2	<i>Soriculus macrusus</i>	Arboreal Brown Toothed Shrew
3	<i>Elephas maximus</i>	Asian elephant
4	<i>Barbastella leucomelas</i>	Asian/Eastern Barbestelle Bat
5	<i>Scotophilus heathi</i>	Asiatic Greater Yellow Bat
6	<i>Bubalus arnee</i>	Asiatic Water Buffalo
7	<i>Macaca assamenis</i>	Assamese Macaque
8	<i>Soriculus baileyi</i>	Bailey's Shrew
9	<i>Tylonycteris pachypus</i>	Bamboo Bat
10	<i>Muntiacus mutjak</i>	Barking Deer
11	<i>Martes foina</i>	Beech or Stone marten
12	<i>Vulpes bengalensis</i>	Bengal Fox
13	<i>Arctictis binturong</i>	Binturong/ Asian Bearcat
14	<i>Rattus rattus</i>	Black Rat/ House Rat
15	<i>Taphozous melanopogon</i>	Black-bearded Tomb Bat
16	<i>Ochotana curzoniae</i>	Black-lipped Pika <sup>3</sup>
17	<i>Lepus nigricollis</i>	Blacknaped Hare
18	<i>Sphaerias blansfordi</i>	Blanford's Fruit Bat
19	<i>Pseudois nayaur</i>	Blue sheep
20	<i>Rhinolophus Lepidus</i>	Blyth's Horseshoe Bat
21	<i>Plecotus auritus</i>	Brown long-eared Bat
22	<i>Mus platythrix</i>	Brown Spiny Field Mouse
23	<i>Trachypithecus pileatus</i>	Capped Langur
24	<i>Rhinolophus subbadius</i>	Chestnut Horseshoe Bat
25	<i>Manis pentadactyla</i>	Chinese Pangolin
26	<i>Axis axis</i>	Chital/spotted Deer
27	<i>Pipistrellus affinis</i>	Chocolate Pipistrelle
28	<i>Neofelis nebulosa</i>	Clouded leopard
29	<i>Nyctalus noctula</i>	Common Noctule
30	<i>Herpestes edwardsii</i>	Common or Grey Mongoose
31	<i>Lutra lutra</i>	Common Otter
32	<i>Paradoxurus hermaphroditus</i>	Common Palm Civet
33	<i>Ochotona roylei</i>	Common Pika
34	<i>Pipistrellus pipistrellus</i>	Common Pipistrelle
35	<i>Eptesicus serotinus</i>	Common Serotine Bat

<sup>3</sup> Source: Nature Conservation Division, Department of Forests and Park Services

36	<i>Herpestes urva</i>	Crab-eating Mongoose
37	<i>Cuon alpinus primaevus</i>	Dhole/ Wild Dog
38	<i>Scotozous dormer</i>	Dormer's Bat
39	<i>Leopoldamys edwardsi</i>	Edward's Rat
40	<i>Nectogale elegans</i>	Elegant/Tibetan water Shrew
41	<i>Mus saxicola</i>	Elliot's Spiny Mouse
42	<i>Mus cervicolor</i>	Fawn-coloured Mouse
43	<i>Prionailurus viverrinus</i>	Fishing cat
44	<i>Ochotana forresti</i>	Forrest's Pika
45	<i>Rousettus leschenaultia</i>	Fulvous Fruit bat
46	<i>Hipposiderous fulvus</i>	Fulvus Leaf-nosed Bat
47	<i>Platanista gangetica</i>	Ganges River Dolphins
48	<i>Bos gaurus</i>	Gaur
49	<i>Ochotana gloveri</i>	Glover's Pika
50	<i>Catopuma temmincki</i>	Golden cat
51	<i>Trachypithecus geei</i>	Golden Langur
52	<i>Nemorhaedus goral</i>	Goral
53	<i>Petaurista caniceps</i>	Gray-Headed Flying Squirrel
54	<i>Petaurista noblis</i>	Gray's Giant Flying Squirrel
55	<i>Ia io</i>	Great Evening Bat
56	<i>Rhinolophus luctus</i>	Great Indian Horse shoe bat
57	<i>Rhinoceros unicornis</i>	Great one-horned Rhinoceros
58	<i>Murina leucogaster</i>	Great Tube-nosed Bat
59	<i>Bandicota indica</i>	Greater Bandicot Rat
60	<i>Megaderma lyra</i>	Greater False Vampire Bat
61	<i>Hipposiderous arminger</i>	Greater Himalayan Leaf-nosed bat
62	<i>Rhinolophus ferrumequinum</i>	Greater Horseshoe Bat
63	<i>Semnopithecus entellus</i>	Grey Langur/ Hanuman Langur
64	<i>Crocidura attenuate</i>	Grey/Woodland Shrew
65	<i>Myotis annectans</i>	Hairy-faced Bat
66	<i>Harpiocephalus harpia</i>	Hairy-winged Bat
67	<i>Kerivoula hardwickii</i>	Hardwicke's forest Bat
68	<i>Scotomanes ornatus</i>	Harlequin Bat
69	<i>Macroglossus sobrinus</i>	Hill Long- tongued Fruit bat
70	<i>Ursus thibetanus laniger</i>	Himalayan Black Bear
71	<i>Petaurista magnificus</i>	Himalayan Flying Squirrel
72	<i>Paguma larvata</i>	Himalayan Palm Civet
73	<i>Rattus nitidus</i>	Himalayan Rat
74	<i>Capricornis sumatraensis</i>	Himalayan Serow
75	<i>Soriculus nigrescens</i>	Himalayan Shrew/ Sikkim Large Clawed Shrew
76	<i>Alticola stoliczkanus</i>	Himalayan Vole



77	<i>Mustela sibirica</i>	Himalayan Weasel
78	<i>Martes flavigula</i>	Himalayan Yellow-Throated Marten
79	<i>Chimarrogale himalayica</i>	Himalayan Water Shrew
80	<i>Canis lupus</i>	Himalayan Wolf/ Tibetan Wolf
81	<i>Caprolagus hispidus</i>	Hispid Hare
82	<i>Myotis formosus</i>	Hodgson's Bat
83	<i>Soriculus caudatus</i>	Hodgson's Brown Toothed Shrew
84	<i>Arctonyx collaris</i>	Hog badger
85	<i>Axis porcinus</i>	Hog Deer
86	<i>Hipposiderous larvatus</i>	Horsefield's Leaf-nosed Bat
87	<i>Crocidura horsfieldi</i>	Horsefield's Shrew
88	<i>Mus musculus</i>	House Mouse
89	<i>Suncus murinus</i>	House/Musk Shrew
90	<i>Murina huttoni</i>	Hutton's Tube-nosed Bat
91	<i>Golunda ellioti</i>	Indian Bush Rat
92	<i>Pteropus giganteus</i>	Indian Flying Fox
93	<i>Soriculus leucops</i>	Indian long-tailed Shrew
94	<i>Manis crassicaudata</i>	Indian Pangolin
95	<i>Pipistrellus coromandra</i>	Indian Pipistrelle
96	<i>Rhinolophus affinis</i>	Intermediate Horseshoe Bat
97	<i>Pipistrellus javanicus</i>	Javan's Pipistrelle
98	<i>Felis chaus</i>	Jungle Cat
99	<i>Hipposiderous lankadiva</i>	Lankadiva Bat
100	<i>Pipistrellus circumdatus</i>	Large Black Pipistrelle
101	<i>Viverra zibetha</i>	Large Indian civet
102	<i>Rhinolophus macrotis</i>	Large-eared Horseshoe bat
103	<i>Ochotona macrotis</i>	Large-eared Pika
104	<i>Melogale personata</i>	Large-toothed Ferret Badger
105	<i>Dacnomys millardi</i>	Large-toothed Rat
106	<i>Hipposiderous ater Dusky</i>	Leaf-nosed Bat
107	<i>Rhinolophu pusillus</i>	Least Horseshoe Bat
108	<i>Hipposiderous cineraceus</i>	Least Leaf- nosed Bat
109	<i>Panthera pardus</i>	Leopard
110	<i>Prionailurus bengalensis</i>	Leopard cat
111	<i>Bandicota bengalensis</i>	Lesser Bandicoot Rat
112	<i>Cynopterus brachyotis</i>	Lesser Dog-faced Fruit bat
113	<i>Megaderma spasa</i>	Lesser False Vampire Bat
114	<i>Sorex bedfordia</i>	Lesser Stripe-backed Shrew
115	<i>Myotis sicarius</i>	Little Brown bat
116	<i>Niviventerha</i>	Little Himalayan Rat
117	<i>Murina aurata</i>	Little Tube-nosed Bat

118	<i>Vandeleuria oleracea</i>	Long-tailed Tree Mouse
119	<i>Eonycteris spelaea</i>	Long-tongued Fruit Bat
120	<i>Canis aureus</i>	Lower Risk
121	<i>Lynx lynx</i>	Lynx
122	<i>Pardofelis marmorata</i>	Marbled cat
123	<i>Bos frontalis</i>	Mithun
124	<i>Ochotona thibetana</i>	Moupin's Pika
125	<i>Moschus chrysogaster</i>	Musk Deer
126	<i>Taphozous nudiventris</i>	Naked-rumped Tomb Bat
127	<i>Myotis muricola</i>	Nepalese- whiskered Bat
128	<i>Megaerops niphanae</i>	Niphan's Tailless Fruit bat
129	<i>Tupaia belangeri</i>	Northern Tree Shrew
130	<i>Rattus norvegicus</i>	Norway Rat
131	<i>Ochotana nubrica</i>	Nubra Pika
132	<i>Kerivoula picta</i>	Painted Bat
133	<i>Mustela altaica</i>	Pale Weasel
134	<i>Felis manul</i>	Pallas cat
135	<i>Hylopetes alboniger</i>	Parti-coloured Flying Squirrel
136	<i>Pipistrellus paterculus</i>	Paternal Pipistrelle
137	<i>Belomys pearsoni</i>	Pearson's / Hairy footed Flying Squirrel
138	<i>Rhinolophus pearsonii</i>	Pearson's Horseshoe bat
139	<i>Minopterus pusillus</i>	Pusillus Long- Fingered Bat
140	<i>Sus salvanius</i>	Pygmy hog
141	<i>Pipistrellus mimus</i>	Pygmy Pipistrelle
142	<i>Sorex minutes</i>	Pygmy Shrew
143	<i>Suncus etruscus</i>	Pygmy White-toothed Shrew
144	<i>Cervus elaphus wallichi</i>	Red deer/Sikkim Red Deer
145	<i>Vulpes vulpes</i>	Red Fox
146	<i>Petaurista petaurista</i>	Red Giant Flying squirrel
147	<i>Ailurus fulgens</i>	Red Panda
148	<i>Macaca mulatta</i>	Rhesus Macaque
149	<i>Murina cyclotis</i>	Round- eared Tube-nosed bat
150	<i>Rhinolophus rouxii</i>	Rufous Horseshoe Bat
151	<i>Minopterus schreibersii</i>	Schreiber's Long Fingered Bat
152	<i>Talpa micrura</i>	Short - tailed Mole
153	<i>Cynopterus sphinx</i>	Short- nosed Fruit Bat
154	<i>Mus pahari</i>	Sikkim Mouse
155	<i>Rattus sikkimensis</i>	Sikkim Rat
156	<i>Microtus sikimensis</i>	Sikkim Vole
157	<i>Melursus ursinus</i>	Sloth Bear
158	<i>Nycticebus Bengalensis</i>	Slow Loris

159	<i>Cervus unicolor</i>	Smabar
160	<i>Viverricula indica</i>	Small India Civet
161	<i>Herpestes javanicus</i>	Small Indian Mongoose
162	<i>Amblonyx cinerus</i>	Small-Clawed Otter
163	<i>Melogale moschata</i>	Small-toothed Ferret Badger
164	<i>Myotis siligorensis</i>	Small-toothed Whiskered Bat
165	<i>Lutrogale perspicillata</i>	Smooth Coated Otter
166	<i>Uncia uncia</i>	Snow Leopard
167	<i>Millardia meltada</i>	Soft-furred Field Rat/Metad
168	<i>Crocidura fuliginosa</i>	South east Asian White Toothed Shrew
169	<i>Peturista elegans</i>	Spotted Giant Flying Squirrel
170	<i>Prionodon pardicolor</i>	Spotted Linsang
171	<i>Cervus duvauceli</i>	Swamp Deer
172	<i>Coelops frithi</i>	Tail-less Leaf-nosed Bat
173	<i>Budorcas taxicolor</i>	Takin
174	<i>Eptesicus tatei</i>	Tate's Bat
175	<i>Alticola stracheyi</i>	Thoma's Mountain Vole
176	<i>Pipistrellus cadornae</i>	Thomas's Pipistrelle
177	<i>Hesperoptenus tickelli</i>	Tickell's Bat
178	<i>Panthera tigris</i>	Tiger
179	<i>Rhinolophus trifolius</i>	Trefoli Horseshoe Bat
180	<i>Rattus turkestanicus</i>	Turkestan Rat
181	<i>Myotis daubentonii</i>	Water Bat
182	<i>Myotis mystacinus</i>	Whiskered Bat
183	<i>Niviventer niviventer</i>	White-bellied Rat
184	<i>Sus scrofa</i>	Wild boar
185	<i>Apodemus sylvaticus</i>	Wood Mouse
186	<i>Eupetaurus cinereus</i>	Wooly Flying Squirrel
187	<i>Lepus oiostolus</i>	Wooly Hare
188	<i>Bos grunniens</i>	Yak
189	<i>Mustela kathia</i>	Yellow-Bellied Weasel

## 5. Bird Data (F6/7)

SN	Data Item	Definition/Description	Instruction
1	Plot No.	This is the unique identification number given to Plot No. Eg. KKFMU001	<p>2. Select correct Plot No from the drop-down list on electronic field form or record the correct Plot No, if the paper field form is used.</p> <p><b>Note:</b> If Paper Field Forms are to be used only if the android Tablet does not function in the field.</p>
2	Bird species	<p>Refers to identity of the particular bird that has been sighted or identified.</p> <p><i>The list of birds shall be provided in Table 1.34</i></p>	<p>1. Select from the drop-down list and record the bird sighted or identified from the evidence on electronic field form or write down on the paper field form.</p> <p>2. Select “None” if no bird is observed.</p>
3	Bird evidence	<p>Refers to the type of evidence using which the bird is identified. The categories are:</p> <ol style="list-style-type: none"> <li>1. Direct sighting</li> <li>2. Sound/calls</li> <li>3. Droppings</li> <li>4. Eggs</li> <li>5. Skeleton/Cadaver</li> <li>6. Feathers</li> <li>7. Footprints</li> <li>8. Tracks/Paths</li> <li>9. Nests/Burrows</li> <li>10. Not relevant</li> </ol>	<p>1. Select the appropriate evidence type based on which the bird has been identified and record.</p> <p>2. “Not relevant” should be selected when there are no birds are sighted or observed in the 25 m radius from the PC.</p>
4	Species name	Refers to the bird species sighted or observed but not listed in above list. Can be local or common name	<p>1. If the bird is sighted but not listed in the above list or not known, write the common or local name.</p>
5	Remarks	Refers to any relevant information on bird that crew provides.	<p>1. The Crew Leader or the data recorder shall add any additional information on birds.</p>

Table 1.34 Lists of birds

57	<i>Anthraceroceros albirostris</i>	Oriental Pied Hornbill
58	<i>Anthreptes singalensis</i>	Ruby-cheeked Sunbird
59	<i>Anthus campestris</i>	Tawny Pipit
60	<i>Anthus cervinus</i>	Red-throated Pipit
61	<i>Anthus godlenskii</i>	Blyth's Pipit
62	<i>Anthus hodgsoni</i>	Olive-backed Pipit
63	<i>Anthus richardi</i>	Richard's Pipit
64	<i>Anthus roseatus</i>	Rosy Pipit
65	<i>Anthus rubescens</i>	Buff-bellied Pipit
66	<i>Anthus rufulus</i>	Paddyfield Pipit
67	<i>Anthus spinoletta</i>	Water Pipit
68	<i>Anthus trivialis</i>	Tree Pipit
69	<i>Apus nipalensis</i>	House Swift
70	<i>Apus acuticauda</i>	Dark-rumped Swift
71	<i>Apus pacificus</i>	Fork-tailed Swift
72	<i>Aquila chrysaetos</i>	Golden Eagle
73	<i>Aquila clanga</i>	Greater Spotted Eagle
74	<i>Aquila hastata</i>	Indian Spotted Eagle
75	<i>Aquila heliaca</i>	Eastern Imperial Eagle
76	<i>Aquila nipalensis</i>	Steppe Eagle
77	<i>Arachnothera longirostra</i>	Little Spiderhunter
78	<i>Arachnothera magna</i>	Streaked Spiderhunter
79	<i>Arborophila mandellii</i>	Chestnut-breasted Partridge
80	<i>Arborophila rufogularis</i>	Rufous-throated Partridge
81	<i>Arborophila torqueola</i>	Hill Partridge
82	<i>Ardea cinerea</i>	Grey Heron
83	<i>Ardea insignis</i>	White-bellied Heron
84	<i>Ardea purpurea</i>	Purple Heron
85	<i>Ardeola bacchus</i>	Chinese Pond Heron
86	<i>Ardeola grayii</i>	Indian Pond Heron
87	<i>Artamus fuscus</i>	Ashy Woodswallow
88	<i>Asio flammeus</i>	Short-eared Owl
89	<i>Asio otus</i>	Long-eared Owl
90	<i>Athene brama</i>	Spotted Owlet
91	<i>Athene noctua</i>	Little Owl
92	<i>Aviceda jerdoni</i>	Jerdon's Baza
93	<i>Aviceda leuphotes</i>	Black Baza

37	<i>Alcippe nipalensis</i>	Nepal Fulvetta
38	<i>Alcippe rufogularis</i>	Rufous-throated Fulvetta
39	<i>Alcippe vinipectus</i>	White-browed Fulvetta
40	<i>Alophoixus flaveolus</i>	White-throated Bulbul
41	<i>Amaurornis phoenicurus</i>	White-breasted Waterhen
42	<i>Ampeliceps coronatus</i>	Yellow-crested Myna
43	<i>Anas acuta</i>	Northern Pintail
44	<i>Anas chrypeata</i>	Northern Shoveler
45	<i>Anas crecca</i>	Common Teal
46	<i>Anas falcata</i>	Falcated Duck
47	<i>Anas formosa</i>	Baikal Teal
48	<i>Anas penelope</i>	Eurasian Wigeon
49	<i>Anas platyrhynchos</i>	Mallard
50	<i>Anas poecilorhynchos</i>	Indian Spot-billed Duck
51	<i>Anas querquedula</i>	Garganey
52	<i>Anas strepera</i>	Gadwall
53	<i>Anastomus oscitans</i>	Asian Openbill
54	<i>Anser albifrons</i>	Greater White-fronted Goose
55	<i>Anser anser</i>	Greylag Goose
56	<i>Anser indicus</i>	Bar-headed Goose
57	<i>Anthraceroceros albirostris</i>	Oriental Pied Hornbill
58	<i>Anthreptes singalensis</i>	Ruby-cheeked Sunbird
59	<i>Anthus campestris</i>	Tawny Pipit
60	<i>Anthus cervinus</i>	Red-throated Pipit
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67	<i>Anthus spinoletta</i>	Water Pipit
68	<i>Anthus trivialis</i>	Tree Pipit
69	<i>Apus nipalensis</i>	House Swift
70	<i>Apus acuticauda</i>	Dark-rumped Swift
71	<i>Apus pacificus</i>	Fork-tailed Swift
72	<i>Aquila chrysaetos</i>	Golden Eagle
73	<i>Aquila clanga</i>	Greater Spotted Eagle



74	<i>Aquila hastata</i>	Indian Spotted Eagle
75	<i>Aquila heliaca</i>	Eastern Imperial Eagle
76	<i>Aquila nipalensis</i>	Steppe Eagle
77	<i>Arachnothera longirostra</i>	Little Spiderhunter
78	<i>Arachnothera magna</i>	Streaked Spiderhunter
79	<i>Arborophila mandellii</i>	Chestnut-breasted Partridge
80	<i>Arborophila rufogularis</i>	Rufous-throated Partridge
81	<i>Arborophila torqueola</i>	Hill Partridge
82	<i>Ardea cinerea</i>	Grey Heron
83	<i>Ardea insignis</i>	White-bellied Heron
84	<i>Ardea purpurea</i>	Purple Heron
85	<i>Ardeola bacchus</i>	Chinese Pond Heron
86	<i>Ardeola grayii</i>	Indian Pond Heron
87	<i>Artamus fuscus</i>	Ashy Woodswallow
88	<i>Asio flammeus</i>	Short-eared Owl
89	<i>Asio otus</i>	Long-eared Owl
90	<i>Athene brama</i>	Spotted Owlet
91	<i>Athene noctua</i>	Little Owl
92	<i>Aviceda jerdoni</i>	Jerdon's Baza
93	<i>Aviceda leuphotes</i>	Black Baza
94	<i>Aythya baeri</i>	Baer's Pochard
95	<i>Aythya ferina</i>	Common Pochard
96	<i>Aythya fuligula</i>	Tufted Duck
97	<i>Aythya nyroca</i>	Ferruginous Duck
98	<i>Batastus teesa</i>	White-eyed Buzzard
99	<i>Batrachostomus hodgsoni</i>	Hodgson's Frogmouth
100	<i>Blythipicus pyrrhotis</i>	Bay Woodpecker
101	<i>Brachypteryx hypertybra</i>	Rusty-bellied Shortwing
102	<i>Brachypteryx leucobryx</i>	Lesser Shortwing
103	<i>Brachypteryx montana</i>	White-browed Shortwing
104	<i>Brachypteryx stellata</i>	Gould's Shortwing
105	<i>Bradypterus luteoventris</i>	Brown Bush Warbler
106	<i>Bradypterus seebohmii</i>	Russet Bush Warbler
107	<i>Bradypterus tacsanowskii</i>	Chinese Bush Warbler
108	<i>Bradypterus thoracicus</i>	Spotted Bush Warbler
109	<i>Bubo bengalensis</i>	Indian Eagle Owl
110	<i>Bubo bubo</i>	Eurasian Eagle Owl

111	<i>Bubo nipalensis</i>	Spot-bellied Eagle Owl
112	<i>Bubulcus ibis</i>	Cattle Egret
113	<i>Buceros bicornis</i>	Great Hornbill
114	<i>Burhinus indicus</i>	Indian Thick-knee
115	<i>Buteo burmanicus</i>	Himalayan Buzzard
116	<i>Buteo hemilasius</i>	Upland Buzzard
117	<i>Buteo rufinus</i>	Long-legged Buzzard
118	<i>Butorides striata</i>	Striated Heron
119	<i>Cacomantis merulinus</i>	Plaintive Cuckoo
120	<i>Cacomantis passerinus</i>	Grey-bellied Cuckoo
121	<i>Cacomantis sonneratii</i>	Banded Bay Cuckoo
122	<i>Cairina scutulata</i>	White-winged Duck
123	<i>Calandrella acutirostris</i>	Hume's Short-toed Lark
124	<i>Calandrella brachydactyla</i>	Greater Short-toed Lark
125	<i>Calandrella cheleensis</i>	Asian Short-toed Lark
126	<i>Calandrella raytal</i>	Sand Lark
127	<i>Calcarius lapponicus</i>	Lapland Longspur
128	<i>Calidris ferruginea</i>	Curlew Sandpiper
129	<i>Calidris minuta</i>	Little Stint
130	<i>Calidris temminckii</i>	Temminck's Stint
131	<i>Callacanthus burtoni</i>	Spectacled Finch
132	<i>Calinator jacobinus</i>	Jacobin Cuckoo
133	<i>Caprimulgus affinis</i>	Savanna Nightjar
134	<i>Caprimulgus asiaticus</i>	Indian Nightjar
135	<i>Caprimulgus indicus</i>	Grey Nightjar
136	<i>Caprimulgus macrurus</i>	Large-tailed Nightjar
137	<i>Carduelis spinoides</i>	Yellow-breasted Greenfinch
138	<i>Carpodacus edwardsii</i>	Dark-rumped Rosefinch
139	<i>Carpodacus erythrurus</i>	Common Rosefinch
140	<i>Carpodacus nipalensis</i>	Dark-breasted Rosefinch
141	<i>Carpodacus pulcherrimus</i>	Beautiful Rosefinch
142	<i>Carpodacus puniceus</i>	Red-fronted Rosefinch
143	<i>Carpodacus rodochroa</i>	Pink-browed Rosefinch
144	<i>Carpodacus rubescens</i>	Blanford's Rosefinch
145	<i>Carpodacus rubicilloides</i>	Streaked Rosefinch
146	<i>Carpodacus thura</i>	White-browed Rosefinch
147	<i>Carpodacus trifasciatus</i>	Three-banded Rosefinch

148	<i>Casmerodius albus</i>	Great Egret
149	<i>Celeus brachyurus</i>	Rufous Woodpecker
150	<i>Centropus bengalensis</i>	Lesser Coucal
151	<i>Centropus sinensis</i>	Greater Coucal
152	<i>Cephalopyrus flammiceps</i>	Fire-capped Tit
153	<i>Certhia discolor</i>	Brown-throated Treecreeper
154	<i>Certhia hodgsoni</i>	Hodgson's Treecreeper
155	<i>Certhia nipalensis</i>	Rusty-flanked Treecreeper
156	<i>Ceryle rudis</i>	Pied Kingfisher
157	<i>Cettia acanthizoides</i>	Yellowish-bellied Bush Warbler
158	<i>Cettia brunnifrons</i>	Grey-sided Bush Warbler
159	<i>Cettia flavolivacea</i>	Aberrant Bush Warbler
160	<i>Cettia fortipes</i>	Brownish-flanked Bush Warbler
161	<i>Cettia major</i>	Chestnut-crowned Bush Warbler
162	<i>Cettia pallidipes</i>	Pale-footed Bush Warbler
163	<i>Ceyx erithacus</i>	Oriental Dwarf Kingfisher
164	<i>Chaimarrornis leucocephalus</i>	White-capped Water Redstart
165	<i>Chalcophaps indica</i>	Emerald Dove
166	<i>Charadrius alexandrinus</i>	Kentish Plover
167	<i>Charadrius dubius</i>	Little Ringed Plover
168	<i>Charadrius leschenaultii</i>	Greater Sand Plover
169	<i>Charadrius mongolus</i>	Lesser Sand Plover
170	<i>Charadrius placidus</i>	Long-billed Plover
171	<i>Chloropsis aurifrons</i>	Golden-fronted Leafbird
172	<i>Chloropsis hardwickii</i>	Orange-bellied Leafbird
173	<i>Chroicocephalus brunnicephalus</i>	Brown-headed Gull
174	<i>Chroicocephalus genei</i>	Slender-billed Gull
175	<i>Chroicocephalus ridibundus</i>	Black-headed Gull
176	<i>Chrysococcyx maculatus</i>	Asian Emerald Cuckoo
177	<i>Chrysococcyx xanthorhynchus</i>	Violet Cuckoo
178	<i>Chrysocolaptes lucidus</i>	Greater Flameback
179	<i>Chrysoma sinense</i>	Yellow-eyed Babbler
180	<i>Ciconia episcopus</i>	Woolly-necked Stork
181	<i>Ciconia nigra</i>	Black Stork
182	<i>Cinclidium frontale</i>	Blue-fronted Robin
183	<i>Cinclus cinclus</i>	White-throated Dipper
184	<i>Cinclus pallasii</i>	Brown Dipper

185	<i>Circaetus gallicus</i>	Short-toed Snake Eagle
186	<i>Circus spilonotus</i>	Eastern Marsh Harrier
187	<i>Circus aeruginosus</i>	Eurasian Marsh Harrier
188	<i>Circus cyaneus</i>	Hen Harrier
189	<i>Circus macrourus</i>	Pallid Harrier
190	<i>Circus melanoleucos</i>	Pied Harrier
191	<i>Cissa chinensis</i>	Common Green Magpie
192	<i>Clamator coromandus</i>	Chestnut-winged Cuckoo
193	<i>Clangula hyemalis</i>	Long-tailed Duck
194	<i>Cochoa purpurea</i>	Purple Cochoa
195	<i>Cochoa viridis</i>	Green Cochoa
196	<i>Collocalia brevirostris</i>	Himalayan Swiftlet
197	<i>Columba hodgsonii</i>	Speckled Wood Pigeon
198	<i>Columba leuconota</i>	Snow Pigeon
199	<i>Columba livia</i>	Common Pigeon
200	<i>Columba pulchricollis</i>	Ashy Wood Pigeon
201	<i>Columba rupestris</i>	Hill Pigeon
202	<i>Conostoma oemodius</i>	Great Parrotbill
203	<i>Copsychus malabaricus</i>	White-rumped Shama
204	<i>Copsychus saularis</i>	Oriental Magpie Robin
205	<i>Coracias benghalensis</i>	Indian Roller
206	<i>Coracias garrulus</i>	Eurasian Roller
207	<i>Coracina macei</i>	Large Cuckoo shrike
208	<i>Coracina melaschistos</i>	Black-winged Cuckooshrike
209	<i>Corvus leuclanthus</i>	Eastern Jungle Crow
210	<i>Corvus corax</i>	Northern Raven
211	<i>Corvus macrorhynchos</i>	Large-billed Crow
212	<i>Corvus splendens</i>	House Crow
213	<i>Coturnix coturnix</i>	Common Quail
214	<i>Coturnix japonica</i>	Japanese Quail
215	<i>Cuculus canorus</i>	Eurasian Cuckoo
216	<i>Cuculus micropterus</i>	Indian Cuckoo
217	<i>Cuculus poliocephalus</i>	Lesser Cuckoo
218	<i>Cuculus saturatus</i>	Oriental Cuckoo
219	<i>Culicicapa ceylonensis</i>	Grey-headed Canary Flycatcher
220	<i>Cutia nipalensis</i>	Himalayan Cutia
221	<i>Cyornis poliogenys</i>	Pale-chinned Flycatcher

222	<i>Cyornis rubeculoides</i>	Blue-throated Flycatcher
223	<i>Cyornis unicolor</i>	Pale Blue Flycatcher
224	<i>Cypsiurus balasienis</i>	Asian Palm Swift
225	<i>Delichon dasypus</i>	Asian House Martin
226	<i>Delichon nipalensis</i>	Nepal House Martin
227	<i>Dendrocitta formosae</i>	Grey Treepie
228	<i>Dendrocitta frontalis</i>	Collared Treepie
229	<i>Dendrocitta vagabunda</i>	Rufous Treepie
230	<i>Dendrocopos atratus</i>	Stripe-breasted Woodpecker
231	<i>Dendrocopos canicapillus</i>	Grey-capped Pygmy Woodpecker
232	<i>Dendrocopos cathpharius</i>	Crimson-breasted Woodpecker
233	<i>Dendrocopos darjellensis</i>	Darjeeling Woodpecker
234	<i>Dendrocopos hyperythrus</i>	Rufous-bellied Woodpecker
235	<i>Dendrocopos macei</i>	Fulvous-breasted Woodpecker
236	<i>Dendrocygna bicolor</i>	Fulvous Whistling-duck
237	<i>Dendrocygna javanica</i>	Lesser Whistling-duck
238	<i>Dendronanthus indicus</i>	Forest Wagtail
239	<i>Dicaeum chrysorrheum</i>	Yellow-vented Flowerpecker
240	<i>Dicaeum concolor</i>	Plain Flowerpecker
241	<i>Dicaeum cruentatum</i>	Scarlet-backed Flowerpecker
242	<i>Dicaeum erythrorhynchus</i>	Pale-billed Flowerpecker
243	<i>Dicaeum ignipectus</i>	Fire-breasted Flowerpecker
244	<i>Dicaeum melanocephalum</i>	Yellow-bellied Flowerpecker
245	<i>Dicrurus aeneus</i>	Bronzed Drongo
246	<i>Dicrurus annectans</i>	Crow-billed Drongo
247	<i>Dicrurus hottentottus</i>	Spangled Drongo
248	<i>Dicrurus leucophaea</i>	Ashy Drongo
249	<i>Dicrurus macrocerus</i>	Black Drongo
250	<i>Dicrurus paradiseus</i>	Greater Racket-tailed Drongo
251	<i>Dicrurus remifer</i>	Lesser Racket-tailed Drongo
252	<i>Dinopium shorii</i>	Himalayan Flameback
253	<i>Ducula aenea</i>	Green Imperial Pigeon
254	<i>Ducula badia</i>	Mountain Imperial Pigeon
255	<i>Egretta garzetta</i>	Little Egret
256	<i>Elanus caeruleus</i>	Black-winged Kite
257	<i>Emberiza bichanani</i>	Grey-necked Bunting
258	<i>Emberiza godlewskii</i>	Godlewski's Bunting

259	<i>Emberiza melanocephala</i>	Black-headed Bunting
260	<i>Emberiza pusilla</i>	Little Bunting
261	<i>Emberiza rustica</i>	Rustic Bunting
262	<i>Emberiza spodocephala</i>	Black-faced Bunting
263	<i>Enicurus immaculatus</i>	Black-backed Forktail
264	<i>Enicurus leschenaulti</i>	White-crowned Forktail
265	<i>Enicurus maculatus</i>	Spotted Forktail
266	<i>Enicurus schistaceus</i>	Slaty-backed Forktail
267	<i>Enicurus scouleri</i>	Little Forktail
268	<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork
269	<i>Epornis zantholeuca</i>	White-bellied Epornis
270	<i>Esacus recurvirostris</i>	Great Thick-knee
271	<i>Eudynamys scolopacea</i>	Asian Koel
272	<i>Eumyias thalassina</i>	Verditer Flycatcher
273	<i>Eurystomus orientalis</i>	Dollarbird
274	<i>Falco amurensis</i>	Amur Falcon
275	<i>Falco chicquera</i>	Red-necked Falcon
276	<i>Falco columbarius</i>	Merlin
277	<i>Falco peregrinus</i>	Peregrine Falcon
278	<i>Falco severus</i>	Oriental Hobby
279	<i>Falco subbuteo</i>	Eurasian Hobby
280	<i>Falco tinnunculus</i>	Common Kestrel
281	<i>Ficedula albicilla</i>	Taiga Flycatcher
282	<i>Ficedula bodgsonii</i>	Slaty-backed Flycatcher
283	<i>Ficedula hyperythra</i>	Snowy-browed Flycatcher
284	<i>Ficedula monileger</i>	White-gorgeted Flycatcher
285	<i>Ficedula parva</i>	Red-breasted Flycatcher
286	<i>Ficedula sapphira</i>	Sapphire Flycatcher
287	<i>Ficedula strophbiata</i>	Rufous-gorgeted Flycatcher
288	<i>Ficedula subrubra</i>	Kashmir Flycatcher
289	<i>Ficedula superciliaris</i>	Ultramarine Flycatcher
290	<i>Ficedula tricolor</i>	Slaty-blue Flycatcher
291	<i>Ficedula westermanni</i>	Little Pied Flycatcher
292	<i>Francolinus francolinus</i>	Black Francolin
293	<i>Fringilla coelebs</i>	Common Chaffinch
294	<i>Fringilla montifringilla</i>	Brambling
295	<i>Fulica atra</i>	Eurasian Coot



296	<i>Gallinago cinerea</i>	Watercock
297	<i>Gallinago gallinago</i>	Common Snipe
298	<i>Gallinago nemoricola</i>	Wood Snipe
299	<i>Gallinago solitaria</i>	Solitary Snipe
300	<i>Gallinago stenura</i>	Pintail Snipe
301	<i>Gallinula chloropus</i>	Common Moorhen
302	<i>Gallirallus striata</i>	Slaty-breasted Rail
303	<i>Gallus gallus</i>	Red Junglefowl
304	<i>Gampsorhynchus rufulus</i>	White-hooded Babbler
305	<i>Garrulax affinis</i>	Black-faced Laughingthrush
306	<i>Garrulax albogularis</i>	White-throated Laughingthrush
307	<i>Garrulax caerulatus</i>	Grey-sided Laughingthrush
308	<i>Garrulax erythrocephalus</i>	Chestnut-crowned Laughingthrush
309	<i>Garrulax gularis</i>	Rufous-vented Laughingthrush
310	<i>Garrulax imbricatus</i>	Bhutan Laughingthrush
311	<i>Garrulax leucolophus</i>	White-crested Laughingthrush
312	<i>Garrulax monileger</i>	Lesser Necklaced Laughingthrush
313	<i>Garrulax ocellatus</i>	Spotted Laughingthrush
314	<i>Garrulax pectoralis</i>	Greater Necklaced Laughingthrush
315	<i>Garrulax ruficollis</i>	Rufous-necked Laughingthrush
316	<i>Garrulax rufogularis</i>	Rufous-chinned Laughingthrush
317	<i>Garrulax squamatus</i>	Blue-winged Laughingthrush
318	<i>Garrulax striatus</i>	Striated Laughingthrush
319	<i>Garrulax subunicolor</i>	Scaly Laughingthrush
320	<i>Garrulus glandarius</i>	Eurasian Jay
321	<i>Gecinulus grantia</i>	Pale-headed Woodpecker
322	<i>Glareola lactea</i>	Small Pratincole
323	<i>Glaucidium brodiei</i>	Collared Owlet
324	<i>Glaucidium cuculoides</i>	Asian Barred Owlet
325	<i>Glaucidium radiatum</i>	Jungle Owlet
326	<i>Gorsachius melanolophus</i>	Malayan Night Heron
327	<i>Gracula religiosa</i>	Common Hill Myna
328	<i>Grandala coelicolor</i>	Grandala
329	<i>Grus grus</i>	Common Crane
330	<i>Grus nigricollis</i>	Black-necked Crane
331	<i>Grus virgo</i>	Demoiselle Crane
332	<i>Gypaetus barbatus</i>	Bearded Vulture

333	<i>Gyps bengalensis</i>	White-rumped Vulture
334	<i>Gyps himalayensis</i>	Himalayan Griffon
335	<i>Haematospiza sipahi</i>	Scarlet Finch
336	<i>Halcyon coromanda</i>	Ruddy Kingfisher
337	<i>Halcyon pileata</i>	Black-capped Kingfisher
338	<i>Halcyon smyrnensis</i>	White-throated Kingfisher
339	<i>Haliaeetus albicilla</i>	White-tailed Eagle
340	<i>Haliaeetus leucoryphus</i>	Pallas's Fish Eagle
341	<i>Haliastur indus</i>	Brahminy Kite
342	<i>Harpactes erythrocephalus</i>	Red-headed Trogon
343	<i>Harpactes wardi</i>	Ward's Trogon
344	<i>Hemiprocne coronata</i>	Crested Treeswift
345	<i>Hemipus picatus</i>	Bar-winged Flycatcher-shrike
346	<i>Hemixos flavala</i>	Ashy Bulbul
347	<i>Heterophasia annectans</i>	Rufous-backed Sibia
348	<i>Heterophasia picaoides</i>	Long-tailed Sibia
349	<i>Hieraaetus fasciatus</i>	Bonelli's Eagle
350	<i>Hieraaetus kienerii</i>	Rufous-bellied Eagle
351	<i>Hieraaetus pennatus</i>	Booted Eagle
352	<i>Hierococcyx fugax</i>	Hodgson's Hawk Cuckoo
353	<i>Hierococcyx sparveroides</i>	Large Hawk Cuckoo
354	<i>Hierococcyx varius</i>	Common Hawk Cuckoo
355	<i>Himantopus himantopus</i>	Black-winged Stilt
356	<i>Hirundapus caudacutus</i>	White-throated Needletail
357	<i>Hirundo daurica</i>	Red-rumped Swallow
358	<i>Hirundo rupestris</i>	Eurasian Crag Martin
359	<i>Hirundo rustica</i>	Barn Swallow
360	<i>Hodgsonius phaenicuroides</i>	White-bellied Redstart
361	<i>Hydrophasianus chirurgus</i>	Pheasant-tailed Jacana
362	<i>Hypothymis azurea</i>	Black-naped Monarch
363	<i>Hypsipetes leucocephalus</i>	Black Bulbul
364	<i>Ibidorhyncha struthersii</i>	Ibisbill
365	<i>Ichthyaelus ichthyaelus</i>	Pallas's Gull
366	<i>Ichthyophaga humilis</i>	Lesser Fish Eagle
367	<i>Ictinaetus malayensis</i>	Black Eagle
368	<i>Iduna caligata</i>	Booted Warbler
369	<i>Indicator xanthonotus</i>	Yellow-rumped Honeyguide

370	<i>Irena puella</i>	Asian Fairy Bluebird
371	<i>Ithaginis cruentus</i>	Blood Pheasant
372	<i>Ixobrychus cinnamomeus</i>	Cinnamon Bittern
373	<i>Ixos maclellandii</i>	Mountain Bulbul
374	<i>Jynx torquilla</i>	Eurasian Wryneck
375	<i>Ketupa flavipes</i>	Tawny Fish Owl
376	<i>Ketupa zeylonensis</i>	Brown Fish Owl
377	<i>Lanius collurioideus</i>	Burmese Shrike
378	<i>Lanius cristatus</i>	Brown Shrike
379	<i>Lanius schach</i>	Long-tailed Shrike
380	<i>Lanius tephronotus</i>	Grey-backed Shrike
381	<i>Lanius vittatus</i>	Bay-backed Shrike
382	<i>Larus barabensis</i>	Steppe Gull
383	<i>Larus canus</i>	Mew Gull
384	<i>Larus heuglini</i>	Heuglin's Gull
385	<i>Leiothrix argentauris</i>	Silver-eared Mesia
386	<i>Leiothrix lutea</i>	Red-billed Leiothrix
387	<i>Leptopoeile sophiae</i>	White-browed Tit Warbler
388	<i>Leptoptilos javanicus</i>	Lesser Adjutant
389	<i>Lerwa lerwa</i>	Snow Partridge
390	<i>Leucosticte brandti</i>	Brandt's Mountain Finch
391	<i>Leucosticte nemoricola</i>	Plain Mountain Finch
392	<i>Liocichla phoenicea</i>	Red-faced Liocichla
393	<i>Lioparus chrysotis</i>	Golden-breasted Fulvetta
394	<i>Lonchura punctulata</i>	Scaly-breasted Munia
395	<i>Lonchura striata</i>	White-rumped Munia
396	<i>Lophophorus impejanus</i>	Himalayan Monal
397	<i>Lophura leucomelanos</i>	Kalij Pheasant
398	<i>Loxia curvirostra</i>	Red Crossbill
399	<i>Luscinia brunnea</i>	Indian Blue Robin
400	<i>Luscinia calliope</i>	Siberian Rubythroat
401	<i>Luscinia pectoralis</i>	White-tailed Rubythroat
402	<i>Luscinia svecica</i>	Bluethroat
403	<i>Lymnocyrtus minimus</i>	Jack Snipe
404	<i>Macronous gularis</i>	Pin-striped Tit Babbler
405	<i>Macropygia unchall</i>	Barred Cuckoo Dove
406	<i>Malacias capistrata</i>	Rufous Sibia

407	<i>Malacias pulchellus</i>	Beautiful Sibia
408	<i>Malacocincla abbotti</i>	Abbott's Babbler
409	<i>Megaceryle lugubris</i>	Crested Kingfisher
410	<i>Megalaima asiatica</i>	Blue-throated Barbet
411	<i>Megalaima australis</i>	Blue-eared Barbet
412	<i>Megalaima franklinii</i>	Golden-throated Barbet
413	<i>Megalaima haemacephala</i>	Coppersmith Barbet
414	<i>Megalaima lineata</i>	Lineated Barbet
415	<i>Megalaima virens</i>	Great Barbet
416	<i>Megalurus palustris</i>	Striated Grassbird
417	<i>Melanochlora sultanea</i>	Sultan Tit
418	<i>Melophus latbami</i>	Crested Bunting
419	<i>Mergus merganser</i>	Goosander
420	<i>Merops leschenaulti</i>	Chestnut-headed Bee-eater
421	<i>Merops orientalis</i>	Green Bee-eater
422	<i>Merops philippinus</i>	Blue-tailed Bee-eater
423	<i>Mesophox intermedia</i>	Intermediate Egret
424	<i>Metopidius indicus</i>	Bronze-winged Jacana
425	<i>Microhierax caeruleus</i>	Collared Falconet
426	<i>Microhierax melanoleucos</i>	Pied Falconet
427	<i>Milvus migrans</i>	Black Kite
428	<i>Minla cyanouroptera</i>	Blue-winged Siva
429	<i>Minla ignotincta</i>	Red-tailed Minla
430	<i>Minla strigula</i>	Bar-throated Siva
431	<i>Mirafra assamica</i>	Bengal Bushlark
432	<i>Monticola cinclorhynchus</i>	Blue-capped Rock Thrush
433	<i>Monticola rufiventris</i>	Chestnut-bellied Rock Thrush
434	<i>Monticola solitarius</i>	Blue Rock Thrush
435	<i>Motacilla alba</i>	White Wagtail
436	<i>Motacilla cinerea</i>	Grey Wagtail
437	<i>Motacilla citreola</i>	Citrine Wagtail
438	<i>Motacilla flava</i>	Yellow Wagtail
439	<i>Motacilla maderaspatensis</i>	White-browed Wagtail
440	<i>Mulleripicus pulverulentus</i>	Great Slaty Woodpecker
441	<i>Muscicapa dauurica</i>	Asian Brown Flycatcher
442	<i>Muscicapa ferruginea</i>	Ferruginous Flycatcher
443	<i>Muscicapa muttui</i>	Brown-breasted Flycatcher

444	<i>Muscicapa sibirica</i>	Dark-sided Flycatcher
445	<i>Muscicapella hodgsoni</i>	Pygmy Blue Flycatcher
446	<i>Mycerobas affinis</i>	Collared Grosbeak
447	<i>Mycerobas carinipes</i>	White-winged Grosbeak
448	<i>Mycerobas melanozanthos</i>	Spot-winged Grosbeak
449	<i>Myiomela leucura</i>	White-tailed Robin
450	<i>Myophonus caeruleus</i>	Blue Whistling Thrush
451	<i>Myzornis pyrrhura</i>	Fire-tailed Myzornis
452	<i>Napothera epilepidota</i>	Eyebrowed Wren Babbler
453	<i>Nectarinia asiatica</i>	Purple Sunbird
454	<i>Neophron percnopterus</i>	Egyptian Vulture
455	<i>Niltava grandis</i>	Large Niltava
456	<i>Niltava macgrigoriae</i>	Small Niltava
457	<i>Niltava sundara</i>	Rufous-bellied Niltava
458	<i>Niltava vivida</i>	Vivid Niltava
459	<i>Ninox scutulata</i>	Brown Hawk Owl
460	<i>Nisaetus nipalensis</i>	Mountain Hawk Eagle
461	<i>Nucifraga caryocatactes</i>	Spotted Nutcracker
462	<i>Numenius arquata</i>	Eurasian Curlew
463	<i>Numenius phaeopus</i>	Whimbrel
464	<i>Nycticorax nycticorax</i>	Black-crowned Night Heron
465	<i>Nyctyornis athertoni</i>	Blue-bearded Bee-eater
466	<i>Oenanthe isabellina</i>	Isabelline Wheatear
467	<i>Oenanthe pleschanka</i>	Pied Wheatear
468	<i>Oriolus kundoo</i>	Indian Golden Oriole
469	<i>Oriolus tenuirostris</i>	Slender-billed Oriole
470	<i>Oriolus traillii</i>	Maroon Oriole
471	<i>Oriolus xanthornus</i>	Black-hooded Oriole
472	<i>Orthotomus cuculatus</i>	Mountain Tailorbird
473	<i>Orthotomus sutorius</i>	Common Tailorbird
474	<i>Otus lettia</i>	Collared Scops Owl
475	<i>Otus spilocephalus</i>	Mountain Scops Owl
476	<i>Otus sunia</i>	Oriental Scops Owl
477	<i>Pandion haliaetus</i>	Osprey
478	<i>Paradoxornis atrosuperciliaris</i>	Lesser Rufous-headed Parrotbill
479	<i>Paradoxornis fulvifrons</i>	Fulvous Parrotbill
480	<i>Paradoxornis gularis</i>	Grey-headed Parrotbill

482	<i>Paradoxornis ruficeps</i>	Greater Rufous-headed Parrotbill
483	<i>Paradoxornis unicolor</i>	Brown Parrotbill
484	<i>Parus ater</i>	Coal Tit
485	<i>Parus dichrous</i>	Grey-crested Tit
486	<i>Parus major</i>	Great Tit
487	<i>Parus monticolus</i>	Green-backed Tit
488	<i>Parus rubidiventris</i>	Rufous-vented Tit
489	<i>Parus spilonotus</i>	Yellow-cheeked Tit
490	<i>Passer domesticus</i>	House Sparrow
491	<i>Passer montanus</i>	Eurasian Tree Sparrow
492	<i>Passer rutilans</i>	Russet Sparrow
493	<i>Pavo cristatus</i>	Indian Peafowl
494	<i>Pelargopsis capensis</i>	Stork-billed Kingfisher
495	<i>Pellorneum albiventris</i>	Spot-throated Babbler
496	<i>Pellorneum ruficeps</i>	Puff-throated Babbler
497	<i>Perdix hodgsoniae</i>	Tibetan Partridge
498	<i>Pericrocotus speciosus</i>	Scarlet Minivet
499	<i>Pericrocotus brevirostris</i>	Short-billed Minivet
500	<i>Pericrocotus cinnamomeus</i>	Small Minivet
501	<i>Pericrocotus divaricatus</i>	Ashy Minivet
502	<i>Pericrocotus ethologus</i>	Long-tailed Minivet
503	<i>Pericrocotus roseus</i>	Rosy Minivet
504	<i>Pericrocotus solaris</i>	Grey-chinned Minivet
505	<i>Pernis ptilorhynchus</i>	Oriental Honey-buzzard
506	<i>Phaenicophaeus tristis</i>	Green-billed Malkoha
507	<i>Phalacrocorax carbo</i>	Great Cormorant
508	<i>Phalacrocorax fuscicollis</i>	Indian Cormorant
509	<i>Phalacrocorax niger</i>	Little Cormorant
510	<i>Philomachus pugnax</i>	Ruff
511	<i>Phodilus badius</i>	Oriental Bay Owl
512	<i>Phoenicurus aureus</i>	Daurian Redstart
513	<i>Phoenicurus coeruleocephala</i>	Blue-capped Redstart
514	<i>Phoenicurus erythrogaster</i>	White-winged Redstart
515	<i>Phoenicurus frontalis</i>	Blue-fronted Redstart
516	<i>Phoenicurus hodgsoni</i>	Hodgson's Redstart
517	<i>Phoenicurus ocburoos</i>	Black Redstart
518	<i>Phoenicurus schisticeps</i>	White-throated Redstart



519	<i>Phylloscopus mandellii</i>	Mandelli's Leaf Warbler
520	<i>Phylloscopus affinis</i>	Tickell's Leaf Warbler
521	<i>Phylloscopus cantator</i>	Yellow-vented Warbler
522	<i>Phylloscopus chloronotus</i>	Lemon-rumped Warbler
523	<i>Phylloscopus collybita</i>	Common Chiffchaff
524	<i>Phylloscopus fuliginiventer</i>	Smoky Warbler
525	<i>Phylloscopus fuscatus</i>	Dusky Warbler
526	<i>Phylloscopus humei</i>	Hume's Warbler
527	<i>Phylloscopus inornatus</i>	Yellow-browed Warbler
528	<i>Phylloscopus maculipennis</i>	Ashy-throated Warbler
529	<i>Phylloscopus magnirostris</i>	Large-billed Leaf Warbler
530	<i>Phylloscopus pulcher</i>	Buff-barred Warbler
531	<i>Phylloscopus reguloides</i>	Blyth's Leaf Warbler
532	<i>Phylloscopus trochiloides</i>	Greenish Warbler
533	<i>Pica pica</i>	Eurasian Magpie
534	<i>Picumnus innominatus</i>	Speckled Piculet
535	<i>Picus canus</i>	Grey-headed Woodpecker
536	<i>Picus chlorolophus</i>	Lesser Yellownape
537	<i>Picus flavinucha</i>	Greater Yellownape
538	<i>Picus xanthopygaus</i>	Streak-throated Woodpecker
539	<i>Pitta cyanea</i>	Blue Pitta
540	<i>Pitta nipalensis</i>	Blue-naped Pitta
541	<i>Pitta sordida</i>	Hooded Pitta
542	<i>Ploceus benghalensis</i>	Black-breasted Weaver
543	<i>Ploceus manyar</i>	Streaked Weaver
544	<i>Ploceus philippinus</i>	Baya Weaver
545	<i>Pluvialis apricaria</i>	European Golden Plover
546	<i>Pluvialis fulva</i>	Pacific Golden Plover
547	<i>Pnoepyga albiventer</i>	Scaly-breasted Wren Babbler
548	<i>Pnoepyga pusilla</i>	Pygmy Wren Babbler
549	<i>Podiceps cristatus</i>	Great Crested Grebe
550	<i>Podiceps nigricollis</i>	Black-necked Grebe
551	<i>Polyplectron bicalcaratum</i>	Grey Peacock Pheasant
552	<i>Pomatorhinus erythrocnemis</i>	Spot-breasted Scimitar Babbler
553	<i>Pomatorhinus erythrogenys</i>	Rusty-cheeked Scimitar Babbler
554	<i>Pomatorhinus ferruginosus</i>	Coral-billed Scimitar Babbler
555	<i>Pomatorhinus ruficollis</i>	Streak-breasted Scimitar Babbler

556	<i>Pomatorhinus schisticeps</i>	White-browed Scimitar Babbler
557	<i>Porphyrio porphyrio</i>	Purple Swampphen
558	<i>Porzana bicolor</i>	Black-tailed Crake
559	<i>Porzana fusca</i>	Ruddy-breasted Crake
560	<i>Porzana parva</i>	Little Crake
561	<i>Prinia atrogularis</i>	Hill Prinia
562	<i>Prinia cinereocapilla</i>	Grey-crowned Prinia
563	<i>Prinia criniger</i>	Striated Prinia
564	<i>Prinia hodgsonii</i>	Grey-breasted Prinia
565	<i>Prinia inornata</i>	
566	<i>Prinia rufescens</i>	Rufescent Prinia
567	<i>Prinia socialis</i>	Ashy Prinia
568	<i>Prinia sylvatica</i>	Jungle Prinia
569	<i>Propyrrhula subhimachala</i>	Crimson-browed Finch
570	<i>Prunella collaris</i>	Alpine Accentor
571	<i>Prunella fulvescens</i>	Brown Accentor
572	<i>Prunella himalayana</i>	Altai Accentor
573	<i>Prunella immaculata</i>	Maroon-backed Accentor
574	<i>Prunella rubeculoides</i>	Robin Accentor
575	<i>Prunella strophiata</i>	Rufous-breasted Accentor
576	<i>Psarisomus dalbousiae</i>	Long-tailed Broadbill
577	<i>Pseudibis papillosa</i>	Red-naped Ibis
578	<i>Pseudominla cinerea</i>	Yellow-throated Fulvetta
579	<i>Psittacula alexandri</i>	Red-breasted Parakeet
580	<i>Psittacula eupatria</i>	Alexandrine Parakeet
581	<i>Psittacula finschii</i>	Grey-headed Parakeet
582	<i>Psittacula himalayana</i>	Slaty-headed Parakeet
583	<i>Psittacula krameri</i>	Rose-ringed Parakeet
584	<i>Psittacula roseata</i>	Blossom-headed Parakeet
585	<i>Pteruthius flaviscapis</i>	White-browed Shrike Babbler
586	<i>Pteruthius melanotis</i>	Black-eared Shrike Babbler
587	<i>Pteruthius rufiventer</i>	Black-headed Shrike Babbler
588	<i>Pteruthius xanthochlorus</i>	Green Shrike Babbler
589	<i>Pycnonotus cafer</i>	Red-vented Bulbul
590	<i>Pycnonotus jocosus</i>	Red-whiskered Bulbul
591	<i>Pycnonotus leucogenys</i>	Himalayan Bulbul
592	<i>Pycnonotus melanicterus</i>	Black-crested Bulbul

593	<i>Pycnonotus striatus</i>	Striated Bulbul
594	<i>Pyrrhocorax graculus</i>	Yellow-billed Chough
595	<i>Pyrrhocorax pyrrhocorax</i>	Red-billed Chough
596	<i>Pyrrhoplectes epauletta</i>	Gold-naped Finch
597	<i>Pyrrhula erythaca</i>	Grey-headed Bullfinch
598	<i>Pyrrhula erythrocephala</i>	Red-headed Bullfinch
599	<i>Pyrrhula nipalensis</i>	Brown Bullfinch
600	<i>Recurvirostra avosetta</i>	Pied Avocet
601	<i>Regulus regulus</i>	Goldcrest
602	<i>Rhipidura albicollis</i>	White-throated Fantail
603	<i>Rhipidura hypoxantha</i>	Yellow-bellied Fantail
604	<i>Rhodonessa rufina</i>	Red-crested Pochard
605	<i>Rhyacornis fuliginosus</i>	Plumbeous Water Redstart
606	<i>Rimotor malacoptilus</i>	Long-billed Wren Babbler
607	<i>Riparia diluta</i>	Pale Martin
608	<i>Riparia paludicola</i>	Plain Martin
609	<i>Riparia riparia</i>	Sand Martin
610	<i>Rostratula benghalensis</i>	Greater Painted-snipe
611	<i>Sarcogyps calvus</i>	Red-headed Vulture
612	<i>Saroglossa spiloptera</i>	Spot-winged Starling
613	<i>Sasia ochracea</i>	White-browed Piculet
614	<i>Saxicola caprata</i>	Pied Bushchat
615	<i>Saxicola ferrea</i>	Grey Bushchat
616	<i>Saxicola insignis</i>	Hodgson's Bushchat
617	<i>Saxicola torquata</i>	Common Stonechat
618	<i>Saxicoloides fulicata</i>	Indian Robin
619	<i>Schoeniparus dubia</i>	Rusty-capped Fulvetta
620	<i>Scolopax rusticola</i>	Eurasian Woodcock
621	<i>Seiurus affinis</i>	White-spectacled Warbler
622	<i>Seiurus burkii</i>	Green-crowned Warbler
623	<i>Seiurus castaniceps</i>	Chestnut-crowned Warbler
624	<i>Seiurus poliogenys</i>	Grey-cheeked Warbler
625	<i>Seiurus whistleri</i>	Whistler's Warbler
626	<i>Seiurus xanthoschistos</i>	Grey-hooded Warbler
627	<i>Serilophus lunatus</i>	Silver-breasted Broadbill
628	<i>Serinus pusillus</i>	Red-fronted Serin
629	<i>Serinus thibetanus</i>	Tibetan Serin

530	<i>Phylloscopus pulcher</i>	Buff-barred Warbler
531	<i>Phylloscopus reguloides</i>	Blyth's Leaf Warbler
532	<i>Phylloscopus trochiloides</i>	Greenish Warbler
533	<i>Pica pica</i>	Eurasian Magpie
534	<i>Picumnus innominatus</i>	Speckled Piculet
535	<i>Picus canus</i>	Grey-headed Woodpecker
536	<i>Picus chlorolophus</i>	Lesser Yellownape
537	<i>Picus flavinucha</i>	Greater Yellownape
538	<i>Picus xanthopygaes</i>	Streak-throated Woodpecker
539	<i>Pitta cyanea</i>	Blue Pitta
540	<i>Pitta nipalensis</i>	Blue-naped Pitta
541	<i>Pitta sordida</i>	Hooded Pitta
542	<i>Ploceus benghalensis</i>	Black-breasted Weaver
543	<i>Ploceus manyar</i>	Streaked Weaver
544	<i>Ploceus philippinus</i>	Baya Weaver
545	<i>Pluvialis apricaria</i>	European Golden Plover
546	<i>Pluvialis fulva</i>	Pacific Golden Plover
547	<i>Pnoepyga albiventer</i>	Scaly-breasted Wren Babbler
548	<i>Pnoepyga pusilla</i>	Pygmy Wren Babbler
549	<i>Podiceps cristatus</i>	Great Crested Grebe
550	<i>Podiceps nigricollis</i>	Black-necked Grebe
551	<i>Polyplectron bicalcaratum</i>	Grey Peacock Pheasant
552	<i>Pomatorhinus erythrocnemis</i>	Spot-breasted Scimitar Babbler
553	<i>Pomatorhinus erythrogenys</i>	Rusty-cheeked Scimitar Babbler
554	<i>Pomatorhinus ferruginosus</i>	Coral-billed Scimitar Babbler
555	<i>Pomatorhinus ruficollis</i>	Streak-breasted Scimitar Babbler
556	<i>Pomatorhinus schisticeps</i>	White-browed Scimitar Babbler
557	<i>Porphyrio porphyrio</i>	Purple Swampphen
558	<i>Porzana bicolor</i>	Black-tailed Crake
559	<i>Porzana fusca</i>	Ruddy-breasted Crake
560	<i>Porzana parva</i>	Little Crake
561	<i>Prinia atrogularis</i>	Hill Prinia
562	<i>Prinia cinereocapilla</i>	Grey-crowned Prinia
563	<i>Prinia criniger</i>	Striated Prinia
564	<i>Prinia hodgsonii</i>	Grey-breasted Prinia
565	<i>Prinia inornata</i>	
566	<i>Prinia rufescens</i>	Rufescent Prinia

567	<i>Prinia socialis</i>	Ashy Prinia
568	<i>Prinia sylvatica</i>	Jungle Prinia
569	<i>Propyrrhula subhimachala</i>	Crimson-browed Finch
570	<i>Prunella collaris</i>	Alpine Accentor
571	<i>Prunella fulvescens</i>	Brown Accentor
572	<i>Prunella himalayana</i>	Altai Accentor
573	<i>Prunella immaculata</i>	Maroon-backed Accentor
574	<i>Prunella rubeculoides</i>	Robin Accentor
575	<i>Prunella strophliata</i>	Rufous-breasted Accentor
576	<i>Psarisomus dalhousiae</i>	Long-tailed Broadbill
577	<i>Pseudibis papillosa</i>	Red-naped Ibis
578	<i>Pseudominla cinerea</i>	Yellow-throated Fulvetta
579	<i>Psittacula alexandri</i>	Red-breasted Parakeet
580	<i>Psittacula eupatria</i>	Alexandrine Parakeet
581	<i>Psittacula finschii</i>	Grey-headed Parakeet
582	<i>Psittacula himalayana</i>	Slaty-headed Parakeet
583	<i>Psittacula krameri</i>	Rose-ringed Parakeet
584	<i>Psittacula roseata</i>	Blossom-headed Parakeet
585	<i>Pteruthius flaviscapis</i>	White-browed Shrike Babbler
586	<i>Pteruthius melanotis</i>	Black-eared Shrike Babbler
587	<i>Pteruthius rufiventer</i>	Black-headed Shrike Babbler
588	<i>Pteruthius xanthochlorus</i>	Green Shrike Babbler
589	<i>Pycnonotus cafer</i>	Red-vented Bulbul
590	<i>Pycnonotus jocosus</i>	Red-whiskered Bulbul
591	<i>Pycnonotus leucogenys</i>	Himalayan Bulbul
592	<i>Pycnonotus melanicterus</i>	Black-crested Bulbul
593	<i>Pycnonotus striatus</i>	Striated Bulbul
594	<i>Pyrrhocorax graculus</i>	Yellow-billed Chough
595	<i>Pyrrhocorax pyrrhocorax</i>	Red-billed Chough
596	<i>Pyrrhoplectes epauletta</i>	Gold-naped Finch
597	<i>Pyrrhula erythaca</i>	Grey-headed Bullfinch
598	<i>Pyrrhula erythrocephala</i>	Red-headed Bullfinch
599	<i>Pyrrhula nipalensis</i>	Brown Bullfinch
600	<i>Recurvirostra avosetta</i>	Pied Avocet
601	<i>Regulus regulus</i>	Goldcrest
602	<i>Rhipidura albicollis</i>	White-throated Fantail
603	<i>Rhipidura hypoxantha</i>	Yellow-bellied Fantail

604	<i>Rhodonessa rufina</i>	Red-crested Pochard
605	<i>Rhyacornis fuliginosus</i>	Plumbeous Water Redstart
606	<i>Rimator malacoptilus</i>	Long-billed Wren Babbler
607	<i>Riparia diluta</i>	Pale Martin
608	<i>Riparia paludicola</i>	Plain Martin
609	<i>Riparia riparia</i>	Sand Martin
610	<i>Rostratula benghalensis</i>	Greater Painted-snipe
611	<i>Sarcogyps calvus</i>	Red-headed Vulture
612	<i>Saroglossa spiloptera</i>	Spot-winged Starling
613	<i>Sasia ochracea</i>	White-browed Piculet
614	<i>Saxicola caprata</i>	Pied Bushchat
615	<i>Saxicola ferrea</i>	Grey Bushchat
616	<i>Saxicola insignis</i>	Hodgson's Bushchat
617	<i>Saxicola torquata</i>	Common Stonechat
618	<i>Saxicoloides fulicata</i>	Indian Robin
619	<i>Schoeniparus dubia</i>	Rusty-capped Fulvetta
620	<i>Scolopax rusticola</i>	Eurasian Woodcock
621	<i>Seiurus affinis</i>	White-spectacled Warbler
622	<i>Seiurus burkii</i>	Green-crowned Warbler
623	<i>Seiurus castaniceps</i>	Chestnut-crowned Warbler
624	<i>Seiurus poliogenys</i>	Grey-cheeked Warbler
625	<i>Seiurus whistleri</i>	Whistler's Warbler
626	<i>Seiurus xanthoschistos</i>	Grey-hooded Warbler
627	<i>Serilophus lunatus</i>	Silver-breasted Broadbill
628	<i>Serinus pusillus</i>	Red-fronted Serin
629	<i>Serinus thibetanus</i>	Tibetan Serin
630	<i>Sitta cinnamoventris</i>	Chestnut-bellied Nuthatch
631	<i>Sitta formosa</i>	Beautiful Nuthatch
632	<i>Sitta frontalis</i>	Velvet-fronted Nuthatch
633	<i>Sitta himalayensis</i>	White-tailed Nuthatch
634	<i>Spelaeornis caudatus</i>	Rufous-throated Wren Babbler
635	<i>Spelaeornis formosus</i>	Spotted Wren Babbler
636	<i>Spelaeornis troglodytoides</i>	Bar-winged Wren Babbler
637	<i>Sphenocichla humei</i>	Himalayan Wedge-billed Babbler
638	<i>Spilornis cheela</i>	Crested Serpent Eagle
639	<i>Spinus spinus</i>	Eurasian Siskin
640	<i>Stachyris chrysaea</i>	Golden Babbler



641	<i>Stachyris nigriceps</i>	Grey-throated Babbler
642	<i>Stachyris ruficeps</i>	Rufous-capped Babbler
643	<i>Stachyris rufifrons</i>	Rufous-fronted Babbler
644	<i>Staphida castaniceps</i>	Striated Yuhina
645	<i>Sterna aurantia</i>	River Tern
646	<i>Sterna hirundo</i>	Common Tern
647	<i>Sternula acuticauda</i>	Black-bellied Tern
648	<i>Stigmatopelia chinensis</i>	Spotted Dove
649	<i>Stigmatopelia senegalensis</i>	Laughing Dove
650	<i>Streptopelia decaocto</i>	Eurasian Collared Dove
651	<i>Streptopelia orientalis</i>	Oriental Turtle Dove
652	<i>Streptopelia tranquebarica</i>	Red Collared Dove
653	<i>Strix nivicola</i>	Himalayan Wood Owl
654	<i>Strix leptogrammica</i>	Brown Wood Owl
655	<i>Sturnus contra</i>	Asian Pied Starling
656	<i>Sturnus malabaricus</i>	Chestnut-tailed Starling
657	<i>Sturnus pagodarum</i>	Brahminy Starling
658	<i>Sturnus vulgaris</i>	Common Starling
659	<i>Surniculus lugubris</i>	Drongo Cuckoo
660	<i>Sylvia curruca</i>	Lesser Whitethroat
661	<i>Sylviparus modestus</i>	Yellow-browed Tit
662	<i>Tachybaptus ruficollis</i>	Little Grebe
663	<i>Tachymarptis melba</i>	Alpine Swift
664	<i>Tadorna ferruginea</i>	Ruddy Shelduck
665	<i>Tadorna tadorna</i>	Common Shelduck
666	<i>Tarsiger chrysaens</i>	Golden Bush Robin
667	<i>Tarsiger cyanurus</i>	Orange-flanked Bush Robin
668	<i>Tarsiger hyperythrus</i>	Rufous-breasted Bush Robin
669	<i>Tarsiger indicus</i>	White-browed Bush Robin
670	<i>Tephrodornis gularis</i>	Large Woodshrike
671	<i>Terpsiphone paradisi</i>	Asian Paradise-flycatcher
672	<i>Tesia castaneocoronata</i>	Chestnut-headed Tesia
673	<i>Tesia cyaniventer</i>	Grey-bellied Tesia
674	<i>Tesia olivea</i>	Slaty-bellied Tesia
675	<i>Tetraogallus tibetanus</i>	Tibetan Snowcock
676	<i>Tichodroma muraria</i>	Wallcreeper
677	<i>Tickellia hodgsoni</i>	Broad-billed Warbler

678	<i>Tragopan blythii</i>	Blyth's Tragopan
679	<i>Tragopan satyra</i>	Satyr Tragopan
680	<i>Tragopan temminckii</i>	Temminck's Tragopan
681	<i>Treron apicauda</i>	Pin-tailed Green Pigeon
682	<i>Treron bicincta</i>	Orange-breasted Green Pigeon
683	<i>Treron curvirostra</i>	Thick-billed Green Pigeon
684	<i>Treron phoenicoptera</i>	Yellow-footed Green Pigeon
685	<i>Treron pompadora</i>	Pompadour Green Pigeon
686	<i>Treron sphenura</i>	Wedge-tailed Green Pigeon
687	<i>Tringa erythropus</i>	Spotted Redshank
688	<i>Tringa glareola</i>	Wood Sandpiper
689	<i>Tringa nebularia</i>	Common Greenshank
690	<i>Tringa ochropus</i>	Green Sandpiper
691	<i>Tringa totanus</i>	Common Redshank
692	<i>Troglodytes troglodytes</i>	Eurasian Wren
693	<i>Turdoides striatus</i>	Jungle Babbler
694	<i>Turdus maximus</i>	Tibetan Blackbird
695	<i>Turdus albocinctus</i>	White-collared Blackbird
696	<i>Turdus atrogularis</i>	Black-throated Thrush
697	<i>Turdus boulboul</i>	Grey-winged Blackbird
698	<i>Turdus eunomus</i>	Dusky Thrush
699	<i>Turdus feae</i>	Grey-sided Thrush
700	<i>Turdus kessleri</i>	Kessler's Thrush
701	<i>Turdus naumanni</i>	Naumann's Thrush
702	<i>Turdus obscurus</i>	Eyebrowed Thrush
703	<i>Turdus rubrocanus</i>	Chestnut Thrush
704	<i>Turdus ruficollis</i>	Red-throated Thrush
705	<i>Turdus unicolor</i>	Tickell's Thrush
706	<i>Turnix suscitator</i>	Barred Buttonquail
707	<i>Turnix tanki</i>	Yellow-legged Buttonquail
708	<i>Tyto alba</i>	Barn Owl
709	<i>Upupa epops</i>	Common Hoopoe
710	<i>Urocissa flavirostris</i>	Yellow-billed Blue Magpie
711	<i>Vanellus cinereus</i>	Grey-headed Lapwing
712	<i>Vanellus duvaucelii</i>	River Lapwing
713	<i>Vanellus indicus</i>	Red-wattled Lapwing
714	<i>Vanellus malarbaricus</i>	Yellow-wattled Lapwing

715	<i>Vanellus vanellus</i>	Northern Lapwing
716	<i>Xiphirynchus superciliaris</i>	Slender-billed Scimitar Babbler
717	<i>Yuhina bakeri</i>	White-naped Yuhina
718	<i>Yuhina flavicollis</i>	Whiskered Yuhina
719	<i>Yuhina gularis</i>	Stripe-throated Yuhina
720	<i>Yuhina nigrimenta</i>	Black-chinned Yuhina
721	<i>Yuhina occipitalis</i>	Rufous-vented Yuhina
722	<i>Zoothera citrina</i>	Orange-headed Thrush
723	<i>Zoothera dauma</i>	Scaly Thrush
724	<i>Zoothera dixonii</i>	Long-tailed Thrush
725	<i>Zoothera mollissima</i>	Plain-backed Thrush
726	<i>Zoothera monticola</i>	Long-billed Thrush
727	<i>Zosterops palpebrosus</i>	Oriental White-eye
728	<i>Turdus dissimilis</i>	Black-breasted Thrush
729	<i>Cyanoptila cyanomelana</i>	Black-and-White Flycatcher
730	<i>Erythrura prasina</i>	Pin-tailed Parrotfinch
731	<i>Chlidonias hybrida</i>	Whiskered Tern
732	<i>Muscicapa ruficauda</i>	Rusty-tailed Flycatcher
733	<i>Psittacula cyanocephala</i>	Plum-headed Parakeet
734	<i>Todiramphus chloris</i>	Collared Kingfisher
735	<i>Pluvialis squatarola</i>	Grey Plover
736	<i>Eremophila alpestris</i>	Horned Lark
737	<i>Bucephala clangula</i>	Common Goldeneye
738	<i>Pellorneum tickelli</i>	Buff-breasted Babbler
739	<i>Botaurus stellaris</i>	Great Bittern
740	<i>Geokichla wardii</i>	Pied Thrush
741	<i>Sternula albifrons</i>	Little Tern
742	<i>Pitta brachyura</i>	Indian Pitta
743	<i>Rallina eurizonoides</i>	Slaty-legged Pitta

Reptile Data (F7/7)

SN	Data Item	Definition/Description	Instruction
1	Plot No.	This is the unique identification number given to Plot No. Eg. KKFMU001	<p>1. Select correct Plot No from the drop-down list on electronic field form or record the correct Plot No, if the paper field form is used.</p> <p><b>Note:</b> If Paper Field Forms are to be used only if the android Tablet does not function in the field.</p>
2	Reptiles species	<p>Refers to identity of the particular reptile that has been sighted or identified.</p> <p>The list of reptiles shall be provided in Table 1.35</p>	<p>1. Select and record the reptile from the drop-down list on electronic field form or record on the paper field form.</p> <p>2. Select “None” if no reptile is observed.</p>
3	Reptile evidence	<p>Refers to the type of evidence using which the reptile is identified. The categories are:</p> <ol style="list-style-type: none"> <li>1. Direct sighting</li> <li>2. Sound/calls</li> <li>3. Dung</li> <li>4. Skin</li> <li>5. Skeleton/Cadaver</li> <li>6. Footprints/pugmarks</li> <li>7. Tracks/Paths</li> <li>8. Burrow</li> <li>9. Den</li> <li>10. Not relevant</li> </ol>	<p>1. Select the appropriate evidence type and record by selecting from the drop-down list on electronic field form or selecting relevant evidence type on paper field form.</p> <p>2. “Not relevant” should be selected when there are no reptiles sighted or observed within the 25 m radius.</p>
4	Species name	Refers to the reptile species sighted or observed but not listed in above list. Can be local or common name	<p>1. If the reptile is sighted but not listed in the above list or not known, write the common or local name.</p>
5	Remarks	Refers to any other relevant information provided by crew.	<p>1. The Crew Leader or the data recorder shall add any additional information on reptiles</p>

Table 1.35 List of reptiles

SN	Scientific name	Common name
1	<i>Ahaetulla nasuta</i>	common vine snake
2	<i>Ahaetulla prasina</i>	Asian vine snake
3	<i>Amphiesma parallelum</i>	
4	<i>Amphiesma platyceps</i>	Himalayan keelback
5	<i>Amphiesma sieboldii</i>	Sikkim keelback
6	<i>Amphiesma stolatum</i>	Buff striped keelback
7	<i>Boiga cyanea</i>	Green Cat Snake
8	<i>Boiga gokool</i>	Arrowback tree snake
9	<i>Boiga multifasciata</i>	Many-banded tree snake
10	<i>Boiga ochracea</i>	Tawny cat snake
11	<i>Chrysopelea ornata</i>	Flying tree snake
12	<i>Coelognathus radiatus</i>	Copperhead rat snake
13	<i>Dendrelaphis cyanochloris</i>	Wall's Bronzeback
14	<i>Dendrelaphis pictus</i>	Painted bronzeback
15	<i>Dendrelaphis tristis</i>	Tree snake
16	<i>Dinodon gammiei</i>	Sikkim False Wolf Snake
17	<i>Dinodon septentrionalis</i>	Wolf snake
18	<i>Dryocalamus davisonii</i>	
19	<i>Enhydryis enhydryis</i>	Rainbow water snake
20	<i>Lycodon aulicus</i>	Indian wolf snake
21	<i>Lycodon fasciatus</i>	Banded wolf snake
22	<i>Lycodon jara</i>	Yellow-speckled wolf snake
23	<i>Oligodon albocinctus</i>	Light-barred kukri snake
24	<i>Oligodon cinereus</i>	Black cross-barred kukri snake, golden kukri snake
25	<i>Oligodon cyclurus</i>	Cantor's Kukri Snake
26	<i>Oligodon dorsalis</i>	Bengalese kukri snake or Gray's kukri snake
27	<i>Oligodon juglandifer</i>	Walnut kukri snake
28	<i>Oreocryptophis porphyracea</i>	Thai bamboo rat snake or red mountain racer
29	<i>Orthriophis cantoris</i>	
30	<i>Orthriophis taeniurus</i>	Beauty ratsnake
31	<i>Psammodynastes pulverulentus</i>	Common mock viper
32	<i>Pseudoxenodon macrops</i>	Large-eyed bamboo snake or Chinese false cobra
33	<i>Ptyas korros</i>	Chinese ratsnake or Indo-Chinese rat snake
34	<i>Ptyas nigromarginata</i>	Green rat snake
35	<i>Ptyas mucosa</i>	Oriental ratsnake, Indian rat snake
36	<i>Rhabdophis himalayanus</i>	Orange-collared keelback
37	<i>Rhabdophis subminiatus</i>	Red-necked keelback
38	<i>Sibynophis collaris</i>	Common many-toothed snake
39	<i>Sibynophis sagittarius</i>	Cantor's black-headed snake.
40	<i>Trachischium leave</i>	Olive Oriental Slender Snake

41	<i>Trachischium guentheri</i>	Rosebelly worm-eating snake
42	<i>Trachischium tenuiceps</i>	Yellowbelly worm-eating snake
43	<i>Xenochrophis piscator</i>	Asiatic water snake
44	<i>Bungarus bungaroides</i>	Northeastern hill krait
45	<i>Bungarus fasciatus</i>	Banded krait
46	<i>Bungarus niger</i>	Greater black krait
47	<i>Naja kaouthia</i>	Monocellate cobra
48	<i>Naja naja</i>	Spectacled cobra, Asian cobra, or binocellate cobra
49	<i>Ophiophagus hannah</i>	King cobra
50	<i>Sinomicrurus maccllellandii</i>	MacClelland's Coral Snake
51	<i>Python molurus</i>	Indian python or Indian rock python
52	<i>Python bivittatus</i>	Burmese python
53	<i>Ramphotyphlops braminus</i>	Brahminy Blindsnake
54	<i>Typhlops jerdonii</i>	Jerom's worm snake
55	<i>Typhlops diardii</i>	Diard's Blindsnake
56	<i>Daboia russelii</i>	Russel's viper
57	<i>Gloydius himalayanus</i>	Himalayan pit viper or Himalayan viper
58	<i>Ovophis monticola</i>	Mountain pit viper
59	<i>Protobothrops jerdonii</i>	Jerdon's Pit viper
60	<i>Trimeresurus jerdonii</i>	Pit viper
61	<i>Trimeresurus albolabris</i>	White-lipped pit viper
62	<i>Trimeresurus erythrurus</i>	Red-tailed bamboo pitviper
63	<i>Protobothrops himalayanus</i>	Himalayan pit viper
64	<i>Calotes bhutanensis</i>	Forest Lizard
65	<i>Calotes jerdonii</i>	Indo-Chinese forest lizard or Jerdon's forest lizard
66	<i>Calotes versicolor</i>	Oriental garden lizard
67	<i>Japalura variegata</i>	Variegated Mountain Lizard
68	<i>Ophisaurus gracilis</i>	Asian glass lizard
69	<i>Cyrtodactylus khasiensis</i>	Khasi Hills bent-toed gecko
70	<i>Gekko gekko</i>	Tokay gecko
71	<i>Hemidactylus brookei</i>	Brooke's house gecko or spotted house gecko
72	<i>Hemidactylus frenatus</i>	Common house gecko
73	<i>Hemidactylus platyurus</i>	Flat-tailed house gecko
74	<i>Asymblepharus sikimensis</i>	Sikkim ground skink or bronzy-brown skink
75	<i>Eutropis carinata</i>	Golden skink
76	<i>Eutropis macularia</i>	Bronze grass skink
77	<i>Eutropis quadratilobus</i>	
78	<i>Riopa punctata</i>	
79	<i>Sphenomorphus indicus</i>	Himalayan litter skink
80	<i>Sphenomorphus maculatus</i>	Spotted forest skink
81	<i>Varanus bengalensis</i>	Bengal monitor or common Indian monitor
82	<i>Varanus flavescens</i>	Yellow monitor or golden monitor





Department of Forests and Park Services  
Forest Resources Management Division  
**FMU INVENTORY FIELD FORM**  
Plot Description Form

F1/7

1. District Name:

2. Forest Management Unit Name:

3. Plot No.:

4. Region:

5. Coordinate:

6. Crew Leader:

7. Date

8. Time

9. Altitude (m)

10. Land use

11. Forest Type

**12. Stand height**

**13. Canopy Closure**

**14. Accessibility**

a. Yes

b. No

**15. Aspect**

i. Northern

ii. North-eastern

iii. Eastern

iv. South-eastern

v. Southern

vi. South-western

vii. Western

viii. North-western

ix. No aspect

**16. Slope** (Slope should be in degrees)

i. Slope up

ii. Slope down

**17. Common Mistletoe:**

Yes

No.

**18. Dwarf mistletoe**

Yes

No.

**19. Bark beetle**

Yes

No

**20. Dieback (fir)**

Yes

No

21. Understory Cover percent  (Write percentage figure)

22. Main Understorey type (Tick appropriately)

i. Moss ☐ ii. Grass ☐ iii. Herbs ☐ iv. Bamboo ☐ v. Shrubs ☐ vi. Others ☐

23. Bamboo Cover percent

i. None ☐ ii. 1-20% ☐ iii. 21-40% ☐ iv. 41-60% ☐ v. 61-80% ☐ vi. 81-100% ☐

24. Bamboo type (Tick appropriately)

i. Spreading ☐ ii. Clump ☐

25. Bamboo scientific name

26. Bamboo dbh (Tick appropriately)

i. < 2 cm ☐ ii. 2-4 cm ☐ iii. >4 cm ☐

27. Cane Cover percent

i. None ☐ ii. 1-20% ☐ iii. 21-40% ☐ iv. 41-60% ☐ v. 61-80% ☐ vi. 81-100% ☐

**28. Cane dbh** (Tick appropriately)

i. < 2 cm ☐ ii. >2 cm ☐

**29. Daphne Cover Percent**

i. None ☐ ii. 1-20% ☐ iii. 21-40% ☐ iv. 41-60% ☐ v. 61-80% ☐ vi. 81-100% ☐

**30. Snag** (Tick appropriately)

i. Yes ☐ ii. No ☐

**31. Snag count**

**32. Fallen Trees**

i. Yes ☐ ii. No ☐

**33. Fallen Trees Count**

**34. Forest Fires**

i. Yes ☐ ii. No ☐

**35. Intensity of forest fire**

i. Heavy ☐ ii. Moderate ☐ iii. Light ☐ iv. No fire ☐

**36. Types of forest fire**

i. Ground fire ☐ ii. Surface fire ☐ iii. Crown fire ☐ iv. Not sure or known ☐ v. Not applicable ☐

- 37. Grazing** (Tick appropriately) i. Yes ☐ ii. No ☐ iii. Not sure ☐
- 38. Intensity of grazing** i. Low ☐ ii. Moderate ☐ iii. Severe ☐ iv. No grazing ☐
- 39. Timber Extraction** i. Yes ☐ ii. No ☐
- 40. Type of timber extraction** i. Clear felling ☐ ii. Selective felling ☐ iii. Group felling ☐ iv. Others ☐ v. No felling ☐
- 41. Mining** i. Yes ☐ ii. No ☐
- 42. Type of mining** i. Yes, Surface collection ☐ ii. Yes, Quarry ☐ iii. None ☐ iv. Don't know ☐
- 43. Transmission lines** i. Yes ☐ ii. No ☐
- 44. Garbage** i. Food wrapper ☐ ii. PET Bottles ☐ iii. Construction wastes ☐ iv. All of the above ☐ v. None ☐
- 45. Depth litter value**
- 46. Humus depth value**
- 47. Fuelbed depth value**
- 48. Litter cover percent**
- 49. Bare soil cover percent**

- 50. Stoniness** ☐ i. None ☐ ii. Rare, < 10% ☐ iii. Few, 10-20% ☐ iv. Common, 20-30% ☐  
v. Many, 20-30% ☐ vi. Abundant, >60% ☐
- 51. Soil Drainage**  
i. Poorly drained ☐ ii. Imperfectly drained ☐ iii. Moderately drained ☐ iv. Well drained ☐
- 52. Top soil moisture**  
i. Dry ☐ ii. Slightly moist ☐ iii. Moist ☐ iv. Wet ☐ v. Water-logged ☐
- 53. Top soil color**  
i. Dark ☐ ii. Reddish ☐ iii. Yellowish ☐ iv. Others ☐
- 54. Top soil texture**  
i. Sand ☐ ii. Sandy loam ☐ iii. Loam ☐ iv. Silty loam ☐ v. Silt ☐ vi. Clay Loam ☐  
vii. Clay ☐
- 55. Stream**  
i. Yes ☐ ii. No ☐
- 56. River**  
i. Yes ☐ ii. No ☐
- 57. Wetland/Marshy area**  
i. Yes ☐ ii. No ☐
- 58. Lakes**  
i. Yes ☐ ii. No ☐
- 59. Remarks:** .....





**FMU INVENTORY FIELD FORM**  
**Regeneration Form (Within  $r < 3.57$  m)**  
**Department of Forests and Park Services**  
**Forest Resources Management Division**

F2/7

## 1. Plot No

2. Date

### 3. Time

[illegible]



**Department of Forests and Park Services**  
Forest Resources Management Division

# FMU INVENTORY FIELD FORM

## Tree Data Form

F3/7

## 1. Plot No

## 2. Date

### 3. Time

#### 4. Tree Data Form ( $>10$ cm DBH)

[illegible]

Department of Forests and Park Services  
Forest Resources Management Division



FMU INVENTORY FIELD FORM  
Sapling Data Form

F4/7

1. Plot No

2. Date  /  /  3. Time  /  hrs

4. Sapling Data Form (Tree species of DBH >5 cm and <10 cm)

SN	Scientific name	Local name			Number of individuals (Nos)			Layer height (m)	Cover percent (%)



Department of Forests and Park Services  
Forest Resources Management Division

**FMU INVENTORY FIELD FORM**  
**Wildlife (Mammal) Data Form**

F5/7

1. Plot No.

2. Date  /  /  3. Time  /  hrs

4. Wildlife (mammal) Data Form (Data to be collected from all three plots) (within 25 m around PC)

SN	Scientific name	Local name	Mammal evidence (Enter code)	Evi- dence (Enter code)	Remarks

SN	Wildlife evidence (Mammal)	Code	SN	Wildlife evidence	Code
1	Direct sighting	ME1	8	Burrow/Den	ME8
2	Sound/calls	ME2	9	Browsing	ME9
3	Dung/Pellets/Scats	ME3	10	Debarking	ME10
4	Skeleton/Cadaver	ME4	11	Fraying	ME11
5	Horns/Antlers	ME5	12	Digging	ME12
6	Footprints/Pugmarks	ME6	13	Not relevant	ME13
7	Tracks/Paths	ME7			



**Department of Forests and Park Services**  
Forest Resources Management Division

**FMU INVENTORY FIELD FORM**  
**Wildlife (Bird) Data Form**

F6/7

1. Plot No

2. Date

 /  / 

3. Time

 /  hrs

4. Wildlife (Bird) Data Form (Data to be collected from all three plots) (within 25 m around PC)

SN	Scientific name	Local name	Bird Evidence (Enter code)	Remarks

SN	Wildlife evidence (Bird)	Code	SN	Wildlife evidence	Code
1	Direct sighting	BE1	6	Feathers	BE6
2	Sound/calls	BE2	7	Footprints	BE7
3	Droppings	BE3	8	Tracks/Paths	BE8
4	Eggs	BE4	9	Nest/Burrows	BE9
5	Skeleton/Cadaver	BE5	10	Not relevant	BE10

Department of Forests and Park Services  
Forest Resources Management Division



**FMU INVENTORY FIELD FORM**  
**Wildlife (Reptile) Data Form**

F7/7

1. Plot No

2. **Date**  /  /  3. **Time**  /  hrs

4. Wildlife (Reptile) Data Form (Data to be collected from all three plots) (within 25 m around PC)

SN	Scientific name	Local name	Reptile dence (code)	Evi- dence (Enter code)	Remarks

SN	Wildlife evidence (Reptile)	Code	SN	Wildlife evidence	Code
1	Direct sighting	RE1	5	Skin	RE5
2	Sound/calls	RE2	6	Tracks/Paths	RE6
3	Eggs	RE3	7	Nests/Burrows	RE7
4	Skeleton	RE4	8	Not relevant	RE8

### 1.8.7. Data analysis

The forest inventory data can be analyzed using any statistical tools including in Microsoft excel, R, python and any data base software developed for the same. Following are the important statistics to be estimated from inventory result;

1. Stem density and total stem
2. Mean basal area and total basal area
3. Mean volume and total volume
4. Mean biomass/carbon and total carbon stock
5. Increment
6. Regeneration status
7. Diameter class distribution

All these statistics are estimated at 95% confidence interval with sampling error of 10% based on the sampling design adopted for the FMU inventory. Currently, all estimates are generated at FMU level and there is scope to generate the estimates a block and compartment level to provide adequate information for management planning and prescription of the interventions.

Furthermore, the inventory results should;

- provide all information required to meet the inventory's objectives.
- be understandable for those who need the information provided and who shall use the results.
- be a detailed technical section for the possibly interested expert.

For estimation of the volume and biomass, appropriate allometric volume and biomass equations should be used. In absence of such equations, volume table may also be used for the analysis of the data. The list of volume equations is provided below:

**(ii) Northwestern Bhutan  
(Thimphu, Paro, Haa, Wangdue, Punakha, Gasa)**

SL No.	Species	Volume
1	<i>Pinus roxburghii</i>	$\exp((-1.251652 + 1.964424 * \log(D) + 1.003778 * \log(H)))$
2	<i>Pinus roxburghii</i>	$\exp((2.609513 + 2.844257 * \log(D)))$
3	<i>Abies densa</i>	$\exp((-0.919947 + 1.859733 * \log(D) + 0.907633 * \log(H)))$
4	<i>Abies densa</i>	$0.007107 + -0.515959 * D + 9.364041 * (D^2)$
5	<i>Tsuga dumosa</i>	$\exp((-1.409685 + 1.846742 * \log(D) + 1.045675 * \log(H)))$
6	<i>Tsuga dumosa</i>	$0.055312 + -1.37978 * D + 11.394329 * (D^2)$
7	<i>Larix griffithiana</i>	$\exp((-1.409685 + 1.846742 * \log(D) + 1.045675 * \log(H)))$
8	<i>Larix griffithiana</i>	$0.055312 + -1.37978 * D + 11.394329 * (D^2)$
9	<i>Pinus wallichiana</i>	$\exp((-1.049334 + 1.926332 * \log(D) + 0.967612 * \log(H)))$
10	<i>Pinus wallichiana</i>	$\exp((2.697278 + 2.659289 * \log(D)))$
11	<i>Picea spinulosa (dbh &gt; 75 cm)</i>	$\exp((-1.074891 + 1.893688 * \log(D) + 0.973121 * \log(H)))$
12	<i>Picea spinulosa (dbh &gt; 75 cm)</i>	$0.056861 + -1.792121 * D + 14.1088 * (D^2)$
13	<i>Picea spinulosa (dbh ≤ 75 cm)</i>	$\exp((-1.074891 + 1.893688 * \log(D) + 0.973121 * \log(H)))$
14	<i>Picea spinulosa (dbh ≤ 75 cm)</i>	$\exp((2.611759 + 2.487319 * \log(D)))$
15	<i>Betula</i>	$\exp((-0.46151 + 2.039844 * \log(D) + 0.837461 * \log(H)))$
16	<i>Betula</i>	$0.050548 + -1.295192 * D + 11.040967 * (D^2)$
17	<i>Acer</i>	$\exp((-0.59555 + 2.02481 * \log(D) + 0.854745 * \log(H)))$



18	<i>Acer</i>	$0.026551 + -1.013426 * D + 9.67034 * (D^2)$
19	<i>Quercus</i> (dbh > 79 cm)	$0.002111 + 0.392382 * D^2 * (H)$
20	<i>Quercus</i> (dbh > 79 cm)	$0.051611 + -1.589755 * D + 12.242112 * (D^2)$
21	<i>Quercus</i> (dbh ≤ 79 cm)	$0.00211 + 0.392382 * D^2 * (H)$
22	<i>Quercus</i> (dbh ≤ 79 cm)	$\exp((2.435867 + 2.436696 * \log(D)))$
23	<i>Juniperus</i>	$\exp((-0.565323 + 1.984601 * \log(D) + 0.822937 * \log(H)))$
24	<i>Juniperus</i>	$\exp((2.101388 + 2.418695 * \log(D)))$
25	<i>Cupressus</i>	$\exp((-0.565323 + 1.984601 * \log(D) + 0.822937 * \log(H)))$
26	<i>Cupressus</i>	$\exp((2.101388 + 2.418695 * \log(D)))$
27	<i>Rest of species</i>	$\exp((-0.565323 + 1.984601 * \log(D) + 0.822937 * \log(H)))$
28	<i>Rest of species</i>	$0.041566 + -1.075224 * D + 9.402206 * (D^2)$

(iii) **Southern Bhutan**  
(Sarpang, Samtse, Dagana, Tsirang,)

SL No.	Species	Volume
1	<i>Pinus roxburghii</i>	$(-0.00156 + 0.32159 * D^2 * (H))$
2	<i>Pinus roxburghii</i>	$(0.291801 + 6.041763 * D + -2.430993 * \text{SQRT}(D))^2$
3	<i>Picea spinulosa</i>	$\exp((-1.29816 + 1.86384 * \log(D) + 1.03333 * \log(H)))$
4	<i>Picea spinulosa</i>	$\exp((2.763193 + 2.605962 * \log(D)))$
5	<i>Abies densa</i>	$\exp((-1.38883 + 1.77028 * \log(D) + 1.04424 * \log(H)))$
6	<i>Abies densa</i>	$0.10774 + -2.09529 * D + 12.62008 * D^2 + -1.61065 * D^3$
9	<i>Tsuga dumosa</i>	$\exp((-1.409685 + 1.846742 * \log(D) + 1.045675 * \log(H)))$
10	<i>Tsuga dumosa</i>	$0.0084144 + -0.597856 * D + 10.619647 * D^2$
11	<i>Quercus</i>	$0.002111 + 0.392382 * D^2 * (H)$
12	<i>Quercus</i>	$0.20699 + -3.13612 * D + 15.76557 * D^2 + -1.95718 * D^3$
13	<i>Betula</i>	$\exp((-0.46151 + 2.039844 * \log(D) + 0.837461 * \log(H)))$
14	<i>Betula</i>	$(0.37101 + 5.19075 * D + -2.12667 * \text{SQRT}(D))^2$
15	<i>Alnus</i>	$\exp((-0.565323 + 1.984601 * \log(D) + 0.822937 * \log(H)))$
16	<i>Alnus</i>	$0.41455 + -1.3712 * \text{SQRT}(D) + 11.33119 * D^2$
17	<i>Acer</i>	$0.03873 + 0.36273 * D^2 * (H)$
18	<i>Acer</i>	$0.20762 + -2.49698 * D + 12.94655 * D^2$
19	<i>Castanopsis</i>	$(-0.00794 + 0.34759 * D^2 * (H))$
20	<i>Castanopsis</i>	$(-0.02301 + 0.12721 * D + 2.4127 * D^2 + 8.12834 * D^3)$
21	<i>Michelia &amp; Alcimandra</i>	$0.00667 + 0.32947 * D^2 * (H)$
22	<i>Michelia &amp; Alcimandra</i>	$(0.53034 + -1.84392 * \text{SQRT}(D) + 11.2917 * D^2)$
23	<i>Terminalia myriocarpa</i>	$(0.00635 + 0.35936 * D^2 * (H))$
24	<i>Terminalia myriocarpa</i>	$2.52144 + 2.31085 * \log(D)$
25	<i>Phoebe hainesiana</i>	$(-0.0432 + 0.3622 * D^2 * (H))$
26	<i>Phoebe hainesiana</i>	$(-0.65767 + 3.2165 * D + 0.80684 * \text{SQRT}(D))^2$
27	<i>Schima wallichii</i>	$(-0.565323 + 1.984601 * \log(D) + 0.822937 * \log(H))$
28	<i>Schima wallichii</i>	$(0.28069 + 4.6198 * D + -1.65381 * \text{SQRT}(D))^2$
29	<i>Aphanomixis polystachya</i>	$(-0.09768 + 0.01051 * H + 0.31875 * D^2 * (H))$
30	<i>Aphanomixis polystachya</i>	$(-0.00144 + 3.94308 * D + -0.79729 * \text{SQRT}(D))^2$
31	<i>Tetrameles nudiflora</i>	$(-1.3361 + 1.75959 * \log(D) + 0.99492 * \log(H))$
32	<i>Tetrameles nudiflora</i>	$(-0.5098 + 2.41166 * D + 1.12639 * \text{SQRT}(D))^2$
33	<i>Duabanga grandiflora</i>	$(-0.565323 + 1.984601 * \log(D) + 0.822937 * \log(H))$
34	<i>Duabanga grandiflora</i>	$(-0.01217 + 3.3993 * D + -0.28981 * \text{SQRT}(D))^2$

35	<i>Ailanthus integrifolia</i>	$(-1.94825 + 1.7273 * \log(D) + 1.1669 * \log(H))$
36	<i>Ailanthus integrifolia</i>	$(0.32056 + 5.16781 * D + -1.83345 * \text{SQRT}(D))^2$
37	<i>Persea</i>	$\exp((-0.56664 + 2.03335 * \log(D) + 0.87279 * \log(H)))$
38	<i>Persea</i>	$0.07116 + -1.33867 * D + 9.8397 * D^2 + 2.29781 * D^3$
39	<i>Symplocos spicata</i>	$0.00155 + 0.34028 * D^2 * (H)$
40	<i>Symplocos spicata</i>	$(-0.2433 + 2.44627 * D + 0.48232 * \text{SQRT}(D))^2$
41	<i>Bombax ceiba</i>	$\exp((-0.70448 + 2.13777 * \log(D) + 0.91127 * \log(H)))$
42	<i>Bombax ceiba</i>	$0.04507 + -0.93461 * D + 5.48513 * D^2 + 9.16037 * D^3$
43	<i>Sterculia villosa</i>	$0.00231 + 0.34018 * D^2 * (H)$
44	<i>Sterculia villosa</i>	$(0.35895 + 4.99513 * D + -2.14135 * \text{SQRT}(D))^2$
45	<i>Engelharatia spicata</i>	$\exp((-0.14969 + 2.1532 * \log(D) + 0.76463 * \log(H)))$
46	<i>Engelharatia spicata</i>	$\exp((2.47635 + 2.51046 * \log(D)))$
47	<i>Beilschmiedia</i>	$\exp((-565323 + 1.984601 * \log(D) + 0.822937 * \log(H)))$
48	<i>Beilschmiedia</i>	$(0.51191 + -1.78643 * \text{SQRT}(D) + 11.19974 * D^2$
49	<i>Rest of species</i>	$\exp((-565323 + 1.984601 * \log(D) + 0.822937 * \log(H)))$
50	<i>Rest of species</i>	$(0.12404 + 4.00303 * D + -1.09844 * \text{SQRT}(D))^2$

(iv) Eastern and Central Bhutan

(Bumthang, Trongsa, Zhemgang, Mongar, Trashigang, Lhuntse, Pemagatshel, Trashiyangtse, Samdrup Jongkhar)

SL No.	Species	Volume
1	<i>Pinus roxburghii</i>	$(-0.00156 + 0.32159 * D^2 * (H))$
2	<i>Pinus roxburghii</i>	$(0.291801 + 6.041763 * D + -2.430993 * \text{SQRT}(D))^2$
3	<i>Pinus wallichiana</i>	$\exp((-1.049334 + 1.926332 * \log(D) + 0.967612 * \log(H)))$
4	<i>Pinus wallichiana</i>	$0.185555 + -3.040264 * D + 16.183975 * D^2$
5	<i>Picea spinulosa</i>	$\exp((-1.29816 + 1.86384 * \log(D) + 1.03333 * \log(H)))$
6	<i>Picea spinulosa</i>	$\exp((2.763193 + 2.605962 * \log(D)))$
7	<i>Abies densa</i>	$\exp((-1.38883 + 1.77028 * \log(D) + 1.04424 * \log(H)))$
8	<i>Abies densa</i>	$0.00259071 + -0.314273 * D + 9.530927 * D^2$
9	<i>Tsuga dumosa</i>	$\exp((-1.409685 + 1.846742 * \log(D) + 1.045675 * \log(H)))$
10	<i>Tsuga dumosa</i>	$(-0.480494 + 2.738112 * D + 0.948655 * \text{SQRT}(D))^2$
11	<i>Quercus</i>	$0.002111 + 0.392382 * D^2 * (H)$
12	<i>Quercus</i>	$(-0.020144 + 4.292089 * D + -0.894675 * \text{SQRT}(D))^2$
13	<i>Betula</i>	$\exp((-0.46151 + 2.039844 * \log(D) + 0.837461 * \log(H)))$
14	<i>Betula</i>	$\exp((2.460537 + 2.447069 * \log(D)))$
15	<i>Acer</i>	$0.03873 + 0.36273 * D^2 * (H)$
16	<i>Acer</i>	$(0.374246 + 4.759591 * D + -1.89151 * \text{SQRT}(D))^2$
17	<i>Castanopsis</i>	$(-0.00794 + 0.34759 * D^2 * (H))$
18	<i>Castanopsis</i>	$\exp((2.319413 + 2.653453 * \log(D)))$
19	<i>Rhododendron</i>	$\exp((-0.565323 + 1.984601 * \log(D) + 0.822937 * \log(H)))$
20	<i>Rhododendron</i>	$(0.306492 + 4.31536 * D + -1.749908 * \text{SQRT}(D))^2$
21	<i>Michelia &amp; Alcimandra</i>	$0.00667 + 0.32947 * D^2 * (H)$
22	<i>Michelia &amp; Alcimandra</i>	$0.0788115 + -1.973758 * D + 12.357088 * D^2$
23	<i>Phoebe hainesiana</i>	$(-0.0432 + 0.3622 * D^2 * (H))$
24	<i>Phoebe hainesiana</i>	$0.041943 + -1.807981 * D + 12.730082 * D^2$
25	<i>Persea</i>	$\exp((-0.56664 + 2.03335 * \log(D) + 0.87279 * \log(H)))$
26	<i>Persea</i>	$0.136186 + -2.1264 * D + 12.734067 * D^2$

27	<i>Symplocos spicata</i>	$0.00155 + 0.34028 * D^2 * (H)$
28	<i>Symplocos spicata</i>	$(-0.212798 + 3.288996 * D + 0.046417 * \text{SQRT}(D))^2$
29	<i>Engelharatia spicata</i>	$\exp((-0.14969 + 2.1532 * \log(D) + 0.76463 * \log(H)))$
30	<i>Engelharatia spicata</i>	$\exp((2.535662 + 2.519379 * \log(D)))$

## 1.9. Forest Function Mapping

Forest function mapping is an essential step for sustainable forest management planning. The function mapping is a process of defining the forest management area into categories of area based on its function. The forest function map provides information on total sustainable production area, area for conservation and areas of ecologically, environmentally and socially important functions which needs to be protected with certain management restrictions.

### 1.9.1. Categories of forest function

The entire landscape for management is divided into six main groups depending on its functions (Table 1.36). These groups include soil conservation, water and watershed conservation, nature conservation, social functions, road buffer and production function. These groups are further divided into sub-groups (protection and conservation) depending upon the management restrictions. The term protection is used where timber extraction is prohibited and the term conservation is used where timber extraction is allowed with limited management intervention.

Table 1.36 List of different forest function groups and sub-functions

Soil Conservation	Water and Watershed Conservation	Nature Conservation	Social Function	Road Buffer	Production Function
Soil Protection (SP)	Riparian Reserve Protection (WRR)	Wildlife Conservation (NWC)	Religious Sites Protection (SocRS)	Road Buffer (RB)	Timber Production
Soil Conservation (SC)	Local Water Supply Protection (WLS)	Biodiversity Conservation (NB)	Social-Local Use Only (SocL)		Research and Development (PR)
	Special Management Areas around Water Courses (WSMA)				
	Watershed Conservation (WC)				

#### 1.9.1.1 Soil Conservation

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

Table 1.37. Soil protection and soil conservation

	Soil Protection (SP)	Soil Conservation (SC)
<b>Definition</b>	Soil Protection includes all areas which are extremely sensitive to soil erosion, land and snow slides. These areas include in particular very steep slopes, rocky and stony areas, water-logged gleys and already eroded areas. Unstable slopes above or near important objects such as villages, settlements, individual houses, roads, agricultural land, etc. are defined for protection reasons as Soil Protection, too.	The Soil Conservation function covers all areas which are sensitive to soil erosion, which are, for example, steep slopes, waterlogged areas and exposed sites.
<b>Objective</b>	(1) to prevent damages caused to the environment and infrastructure by landslides, snow slides, falling stones and other physical impacts; (2) to protect the soil from erosion and to sustain soil fertility.	(1) to minimize or prevent negative impacts due to forest resource use in order to protect the soil from erosion and other degradation processes and to sustain soil fertility.
<b>Legal Restrictions</b>	According to § 14 a (iii) of the Forest and Nature Conservation Act (1995) "no permits shall be issued to fell and to take any timber where the slope is greater than 45 degrees (100%) unless authorized under an approved management plan or by the Head of the Department."	None.
<b>Identification</b>	Soil erosion depends largely on geology, site conditions (soil type, water regime, etc.) and slope gradient. In general, it can be said, the finer the soil texture, the steeper the slope and the higher the water content (saturation) the more sensitive the soil becomes towards erosion and landslides. Unfortunately, up to date soil maps do not exist for Bhutan. The only parameters, which can be easily assessed, are the slope gradient, the land use type and already existing signs of erosion (gullies, rills, landslides, etc.).	
<b>GIS Analysis</b>	The following areas shall be classified as Soil Protection: <ul style="list-style-type: none"> <li>• very steep areas (slope above 45°)</li> <li>• unstable areas and sites prone to landslides and areas with indications of severe erosion.</li> </ul>	The following areas shall be classified as Soil Conservation: <ul style="list-style-type: none"> <li>• steep areas (slopes of 25-45°)</li> <li>• areas with indication of slight to moderate erosion;</li> <li>• exposed sites (ridges, etc.).</li> </ul>

### **GIS Steps**

This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

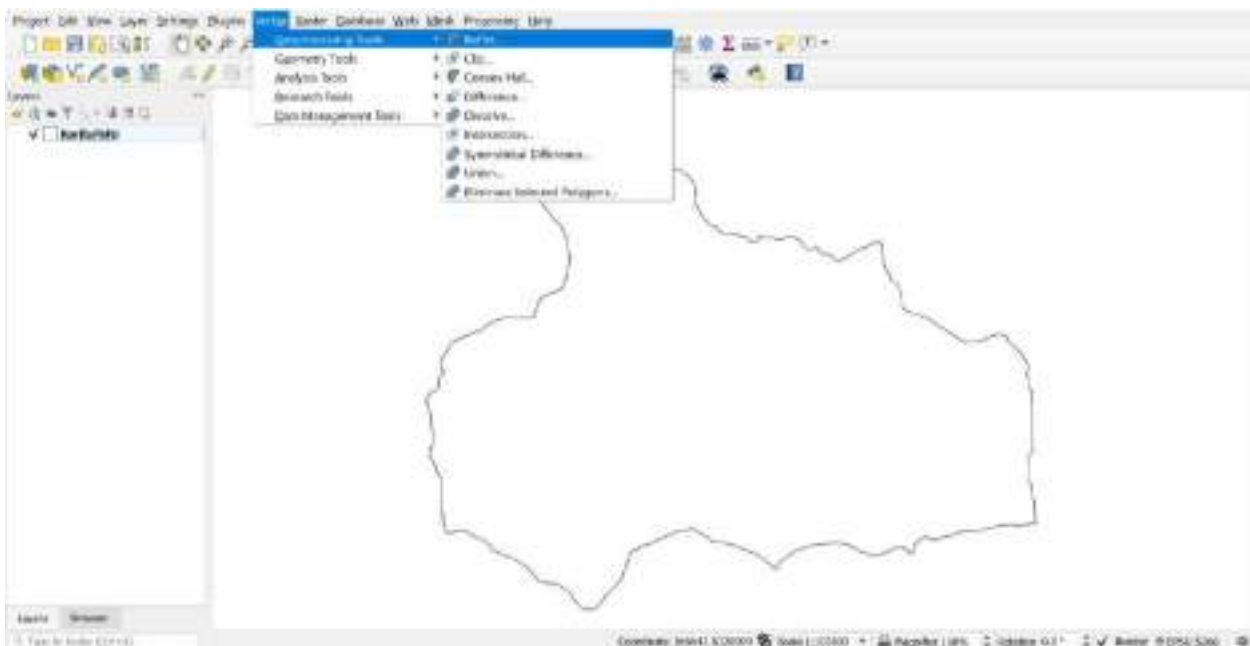
Open QGIS

- *Add FMU boundary layer*

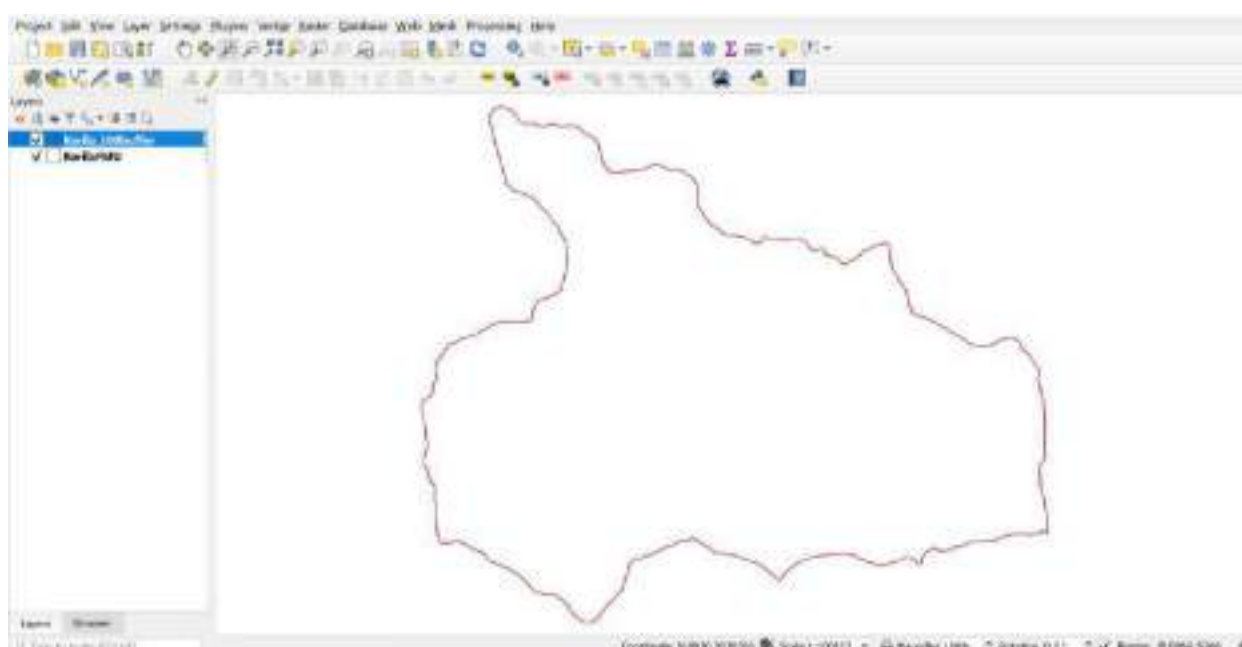
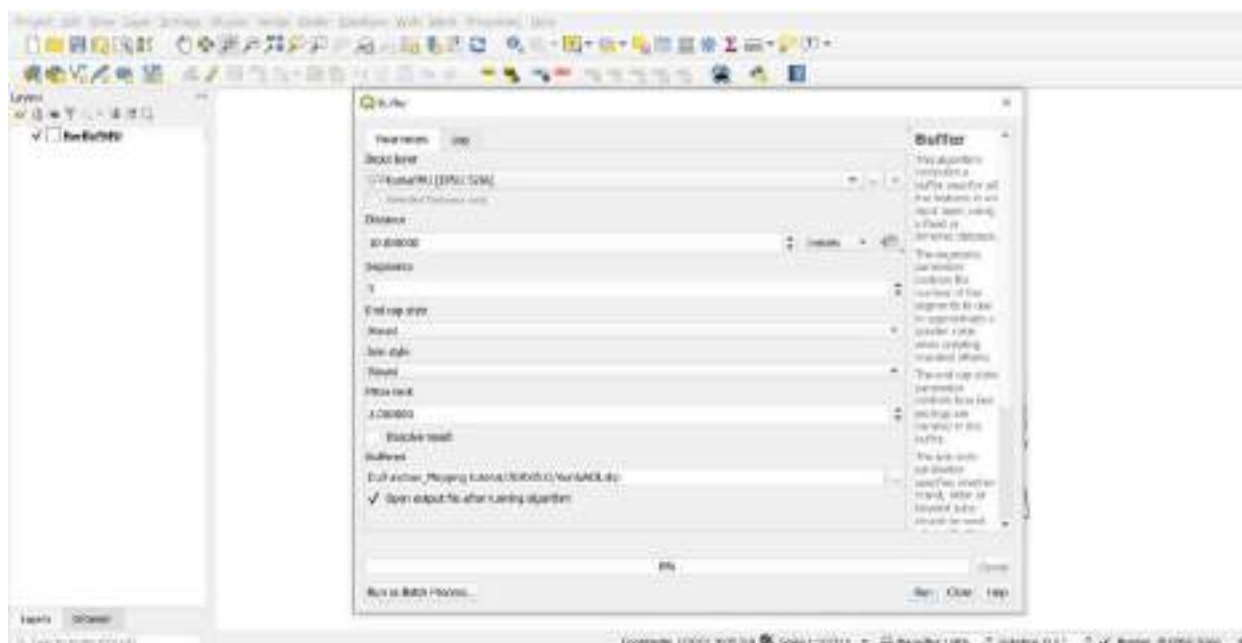


Create a buffer of 500m around the FMU boundary to use it as area of interest (aoi). Buffer is being created to increase the extend of FMU as next steps involves using combination of vector and raster file.

- *Click Vector > Geoprocessing Tools > Buffer*

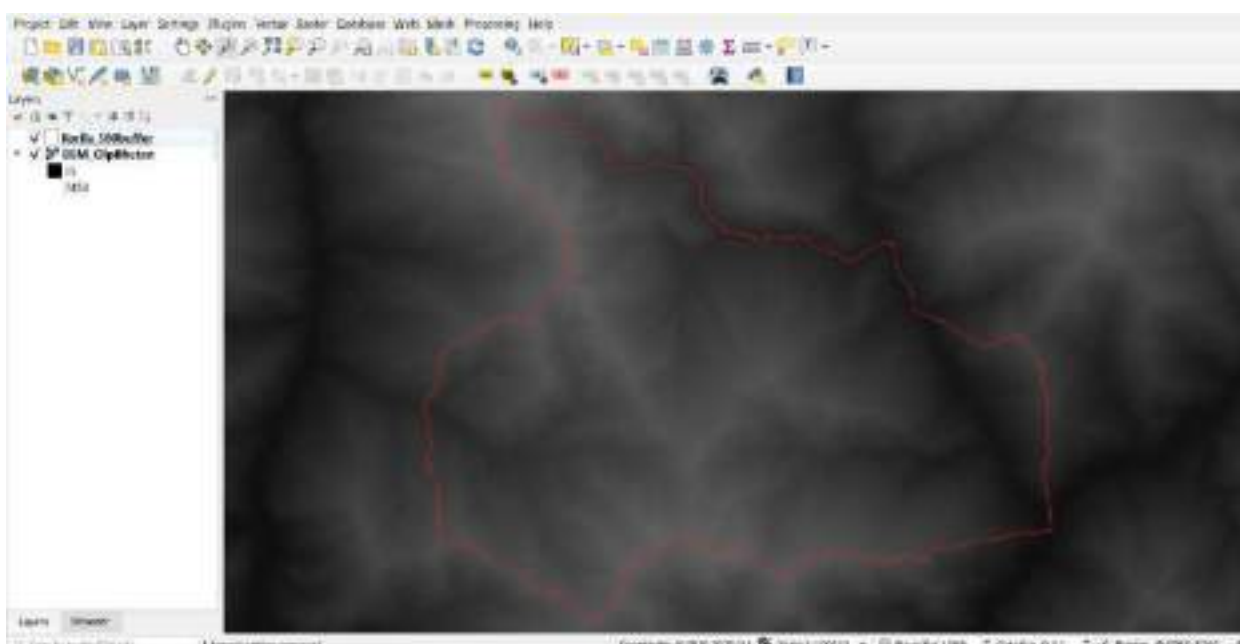


- Save the buffer layer with appropriate name in working directory



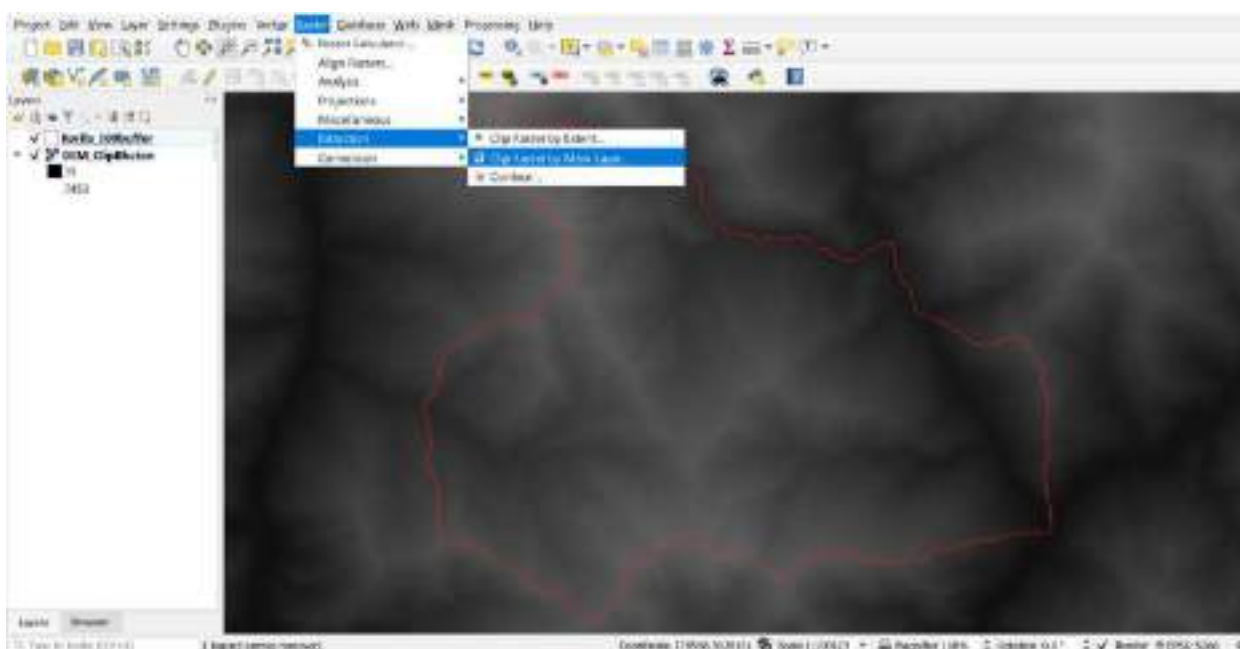
- Add Digital Elevation Model (DEM). DEM is raster data.





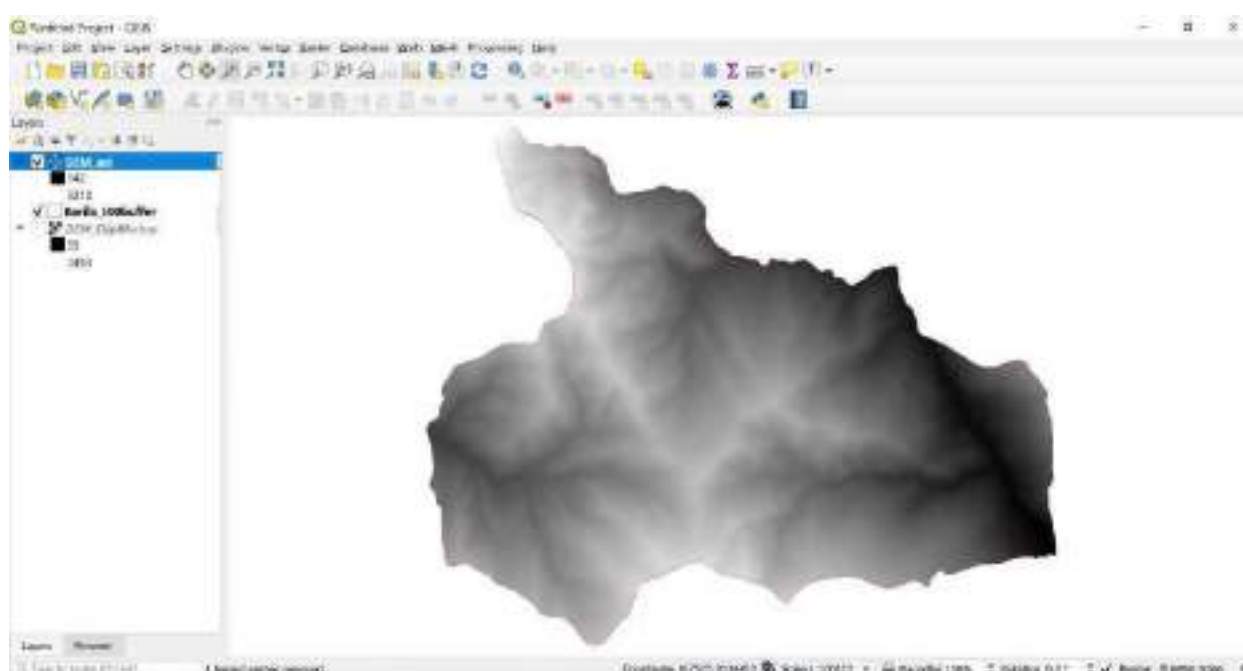
Clip the DEM within the aoi (500m buffer FMU boundary layer)

- *Click Raster > Extraction > Clip Raster by Mask Layer*



- *Input layer: Select DEM of Bhutan*
- *Mask layer: Buffered FMU boundary shapefile*
- *Target CRS: Select EPSG:5266-DRUKREF 03/Bhutan National Grid*
- *Save the clipped DEM with appropriate name in working directory*

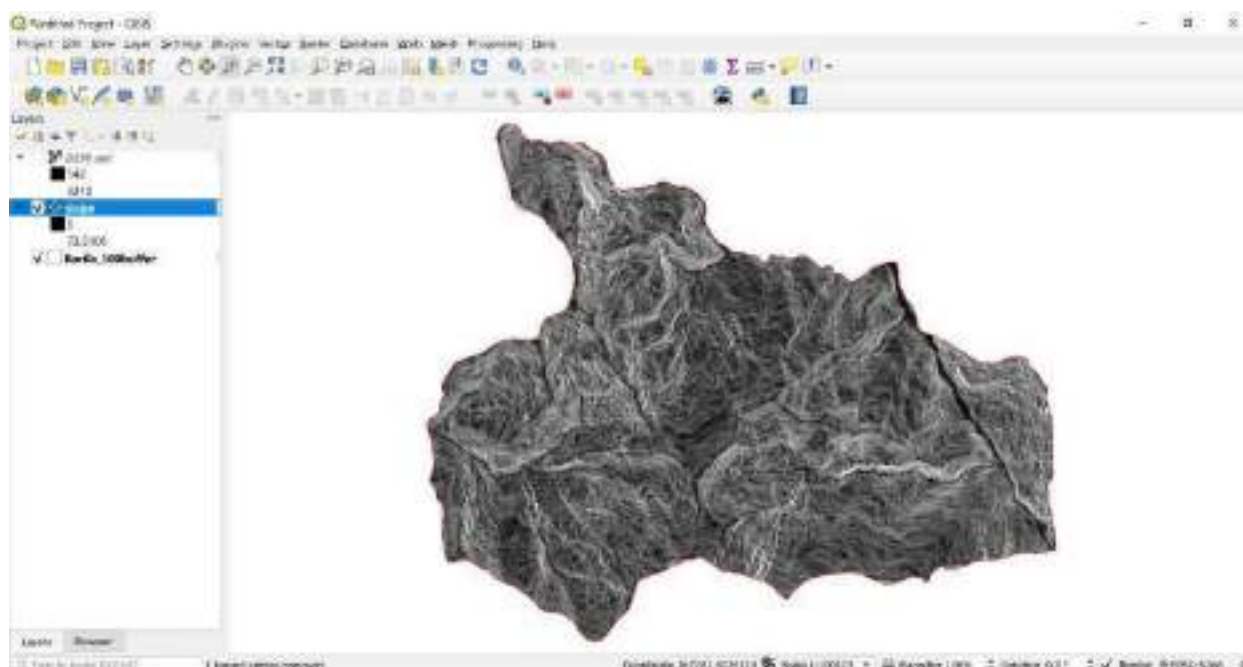




Generate SLOPE using DEM

- *Click Raster > Analysis > Slope*

- [illegible]



Reclassify the SLOPE into following classes

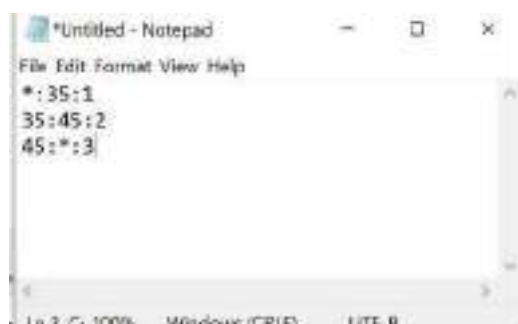
1. 0-35
2. 35-45
3. 45 and above

➤ To carry out this process open *NOTEPAD* and type as following and save the text file with name *slopereclass*.

\*:35:1

35:45:2

45:\*:3



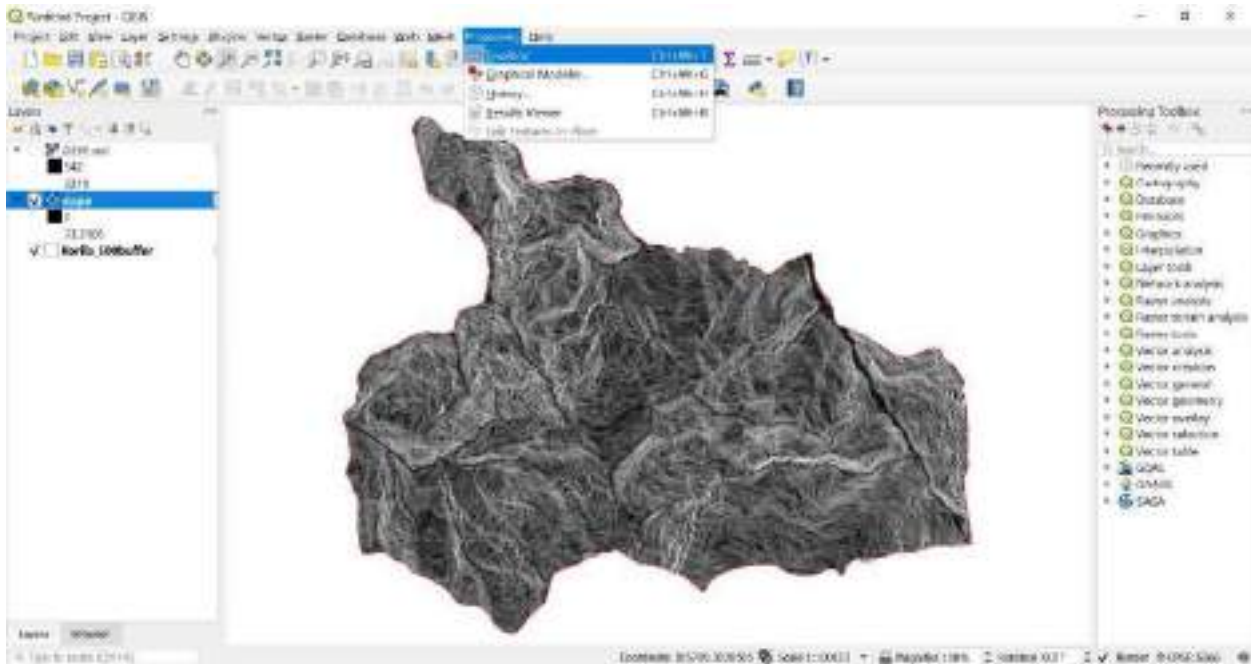
1 means 35 degree and below slope

2 means 35 to 45 degree slope

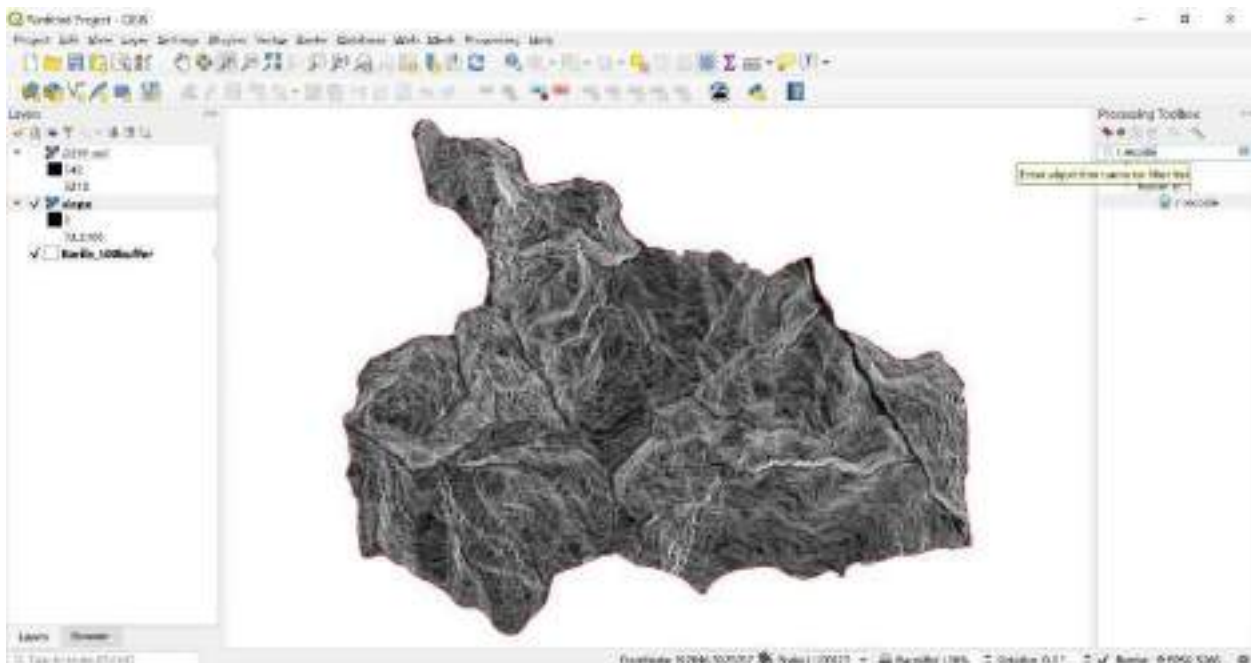
3 means 45 degree and above slope

Open the processing toolbox, if the toolbox is not open

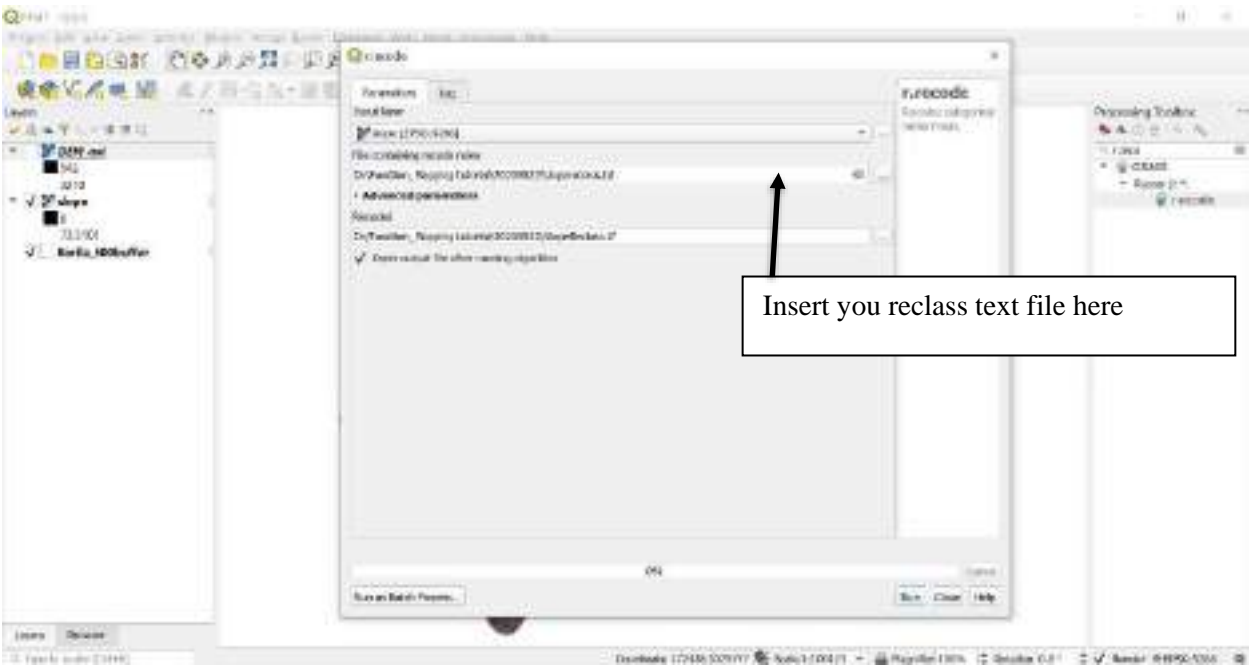
- *Click Processing > Toolbox*



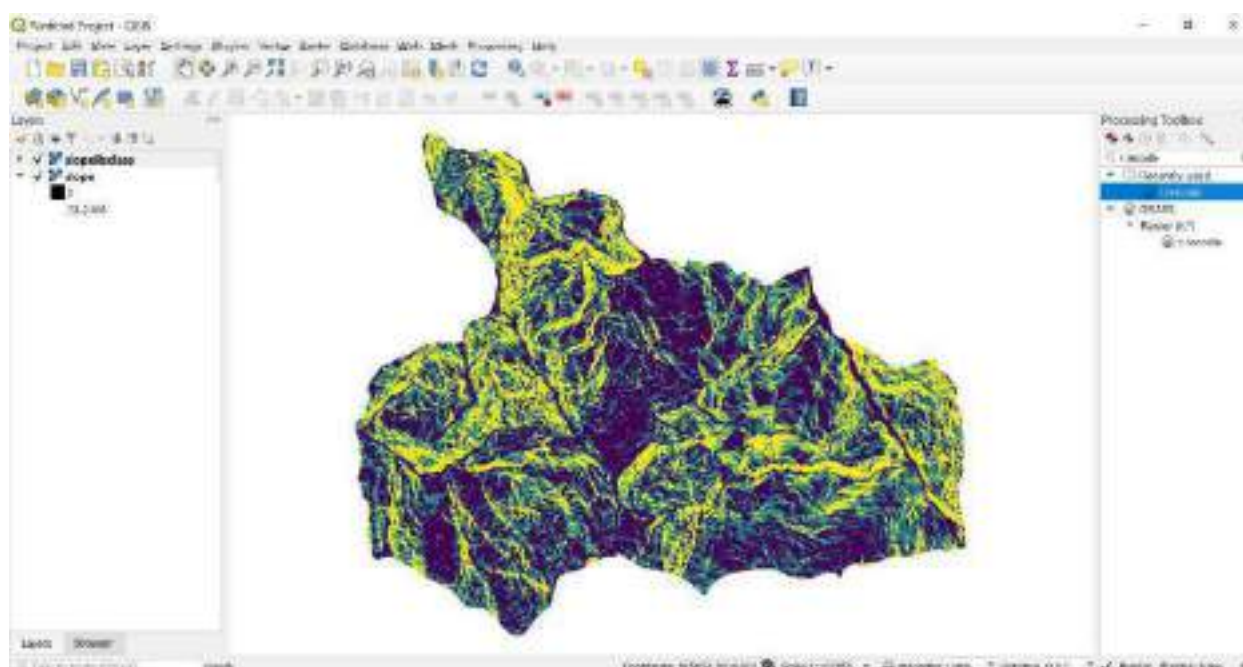
- *Type r.recode in the search box of processing toolbox and open script by double clicking*



- *Input layer: select FMU Slope*
- *File containing recode rules: browse the text file containing reclassification code and insert*
- *Save the reclassified SLOPE with appropriate name in working directory*
- *Click Run*

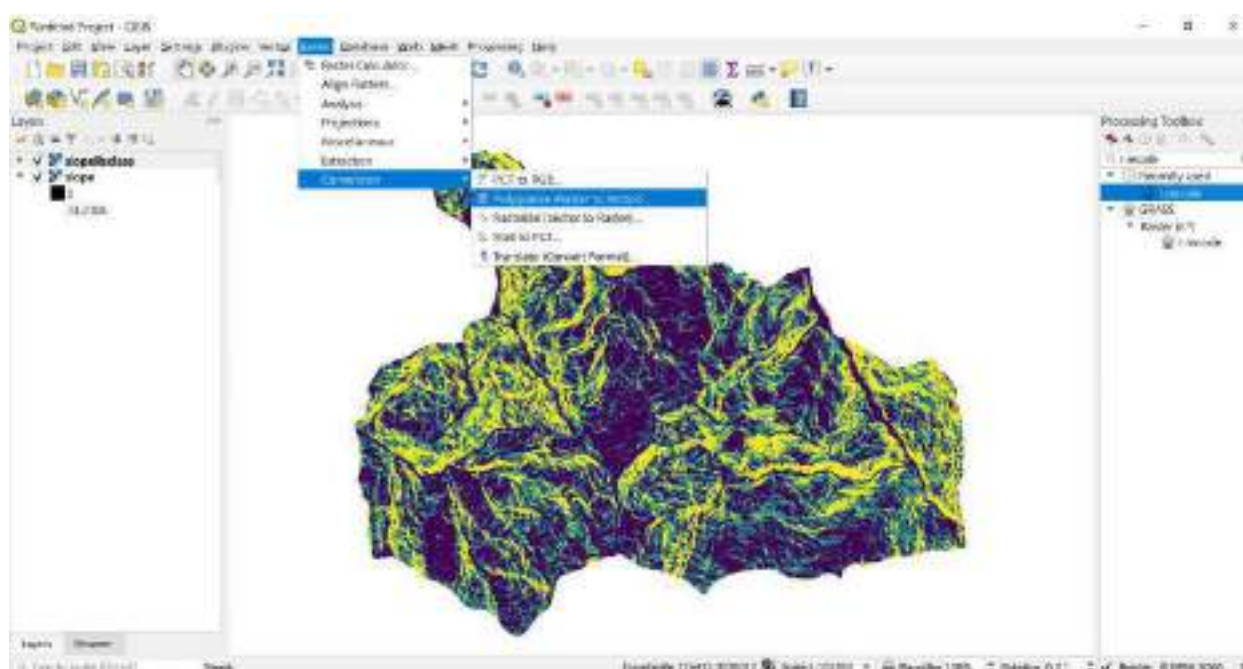






Convert the reclassified slope raster file into vector file

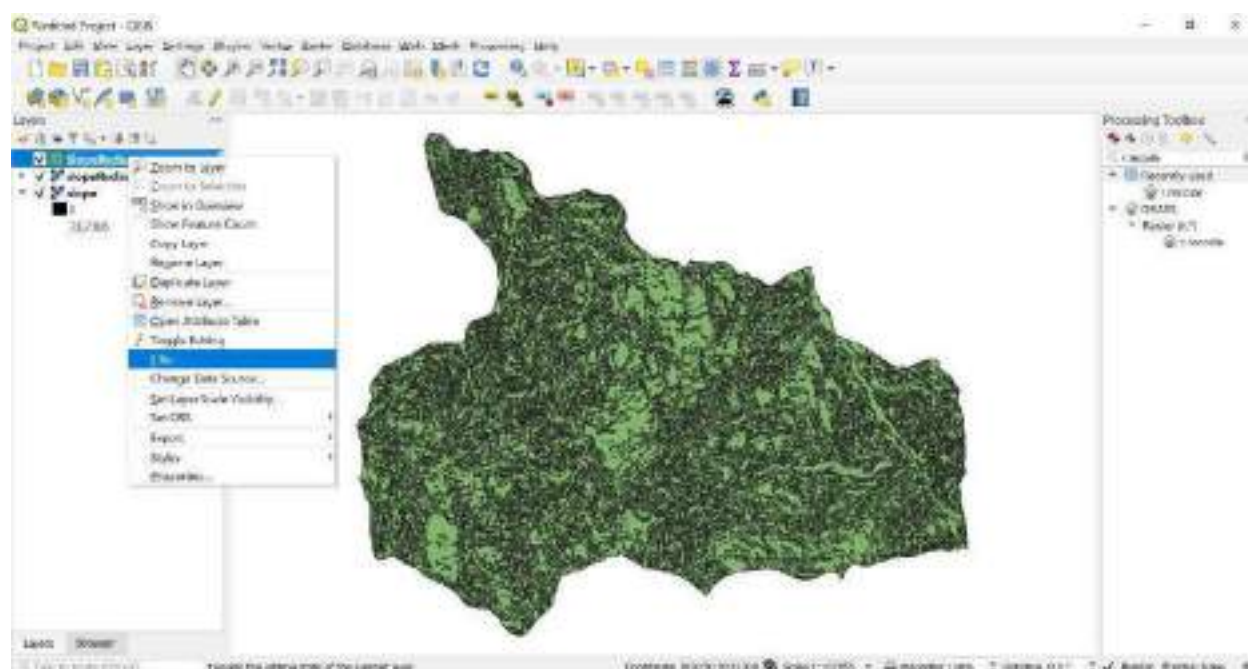
- *Click Raster > Conversion > Polygonize (Raster to Vector)*



- *Input: Select reclassified slope*
- *Leave the rest default*
- *Vectorized: Save the file with appropriate name in working directory*
- *Click run*

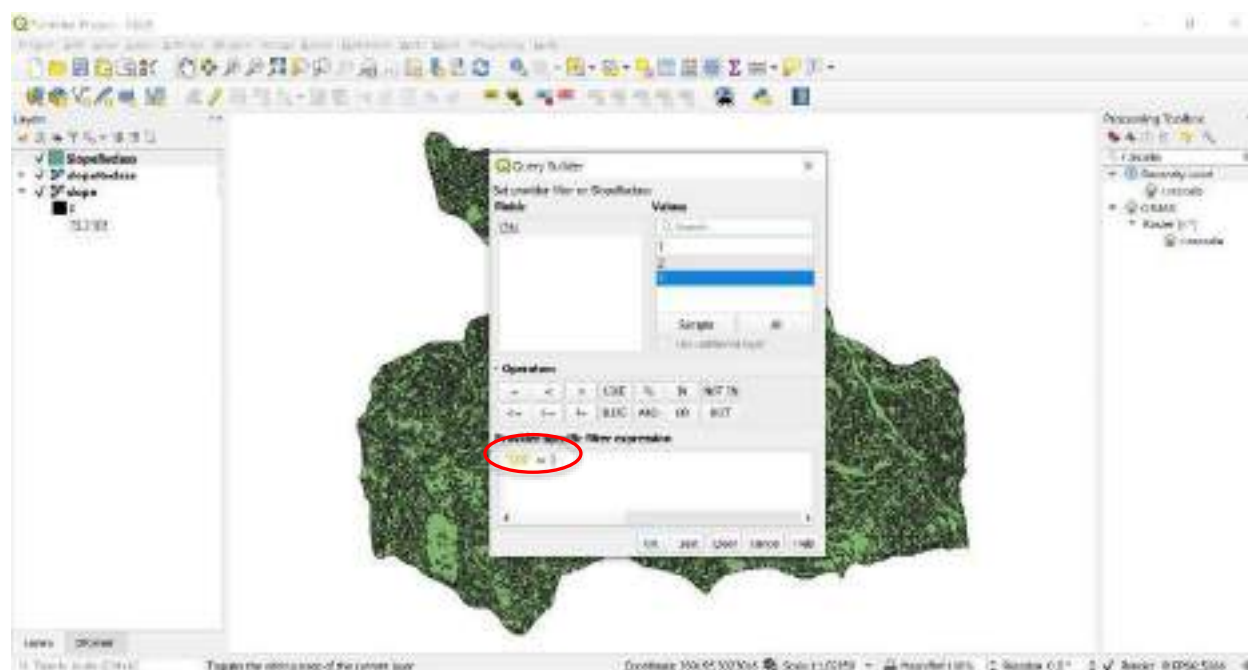
- *Right click vector reclassified slope file > Filter*

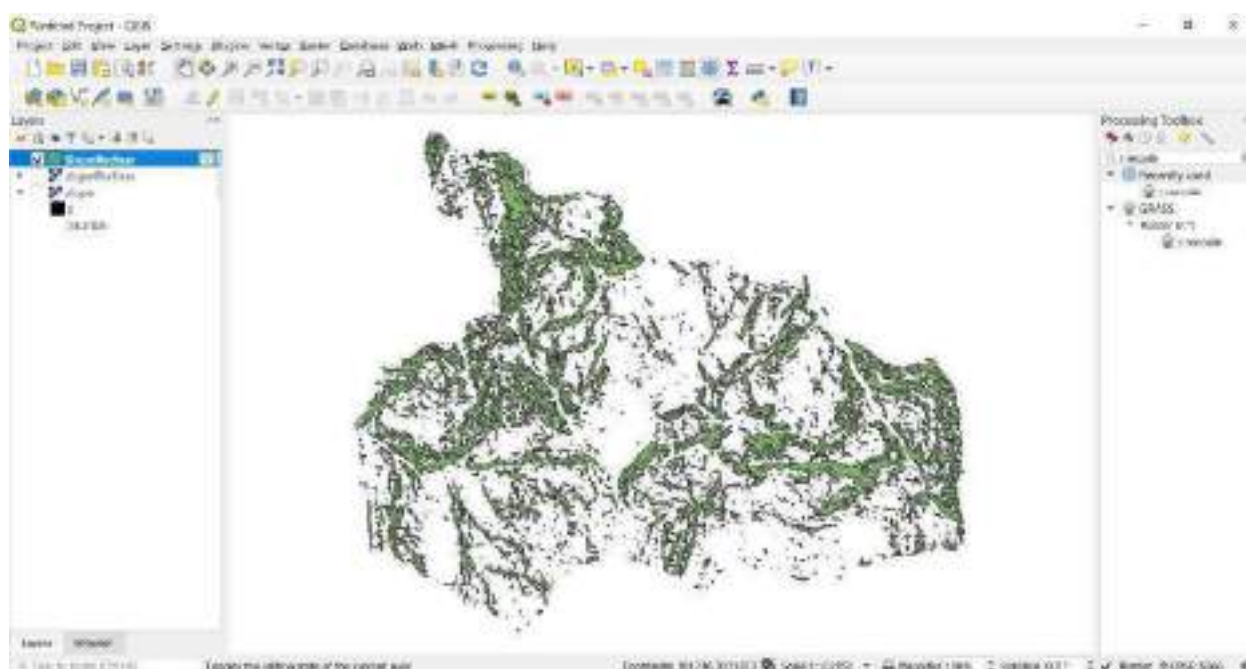




Enter expression as shown in the figure

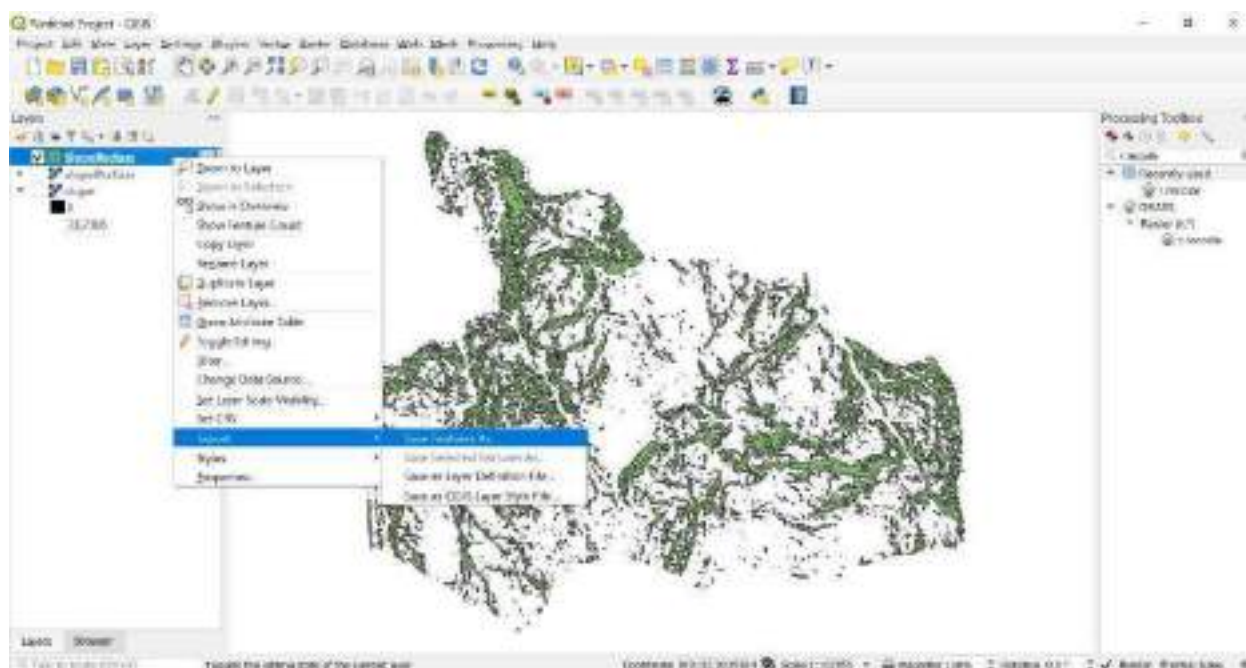
- Double click DN > Click = sign > click All (this shall display all DN value present in attribute table) > double click 3 > ok

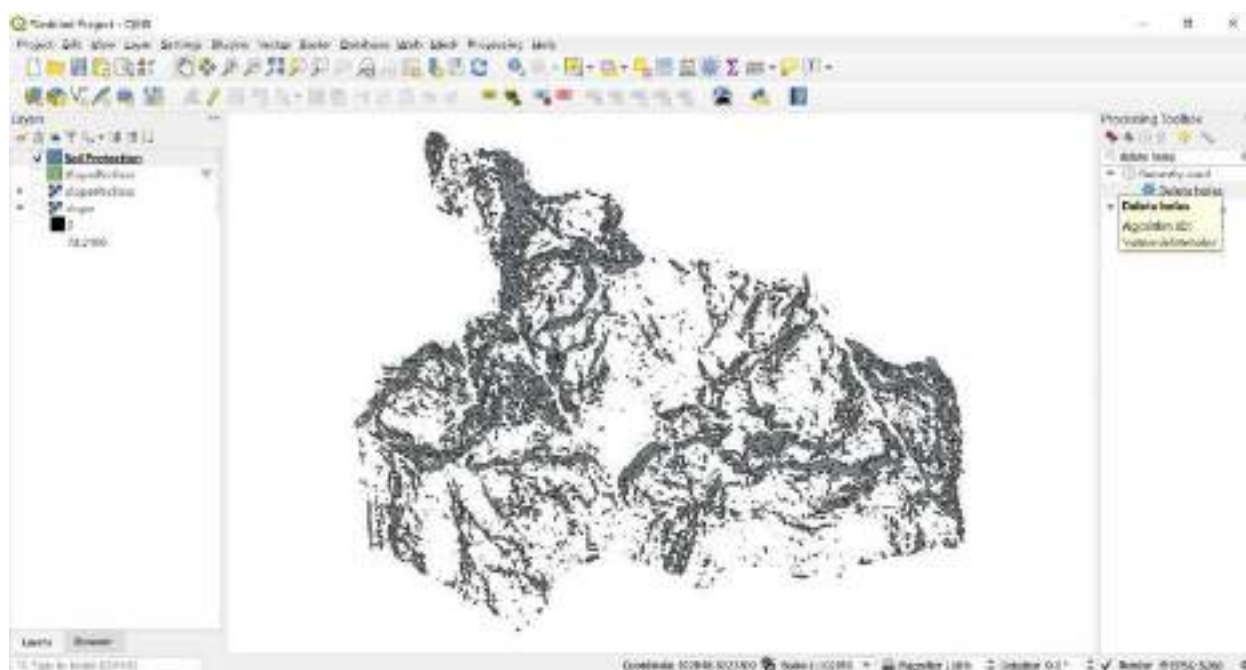
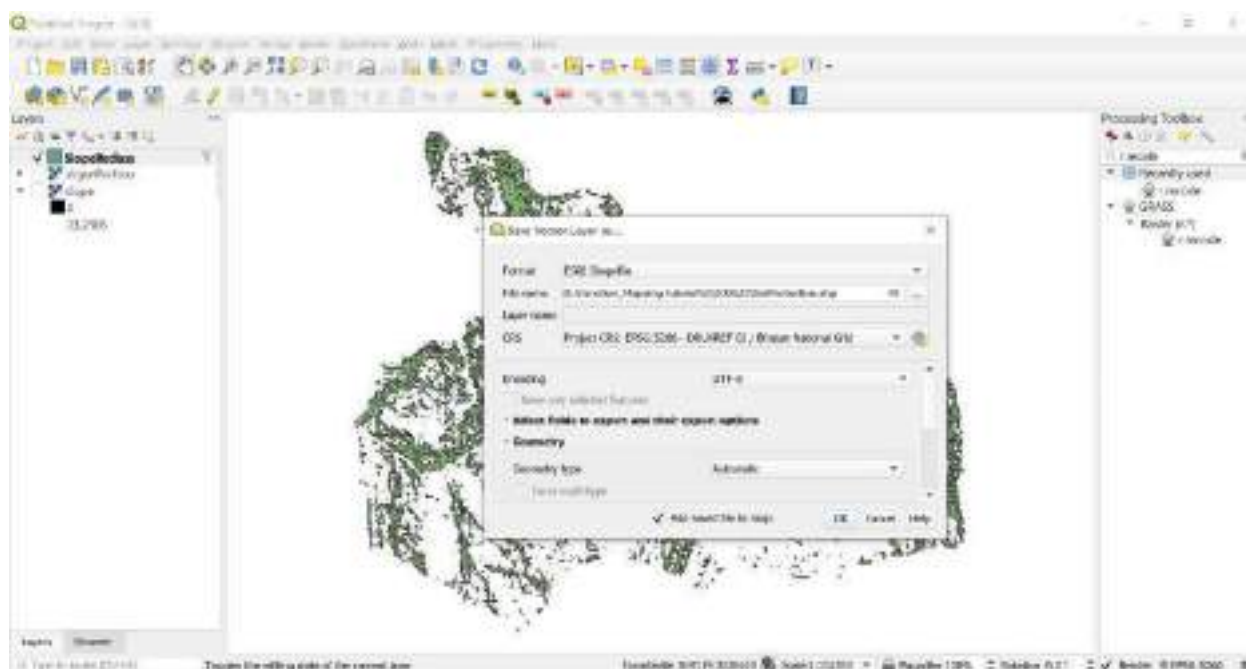




Export the soil protection layer

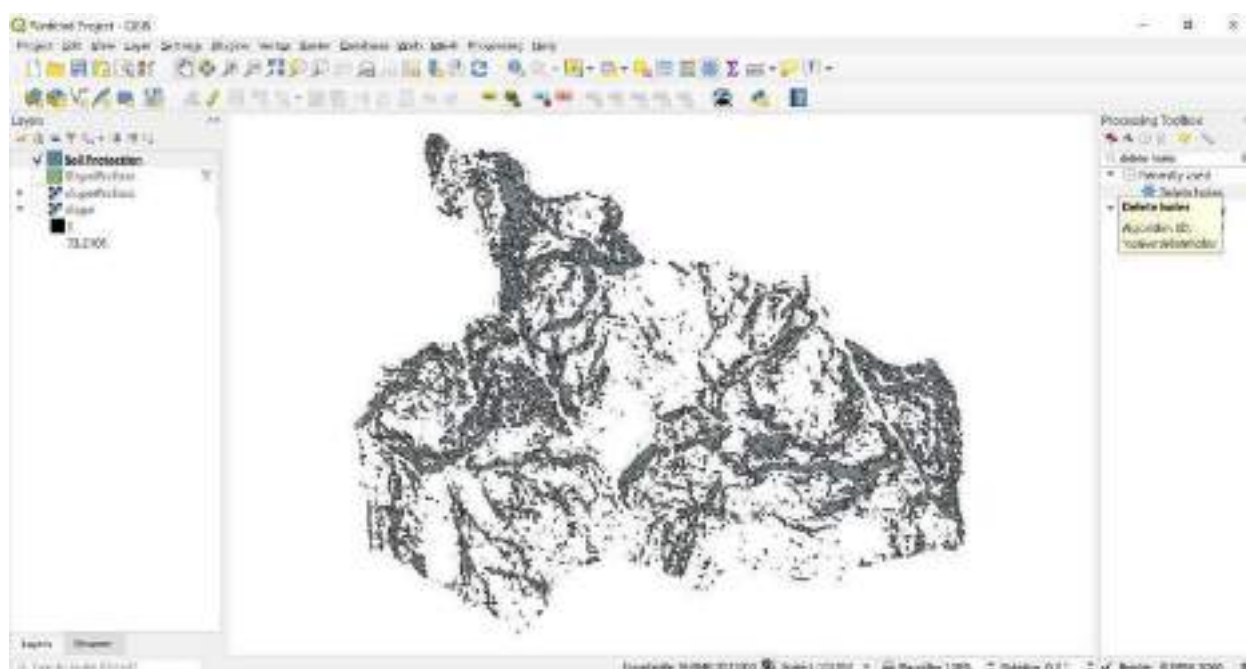
- *Right click on filtered vector reclassified slope file > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *Save the file with appropriate name in working directory*



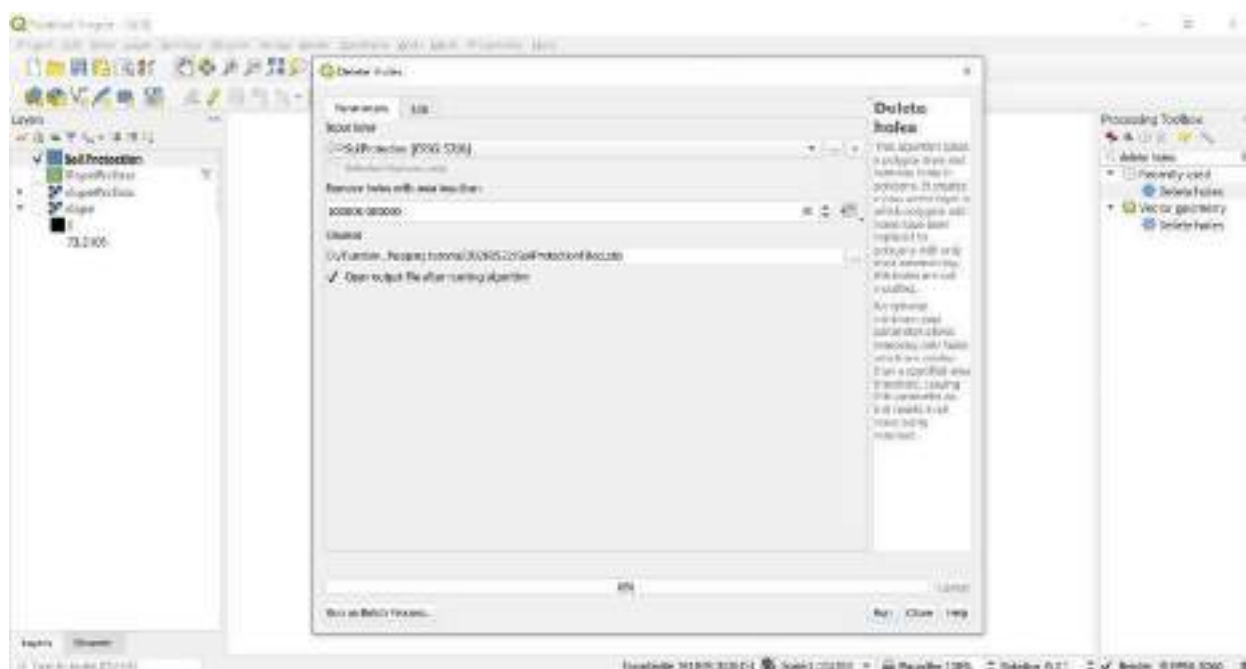


In the exported soil protection file, there are several smaller areas surrounded by steep area. Accessing such areas are impossible, therefore, we need to include those areas under soil protection.

- *In the Processing Toolbox type “delete holes” >double click Delete holes tools*

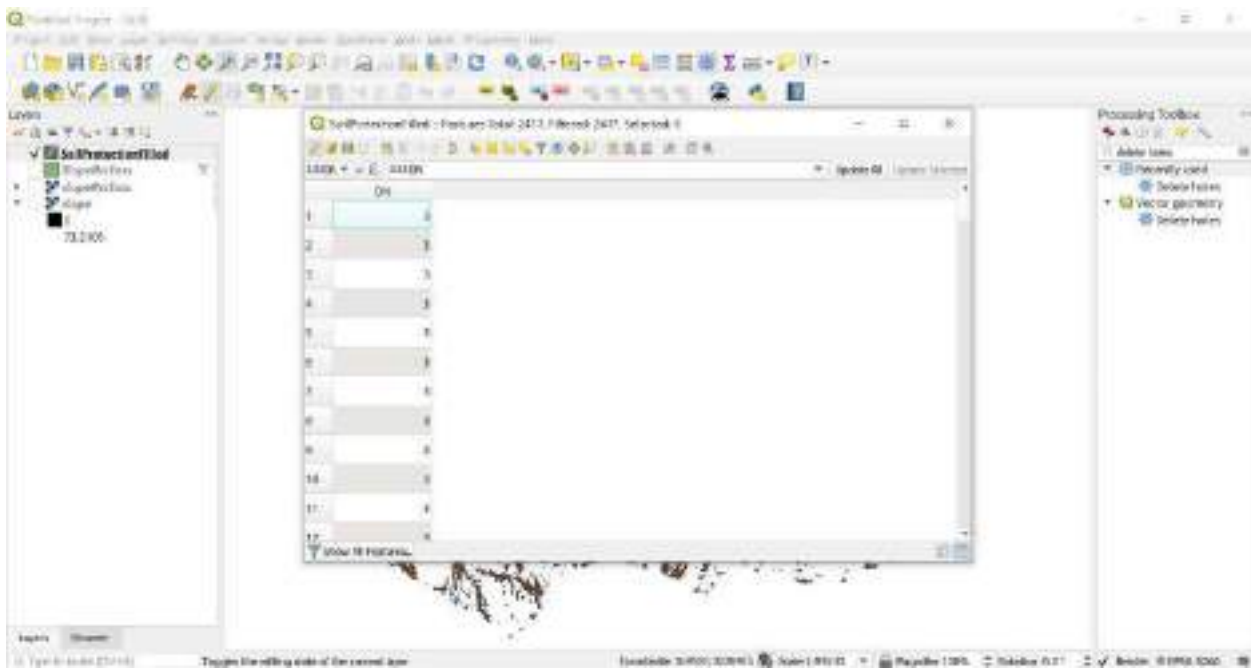


- *In Input layer select soil protection layer*
- *In Remove holes with area less than enter 100000 m<sup>2</sup> (10 ha)*
- *Save the file with appropriate name in working directory*







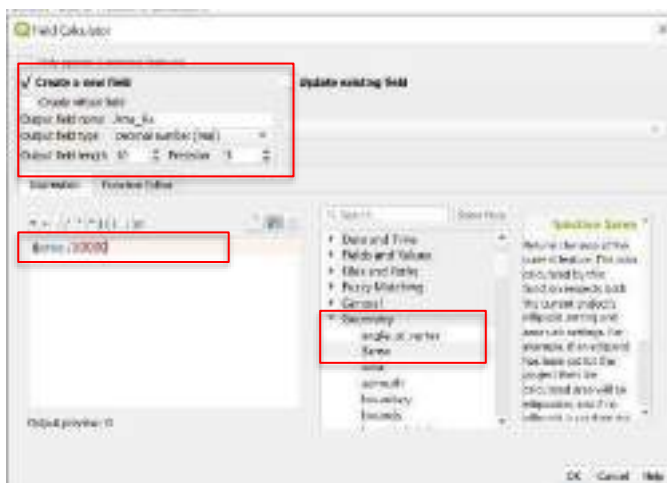


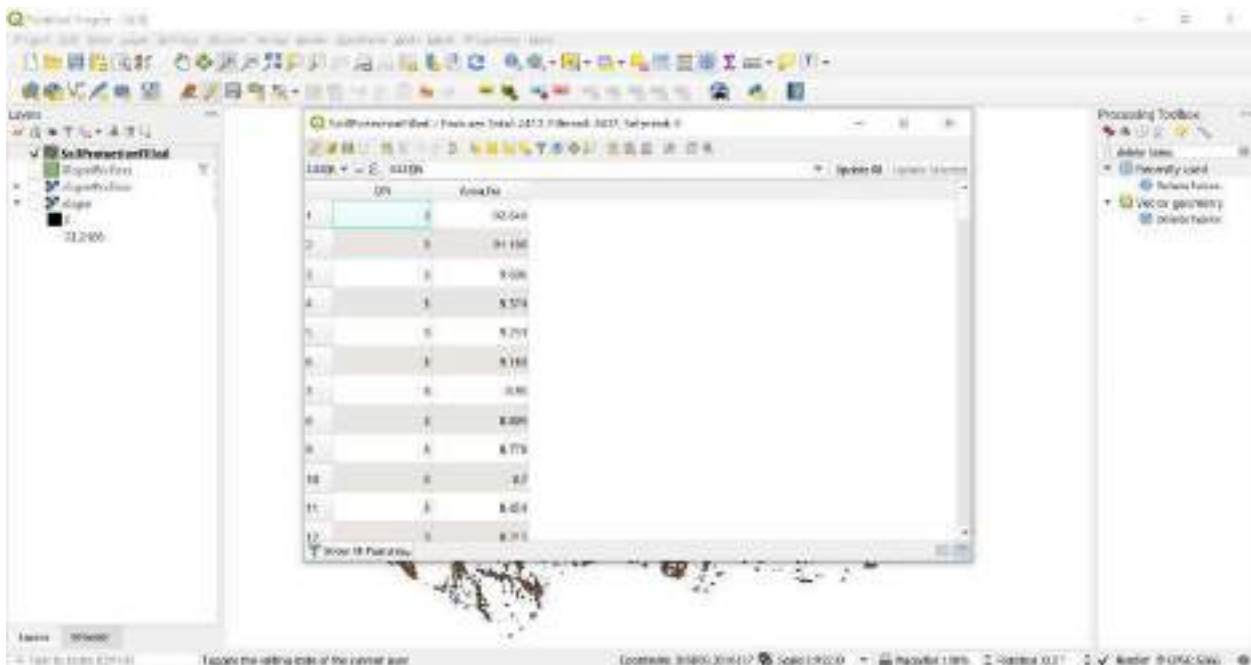
Calculate the area of each polygon

- Click Toggle editing mode > Click Open Field Calculator
- Check in the Create a new field and type as follows
  - Output field name: Area\_ha
  - Output field type: Decimal number (real)
  - Output field length 10 and Precision 3

The expression field should be filled with area calculating expression

- Click Geometry > double click \$area
- In the expression box divide \$area with 10000; this is to convert the calculated area unit from m<sup>2</sup> to hectare.





- Close the editing mode by undo toggle editing

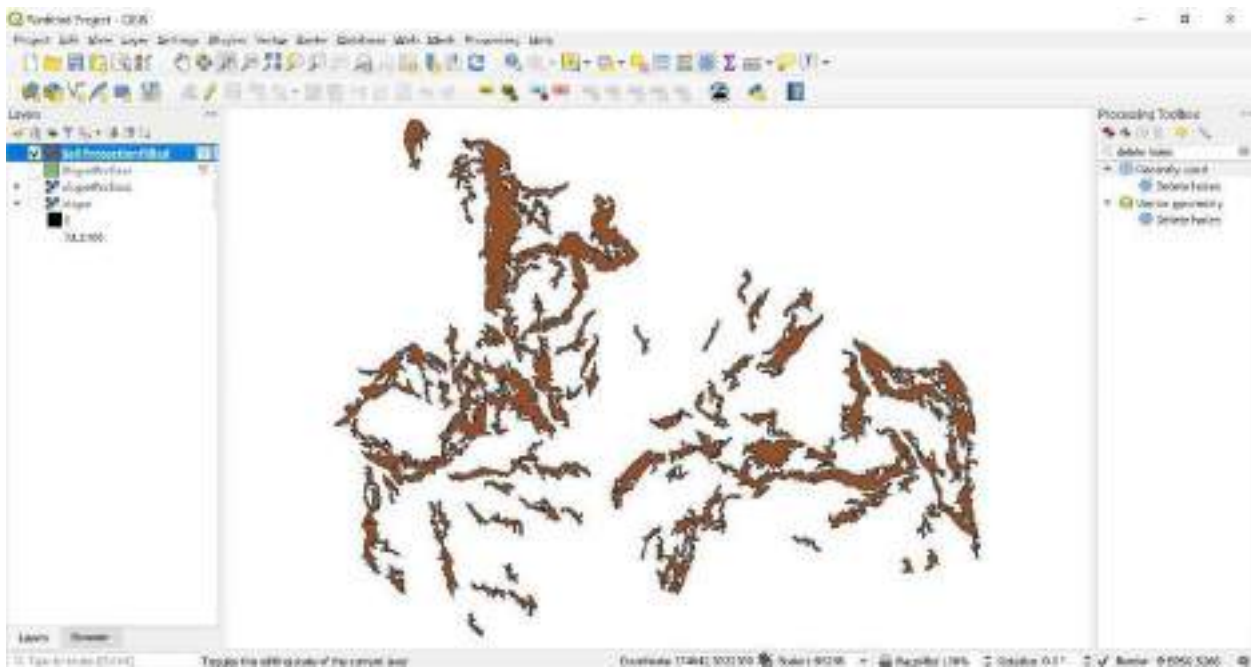
There are also several isolated smaller steep areas, this should be removed from soil protection and merge it with soil conservation layer.

To remove the isolated small patches (of area less than 5 ha) of steep area, filter the area of the soil protection layer for area greater than or equal to 5 ha ( $\geq 5$  ha)

- Right click on working layer > click filter > and enter the expression as shown in picture below in Query Builder

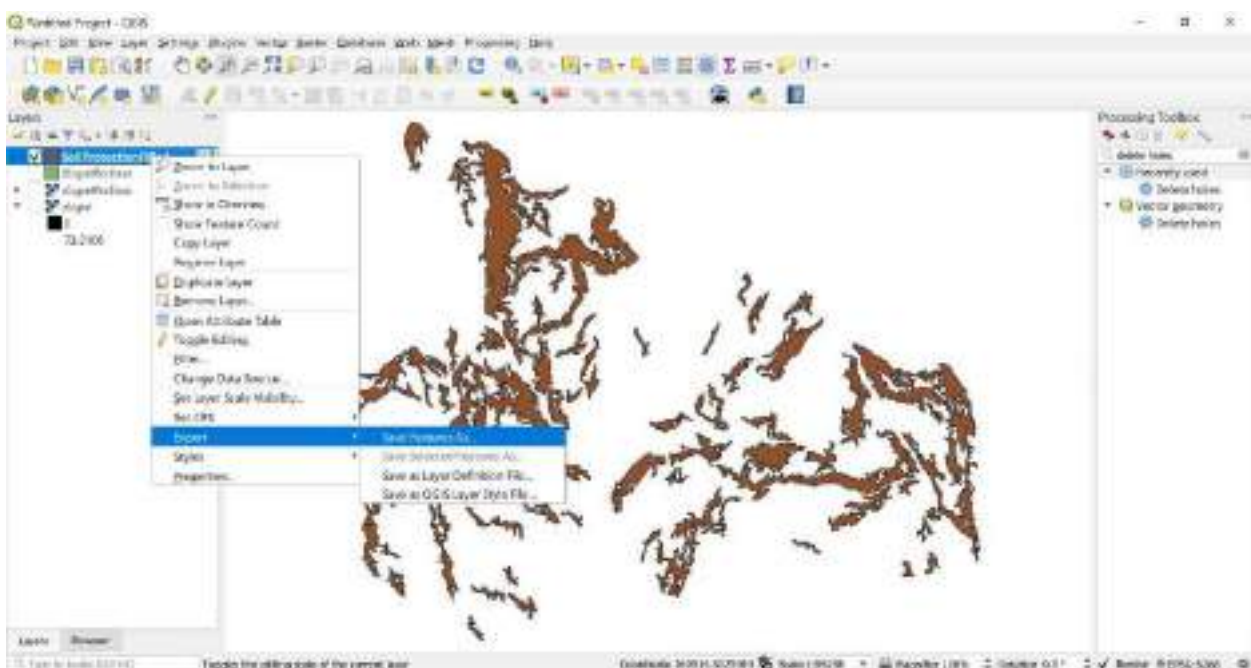






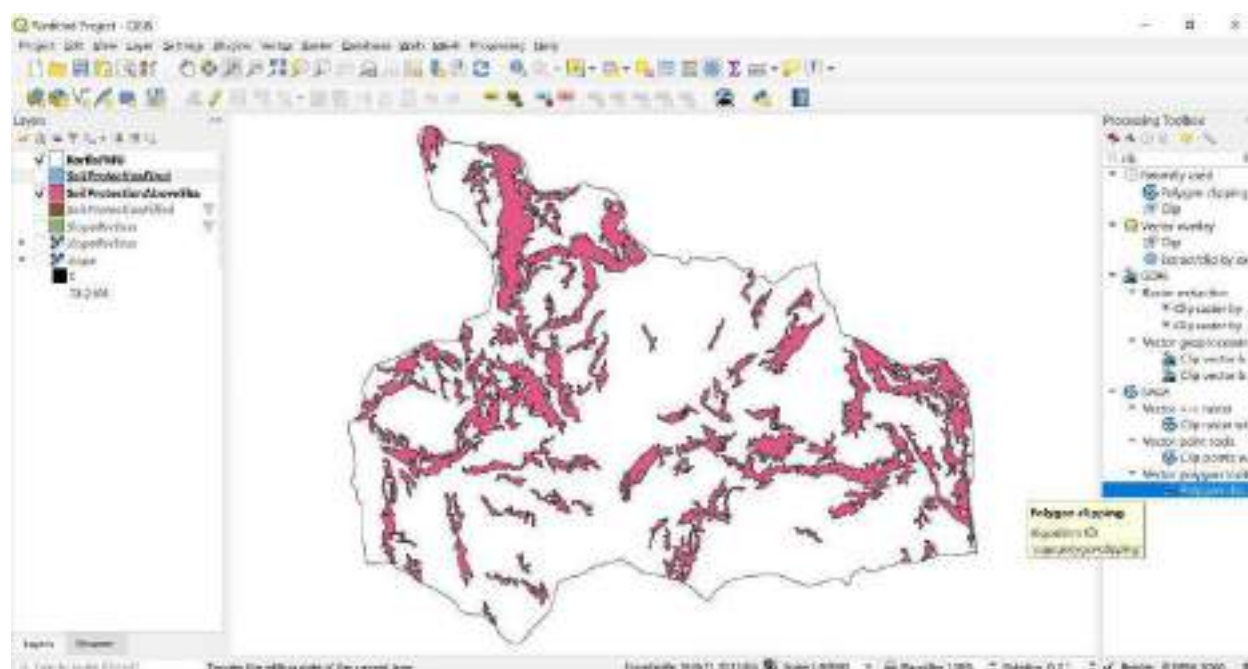
Export the filtered layer and save it as soil protection layer

- *Right click on filtered layer > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *Save the file with appropriate name in working directory*

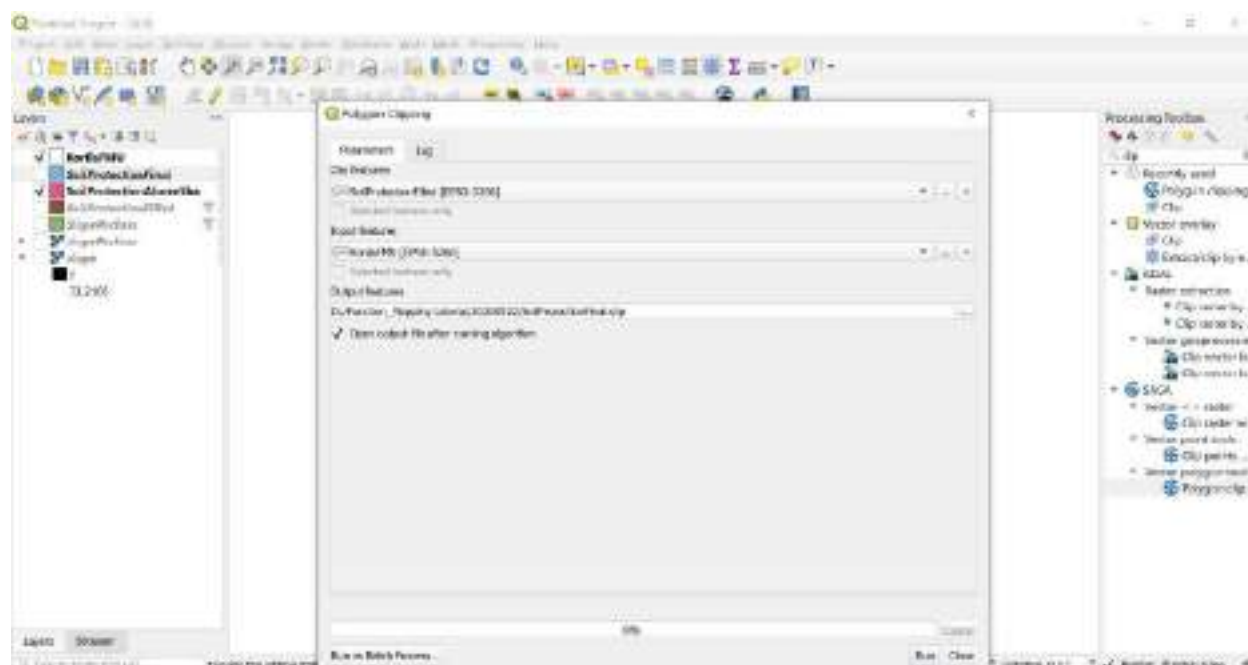


The exported soil portection layer contains area even outside the FMU boundary as we generated the slope for 500 m buffered FMU boundary. Therefore, we need to extract soil protection layer within FMU boundary

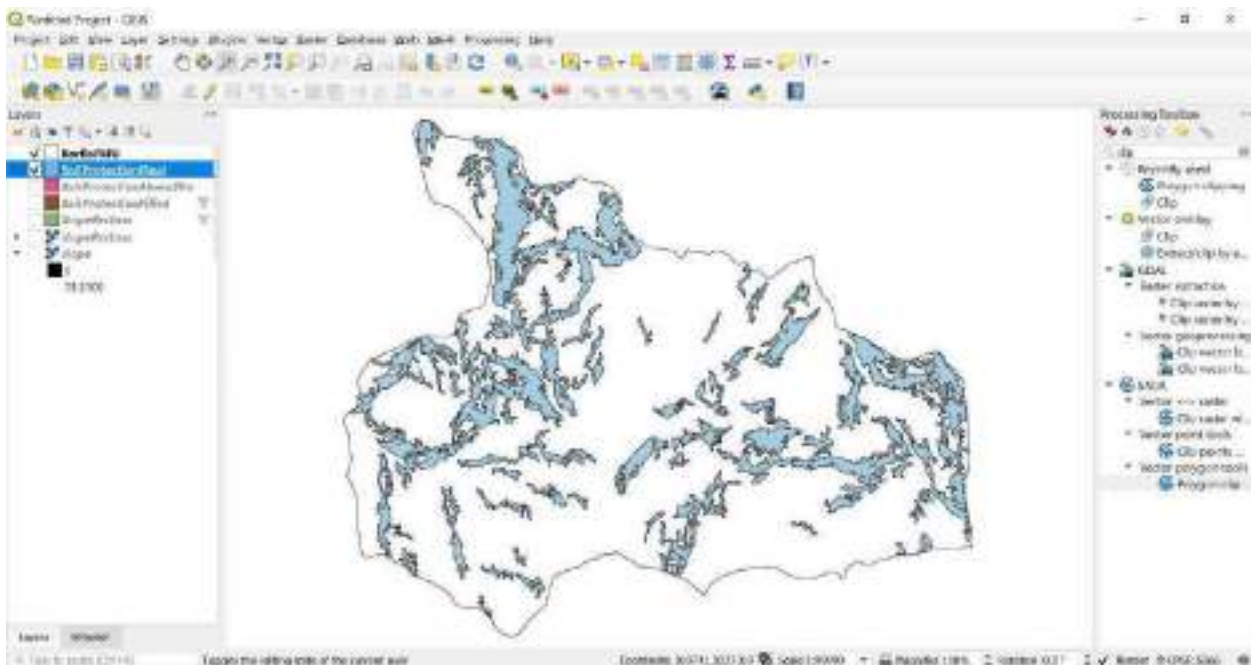
- *Clip with FMU Boundary*
- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*



- *In Clip features: select Soil protection layer*
- *In input features: select FMU boundary layer*
- *Save the file with appropriate name in working directory*



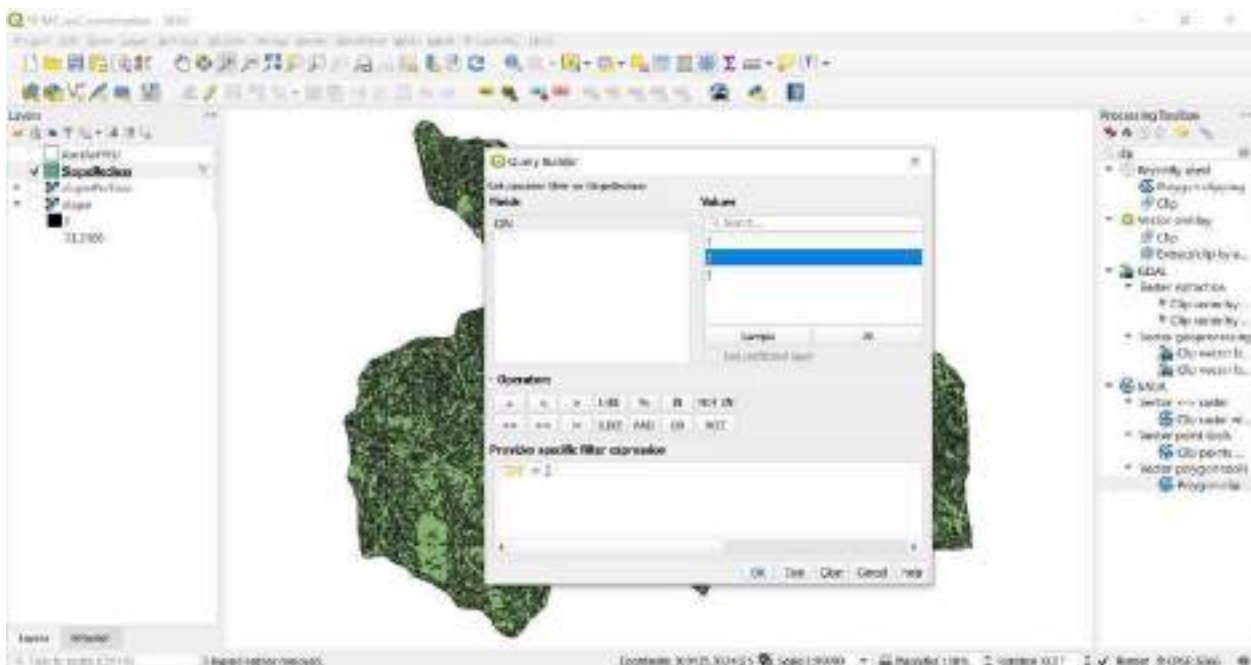
Creation of soil protection is completed



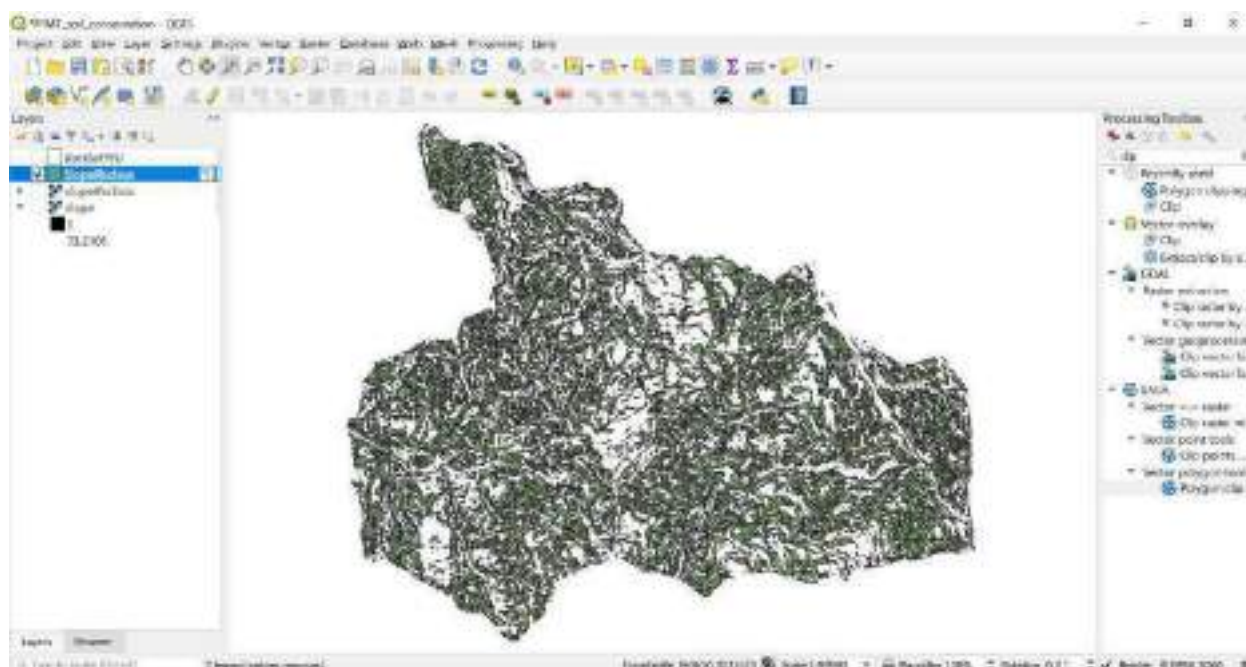
Follow the aforementioned similar step to export soil protection layer with area less than 5 hectare

We need to segregate the reclassified slope into Soil Conservation

- *Right click vector reclassified slope file > Filter*
- *Enter expression as shown in the figure*
- *Double click DN > Click = sign > click All (this shall display all DN value present in attribute table) > double click 2 > ok*

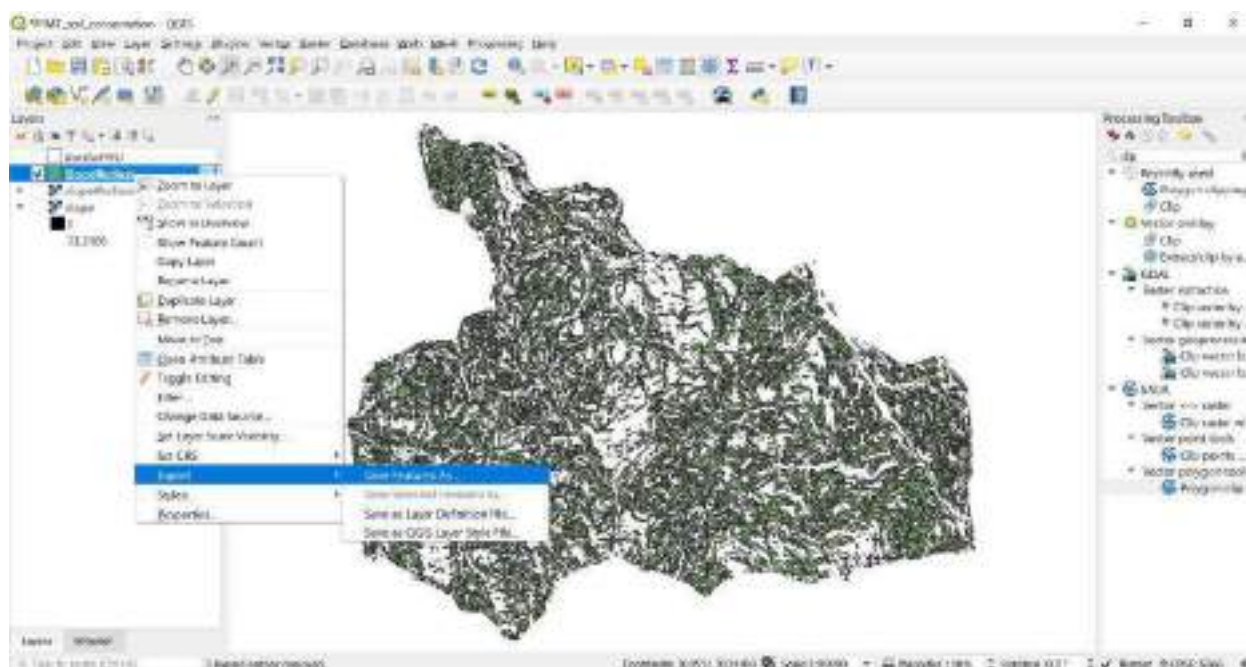


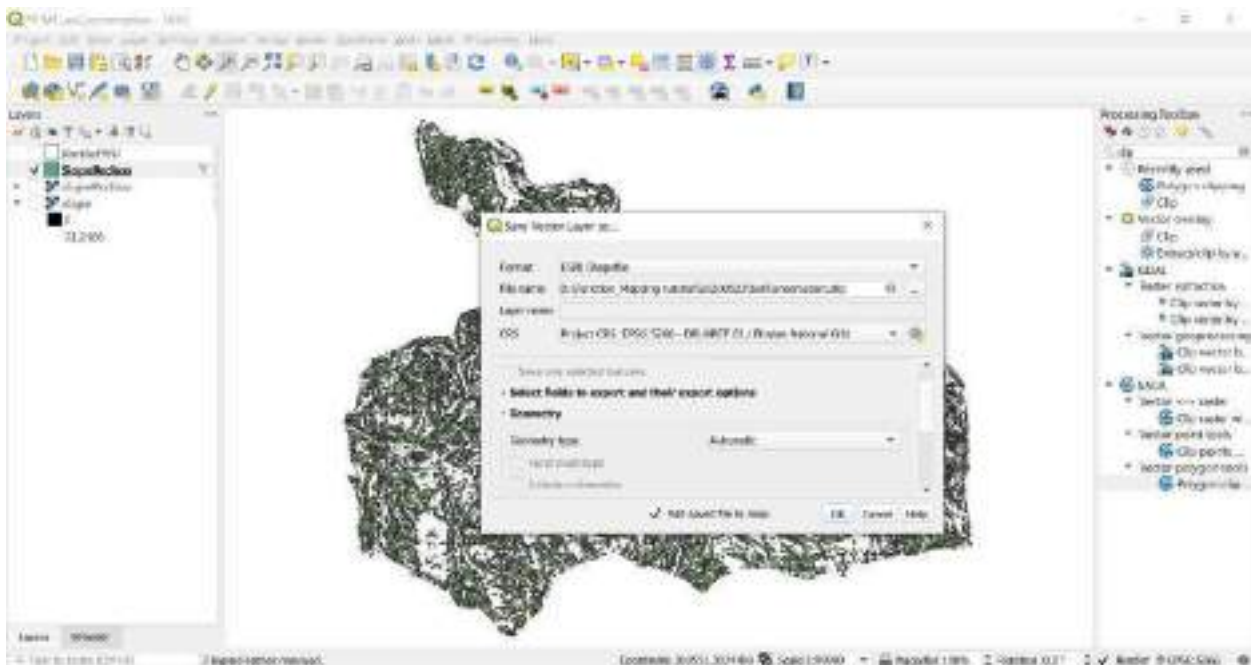




Export the soil conservation layer

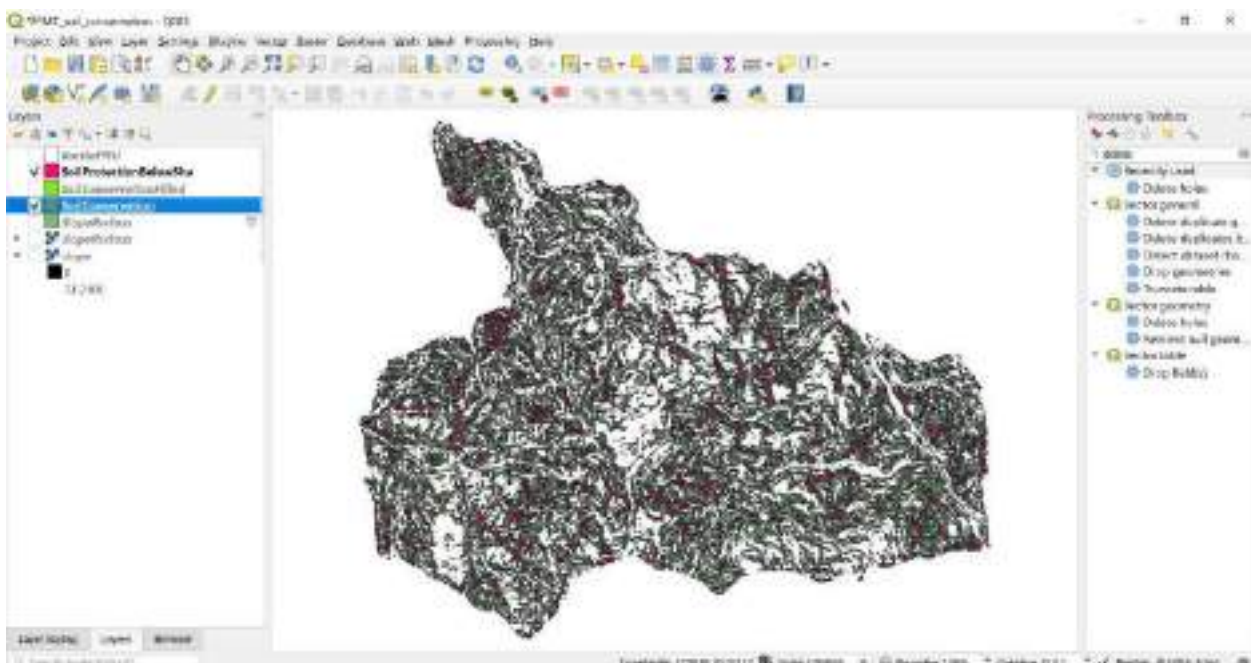
- *Right click on filtered vector reclassified slope file > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *Save the file with appropriate name in working directory*





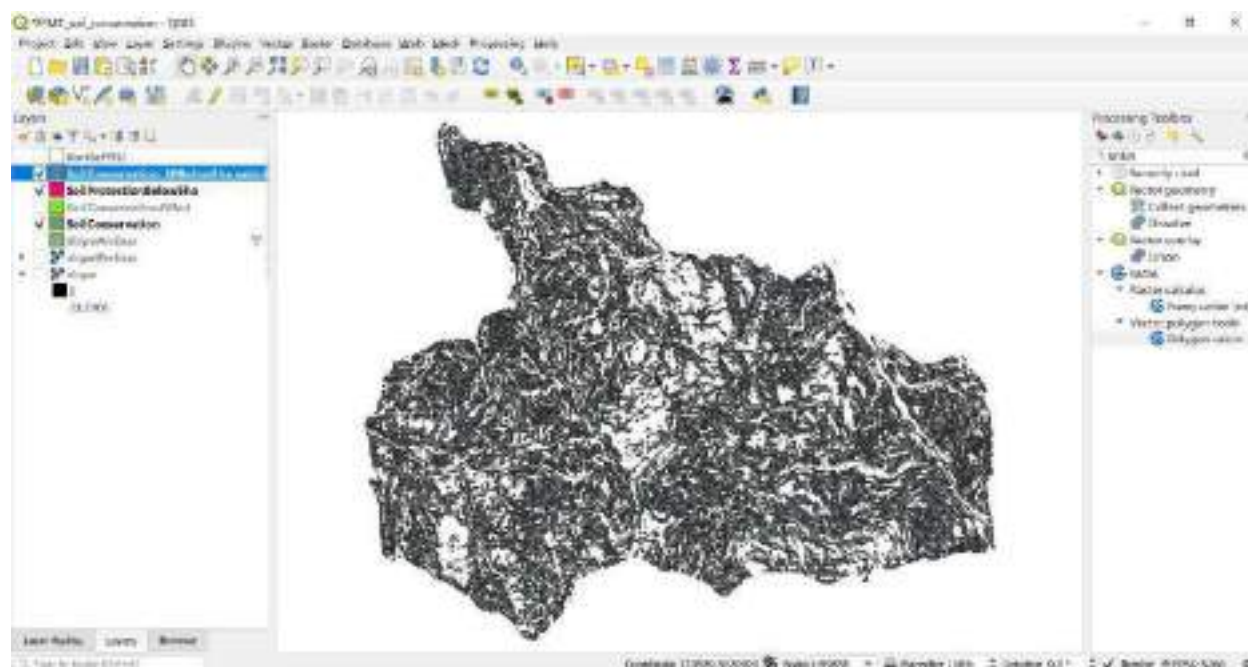
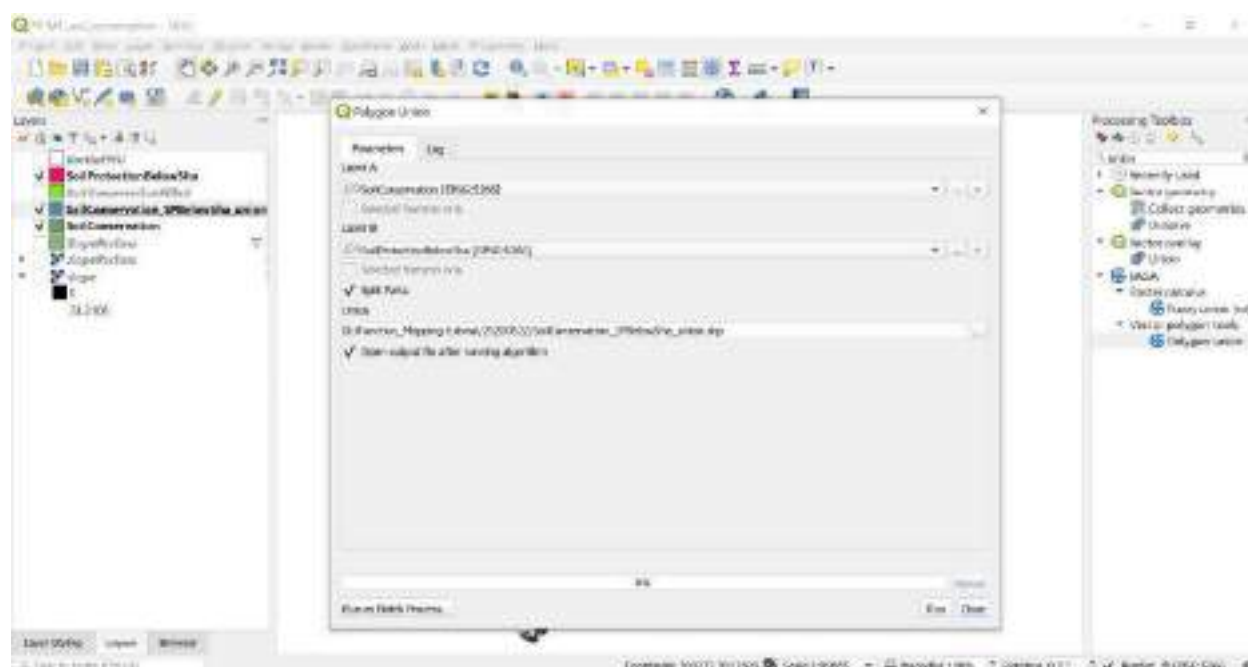
Overlay the soil protection layer with area less than 5 ha

- Add soil conservation layer
- Add soil protection layer less than 5 hectare



We need to combine the filtered soil conservation layer and soil protection area less than 5 ha layer

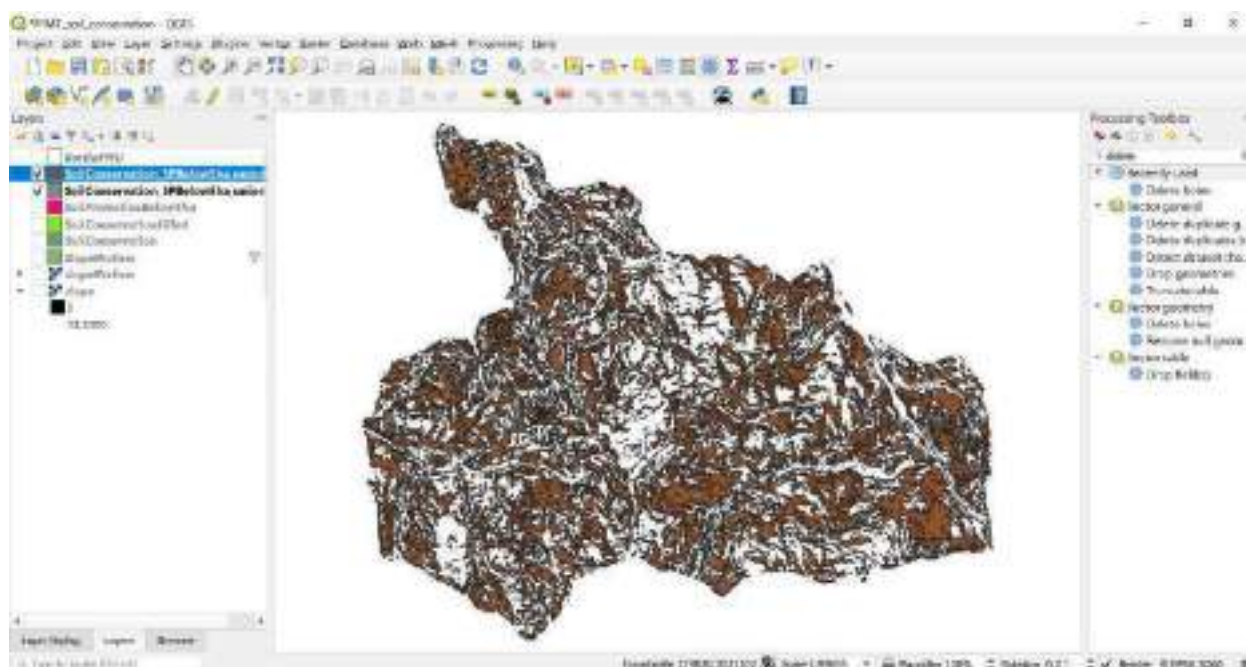
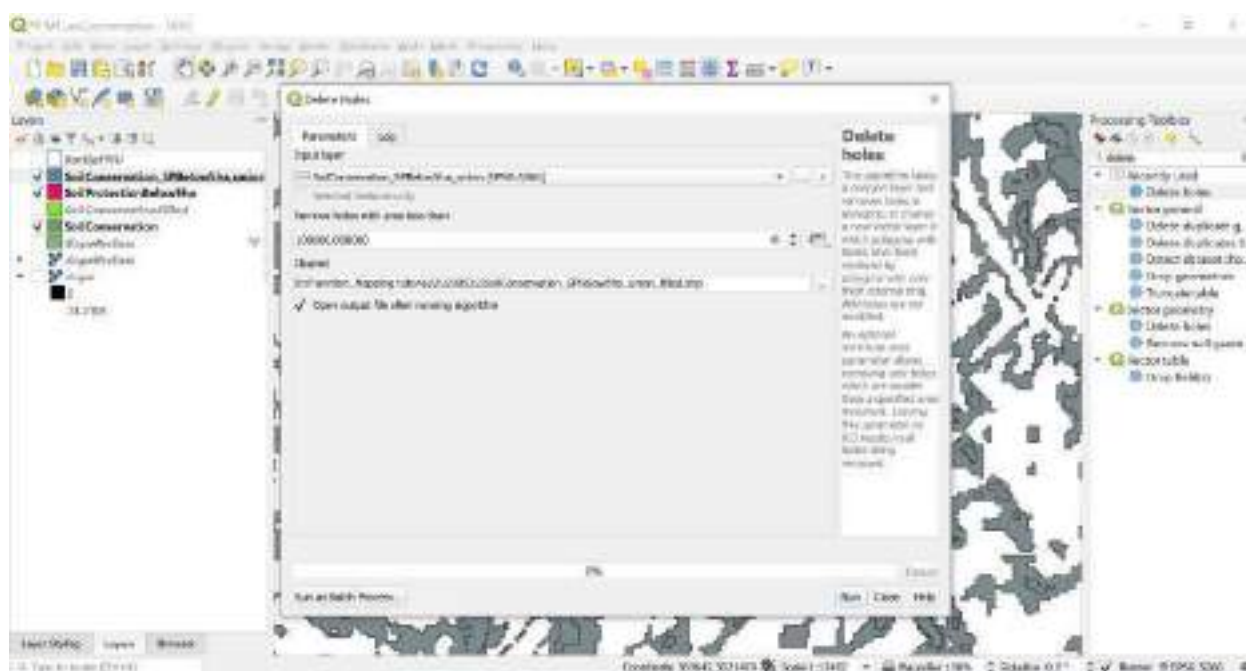
- In the Processing tool box type “Union”
- Double click polygon union under SAGA tools
- In Layer A: Select soil conservation
- In Layer B: Select soil protection below 5 ha
- Save the file with appropriate name in working directory



In the combined soil conservation and soil protection less than 5ha file layer, there are several smaller areas surrounded by steep area. Accessing such areas are impossible, therefore, we need to include those areas under soil conservation.

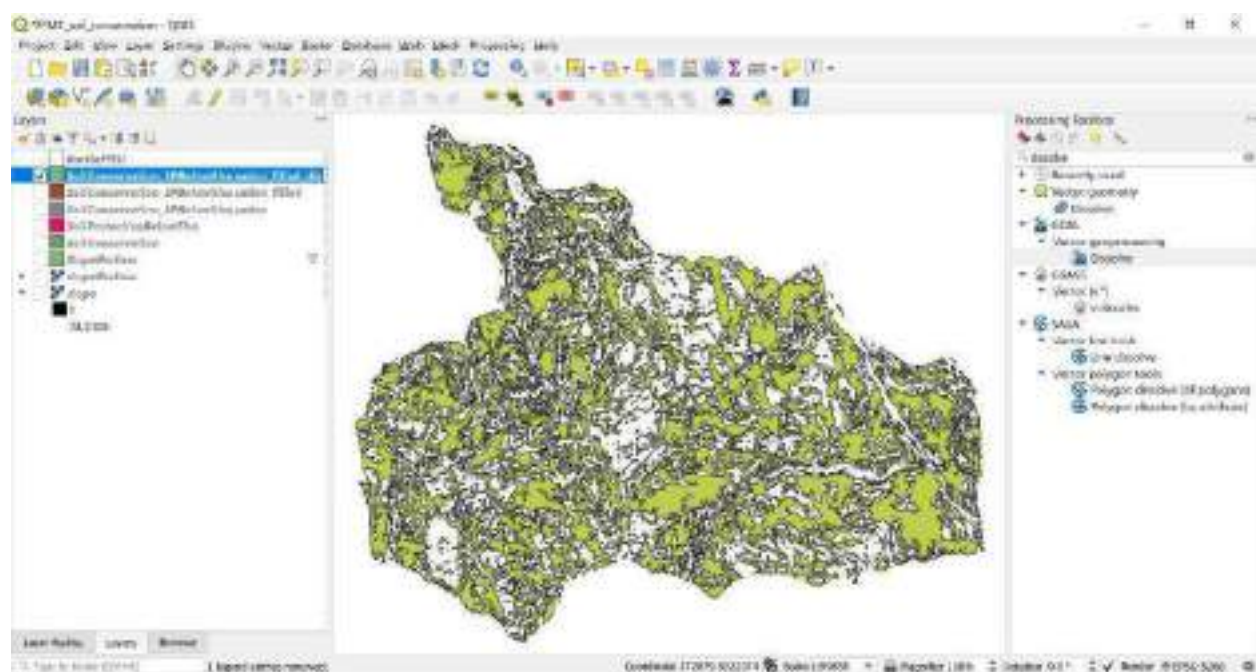
- *In the Processing Toolbox type “delete holes” >double click Delete holes tools*
- *In Input layer select soil protection layer*
- *In Remove holes with area less than enter 100000*
- *Save the file with appropriate name in working directory*





Since there are numerous polygons of soil conservation, these can be made as one polygon for better visualization.

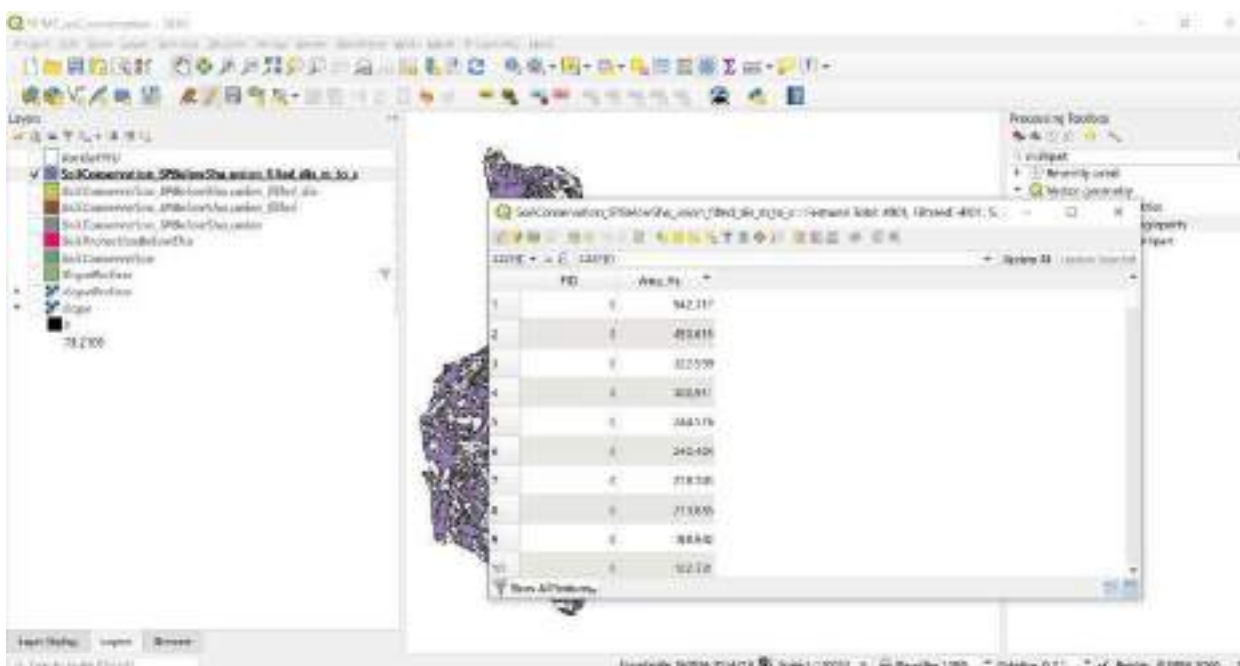
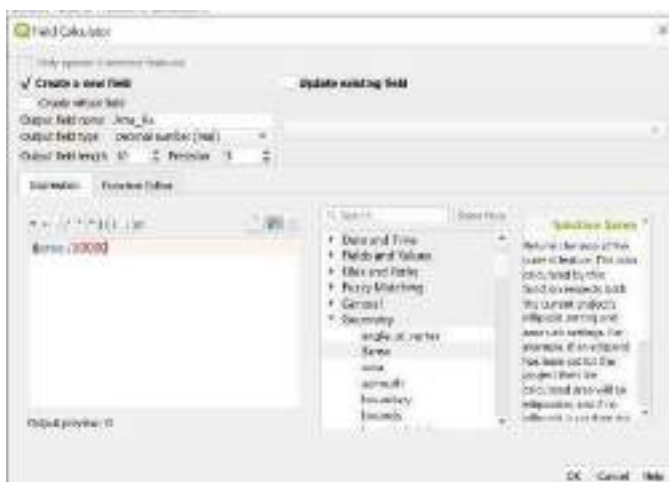
- *Type dissolve in Processing Toolbox*
- *Navigate to GDAL tool and select Dissolve > double click to open the toolbox*
- *Input layer: Select combined soil conservation*
- *Save the file with appropriate name in working directory*



- Click Toggle editing mode > Click Open Field Calculator
- Check in the Create a new field and type as follow
- Output field name: Area\_ha
- Output field type: Decimal number (real)
- Output field length 10 and Precision 3

The expression field should be filled with area calculating expression

- Click Geometry > double click \$area
- In the expression box divide \$area with 10000; this is to convert the calculated area unit from  $m^2$  to hectare.

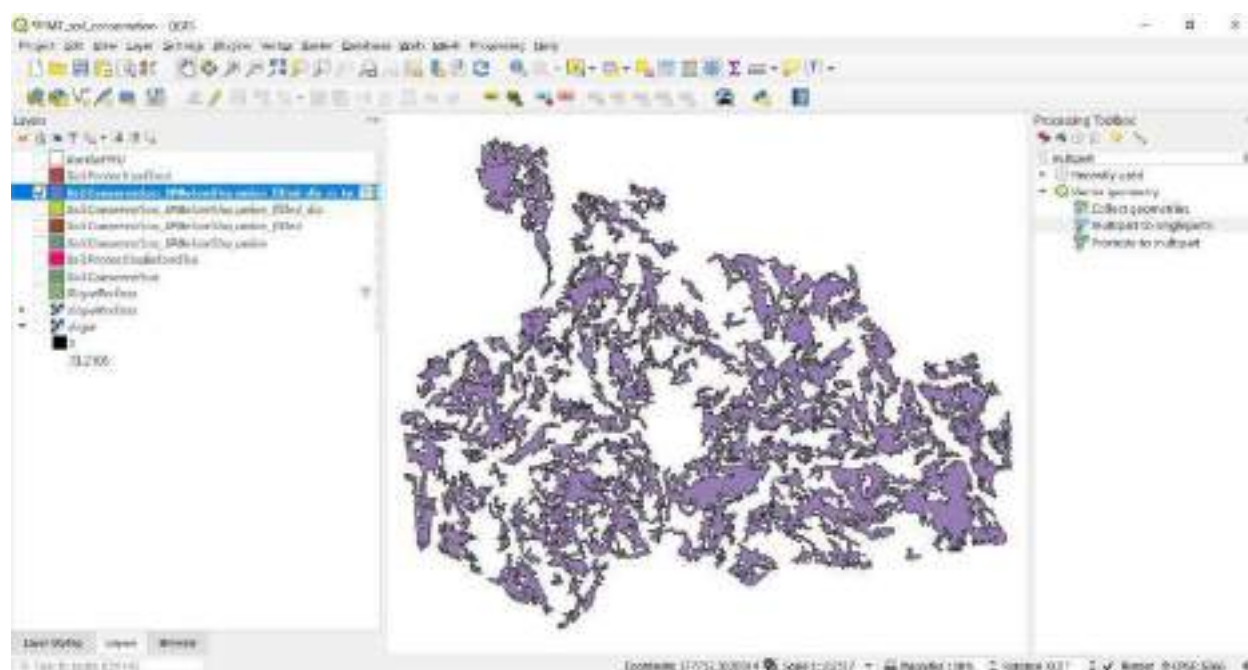
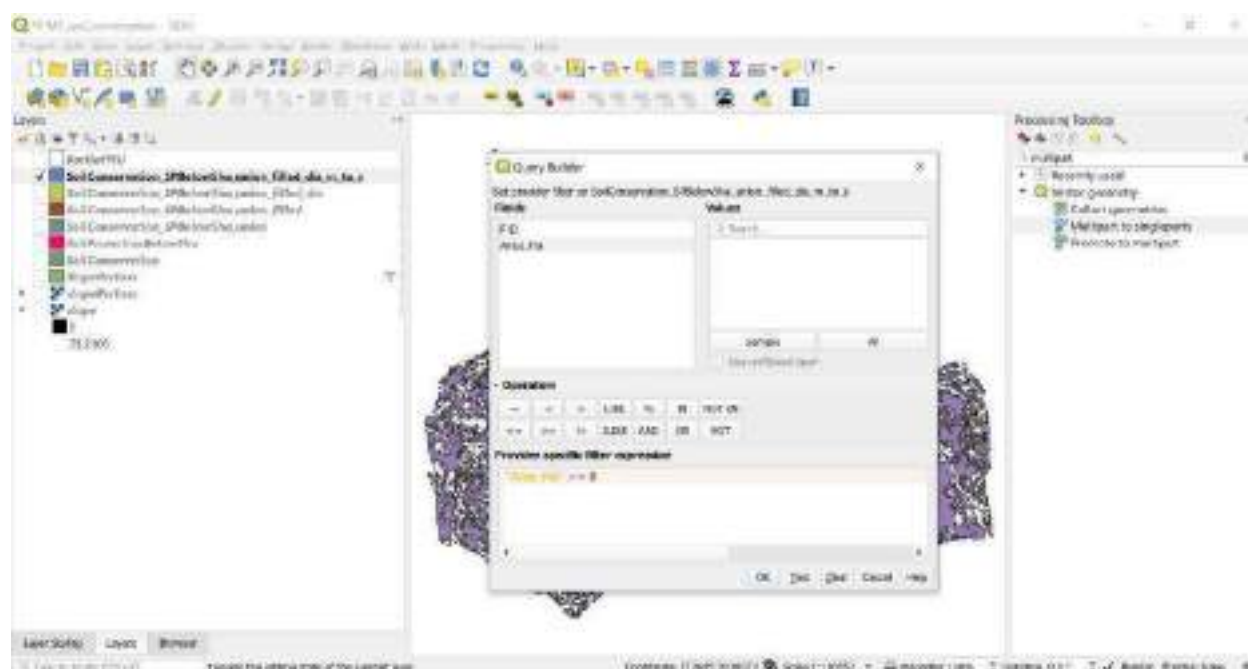


- Close the editing mode by undo toggle editing

Similar to soil protection, here too there are also several isolated smaller areas, this should be removed from soil conservation.

To remove the isolated small patches (of area less than 5 ha) of steep area, filter the area of the soil conservation layer for area greater than or equal to 5 ha ( $\geq 5$  ha)

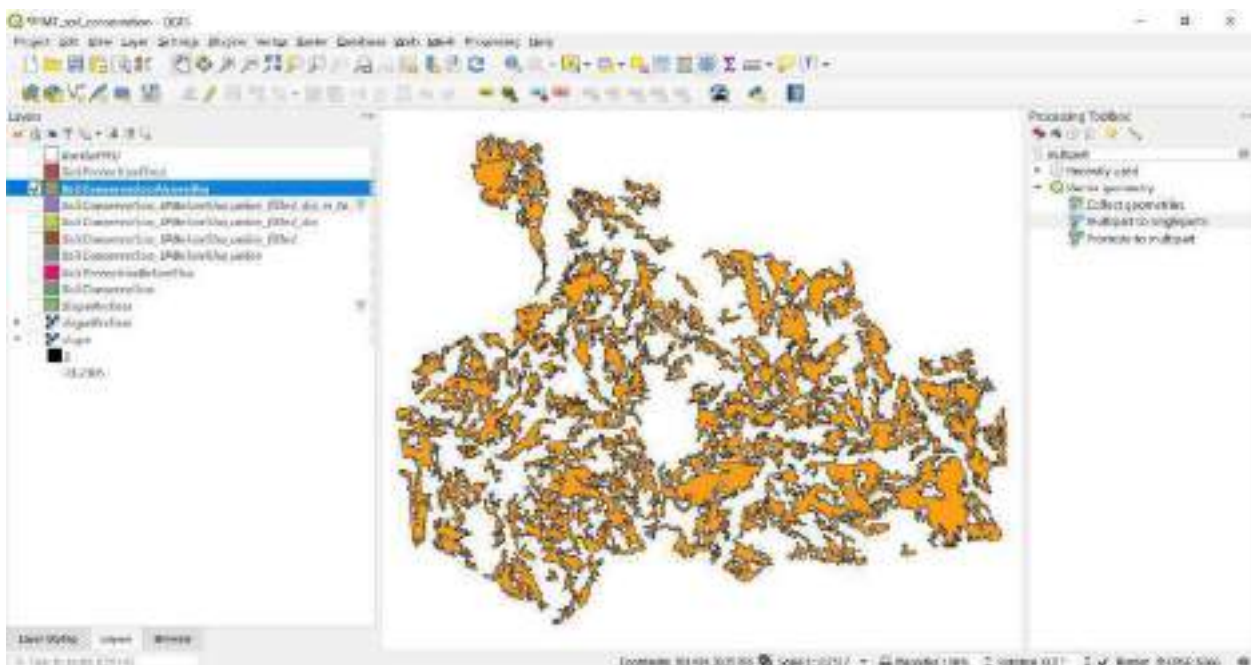
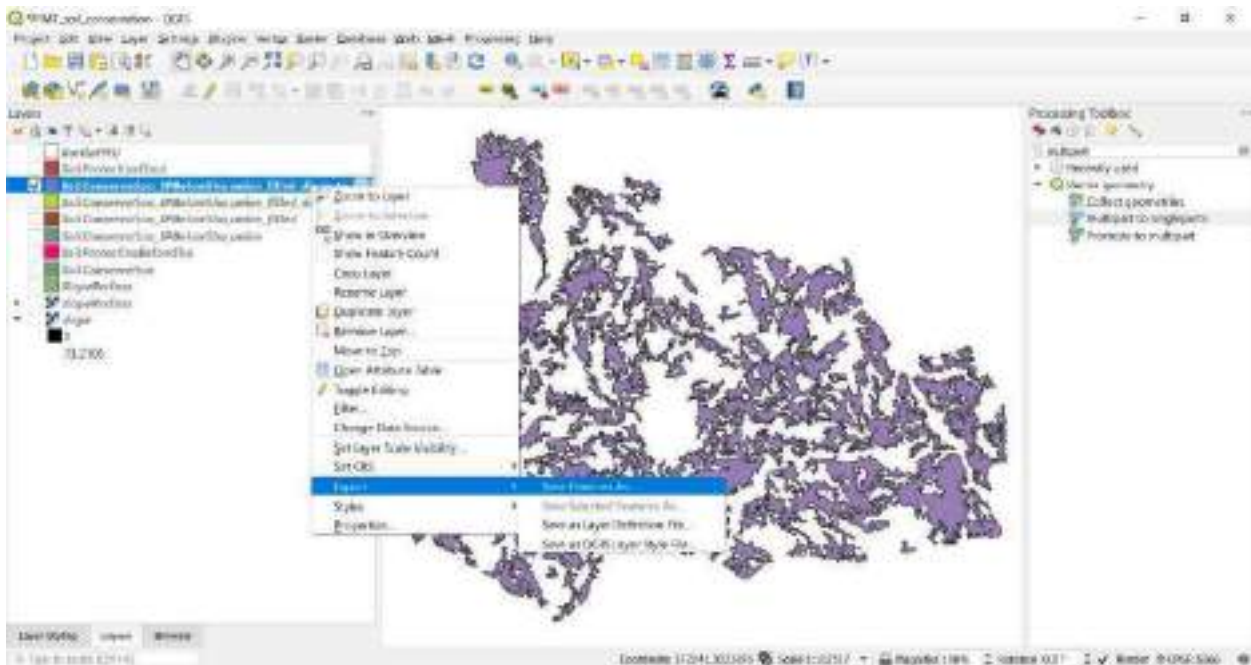
- Right click on working layer > click filter > and enter the expression as shown in picture below in Query Builder



Export the filtered layer and save it as soil conservation layer

- *Right click on filtered layer > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *Save the file with appropriate name in working directory*

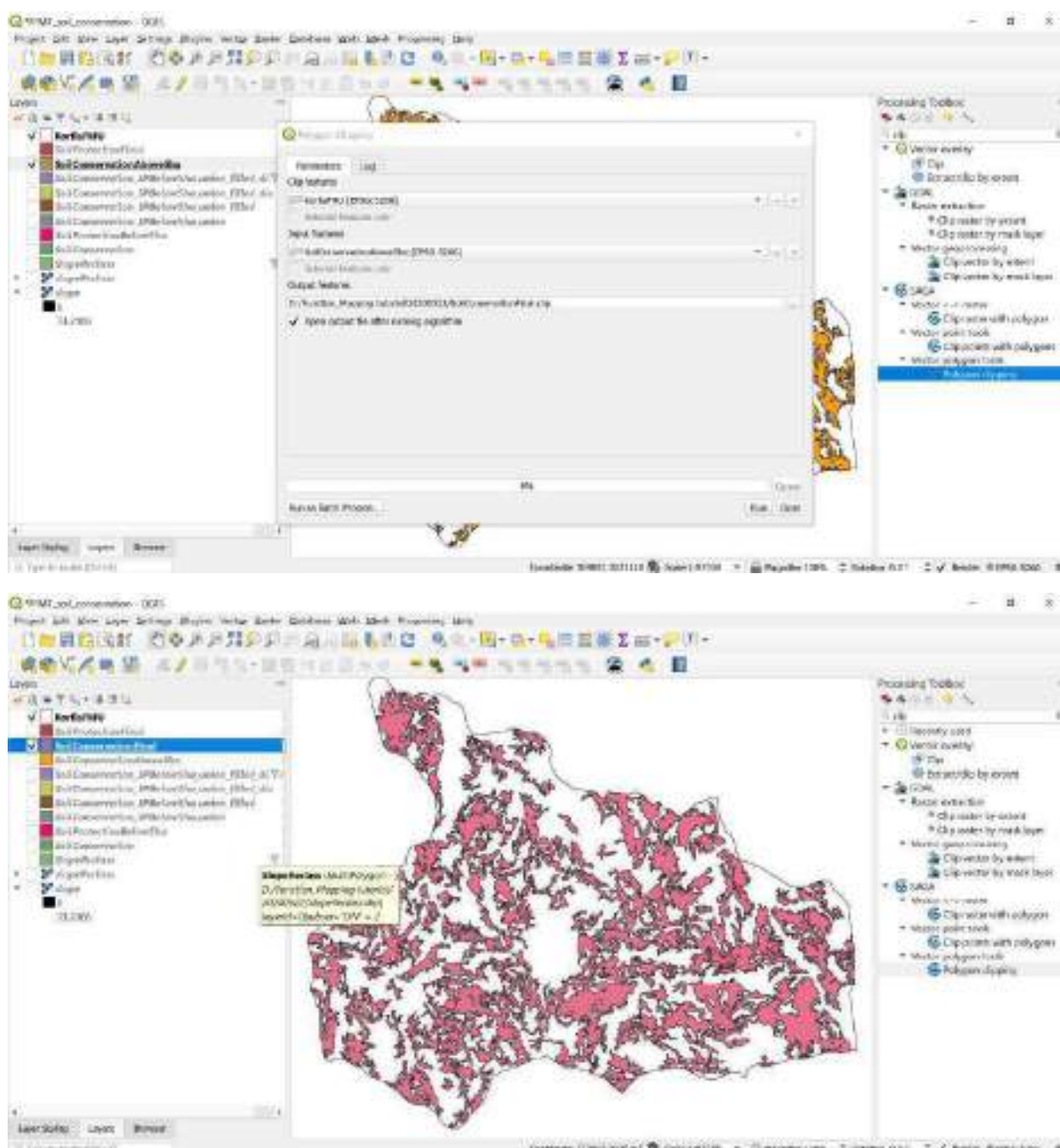




The exported soil conservation layer contains area even outside the FMU boundary as we generated the slope for 500 m buffered FMU boundary. Therefore, we need to extract soil conservation layer within FMU boundary

#### Clip with FMU Boundary

- Type clip in processing toolbox
- Select Polygon clipping from SAGA Tools
- In Clip features: select FMU boundary layer
- In input features: select Soil Conservation layer
- Save the file with appropriate name in working directory



### 1.9.1.2 Water and Watershed Conservation

Water is one of the most valuable natural resources and clean potable water is an indispensable asset for the human population. The protection of water resources therefore gains highest priority in resources management. The function "Water and Watershed Conservation" focuses on the conservation of the cleanliness of the groundwater and surface water bodies and the maintenance of a continuous water supply. According to the objective of the function and the imposed management prescriptions/restriction different sub-functions are defined (Table 1.38).



Table 1.38. Water and Watershed Conservation Functions

	<b>Riparian Reserve Protection (WRR)</b>	<b>Special Management (WSMA)</b>	<b>Local Water Supply Protection (WLS)</b>	<b>Watershed Conservation (WSh)</b>
<b>Definition</b>	<p>Riparian areas occur along the banks of rivers and streams, and around the perimeter of lakes and wetlands. They include the water body itself, areas subject to periodic inundation and flooding, areas with high water tables and immediate adjacent uplands. Streamside vegetation stabilizes stream banks, regulates stream temperatures through shading, and supplies a continual source of coarse woody debris to stabilize stream channels and diversify aquatic habitat. The majority of fish food organisms come from overhanging trees and shrubs, while the nutrients from organic materials that fall or wash into the stream are the basis of aquatic ecosystem productivity. Riparian areas often contain the highest plant and animal diversity, and some of the highest valued non-timber forest resources in the forest landscape. They provide critical habitats, home ranges and travel corridors for many mammal and bird species, and maintain ecologically-important vertical and horizontal linkages throughout the forest landscape.</p>			
<b>Objective</b>	<p>(1) to minimize or prevent negative impacts due to forest resource use on stream channel stability, water quality, and aquatic ecosystem productivity and diversity;</p> <p>(2) to protect and sustain plant diversity associated with riparian areas; and</p> <p>(3) to allow sustainable and environmentally-sound forest uses consistent with objective (1) &amp; (2) above.</p>	<p>(1) to prevent negative impacts due to forest resource use on water quality and stream channel stability</p> <p>(4) to prevent damage to water and irrigation channels</p>	<p>(1) to maintain the cleanliness of both the ground and surface water (water quality);</p> <p>(2) to prevent surface run-off of precipitation and to sustain continuous water supply; and</p> <p>(3) to allow sustainable and environmentally-sound forest uses consistent with objective (1) &amp; (2) above.</p>	<p>Watershed conservation. Forests cover the upper catchment areas of water courses on steep slopes and poorly drained or permanently waterlogged areas.</p>
<b>Legal Restrictions</b>	<p>According to § 14 a (ii) of the Forest and Nature Conservation Act (1995) "no permits shall be issued to fell and take timber within 100 feet (30 m) of the bank or edge of any river, stream, water course and water source.</p>			

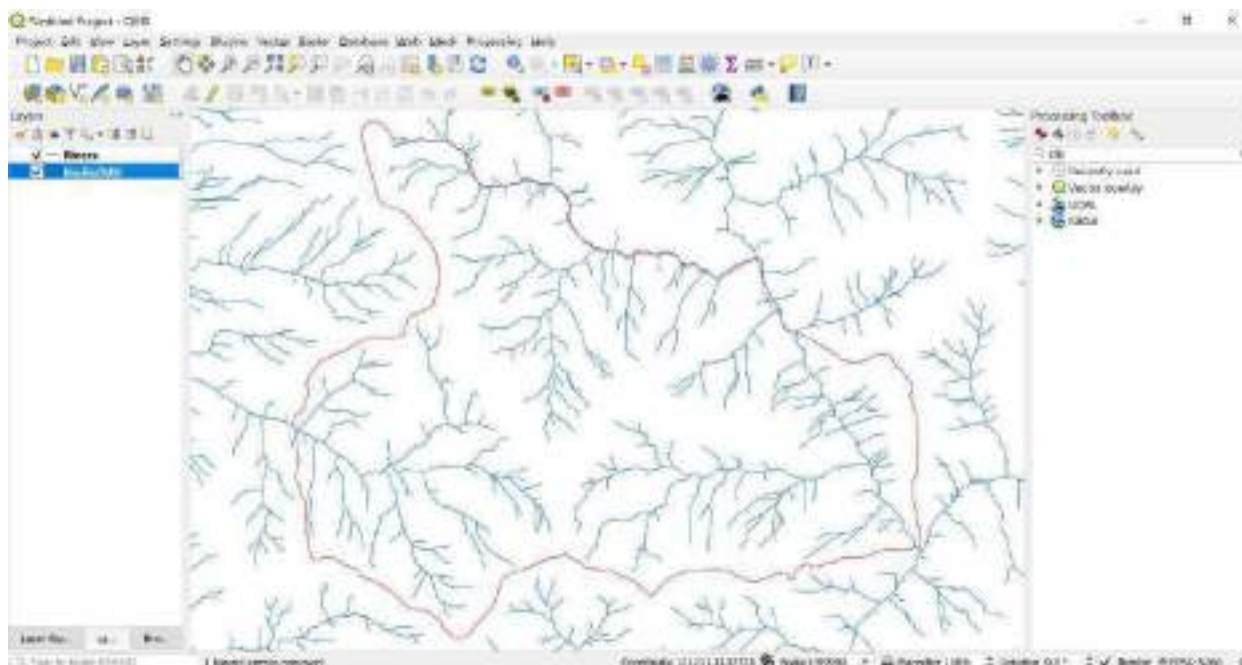
Identification	Stream courses in mountainous landscapes vary considerably in gradient, cross section, flow, stability and ecological importance. To ensure adequate protection the characteristics of the watercourses have to be taken into account.	river, stream, water course and or water source."	The buffer zone consists of the Riparian Reserve (WRR) and an additional 30 m wide protection zone along the outer edge of the Riparian Reserve. Swampy or waterlogged areas feeding the respective water resource shall have to be included. Along water and irrigation channels the buffer zone is 10m each side.	Water conservation measures are necessary in 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, should be classified as Watershed Conservation areas.
GIS Analysis	<ul style="list-style-type: none"> <li>• 30 m buffer on the bank or edge of river</li> <li>• 15 m buffer on the edge of perennial stream</li> <li>• 100 m buffer around lakes</li> </ul>	<p>The size of the Special Management Area extends to the specified distance from the top of the stream bed.</p> <p>Large non-alluvial rivers: 100m</p> <p>Alluvial and semi-alluvial to edge of active rivers and streams: flood plain</p>	<ul style="list-style-type: none"> <li>• 60 m buffer on edge of local water supply stream</li> <li>• 10 m buffer on edge of irrigation channel</li> <li>• 30 m buffer around the water source</li> </ul>	<ul style="list-style-type: none"> <li>• Identify boundaries of upper catchment areas</li> <li>• Identify boundaries of poorly drained or waterlogged sites, moist areas and swamps,</li> <li>• Identify sites serving as water retention or water feeding bodies</li> </ul>
Short Description of Management Prescriptions	<p>Strict Protection!</p> <p>Within buffer zones (riparian reserves) along streams, small rivers and perennials, it is not allowed to carry out any forestry operation except those required to improve the forest condition and to restore its original natural condition. Such rehabilitation activities are: reforestation of cleared sites, beating up, tending, weeding and, if necessary,</p>	<p>Only management restrictions!</p> <p>Forest harvesting operations within the special management zones and 20 m from the top of the entrenchment slopes should minimize disturbance to understory vegetation and damage to residual trees. Silvicultural systems should focus on natural regeneration, with enrichment planting wherever necessary. Clear cutting is prohibited. Woody debris, occurring in the site, should be maintained and no weeding</p>	<p>Strict Protection!</p> <p>No commercial operations shall take place within WLS buffers. Low impact local use shall be permitted, but intensive cattle grazing has to be restricted for hygienic reasons. The establishment of infrastructure, such as, logging camps, log landings and forest roads, is prohibited.</p>	<p>Only management restrictions!</p> <p>Water quality can be affected through the fast decomposition of raw humus layers, the application of chemicals or fertilizers, the wash out of the topsoil and increased surface run-off of precipitation and intensive forest pasture. To sustain and maintain continuous water supply the water infiltration rate should be kept as high as possible. Forest harvesting operations within Watershed Conservation areas should</p>

	<p>sary, from the silvicultural viewpoint in order to increase stability. All those activities have to focus on the establishment of multi-structured, uneven-aged mixed forests and they have to be carried out manually only. The use of machines is strictly prohibited. Local use is limited to the collection of NWFP. Cattle grazing and leaf litter collection are not be allowed. The establishment of infrastructure like logging roads, establishment of log ponds, housing, sawmill and other utilization units, camp-sites, log landings etc. is strictly prohibited within these areas. (Note: Removal of trees shall be considered on epidemic out-break &amp; silvicultural reasons.)</p>	<p>or burning or slash disposal should take place. The conversion of natural forests into plantations is prohibited. Low impact forest use is permitted. However high cattle densities are to be discouraged.</p>	<p><b>Note:</b> Removal of trees shall be considered in the following cases:  1. Epidemic out-break.  2. On silvicultural reasons.</p>	<p>minimize disturbance to under-story vegetation and damage to residual trees. Silvicultural systems should focus on natural regeneration, with enrichment planting only where necessary. Clear cuts and the conversion of natural forests into plantations shall be prohibited. Multi-structured, uneven-aged forests with a high percentage of deep-rooting tree species fulfil the requirements of water conservation in the best way. Local forest use is permitted; however, high cattle densities have to be avoided.  The use of heavy machinery, application of chemicals, dumping of waste (i.e. old oil) and the establishment of logging camps, sawmills, etc. are prohibited.</p>
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## GIS Steps

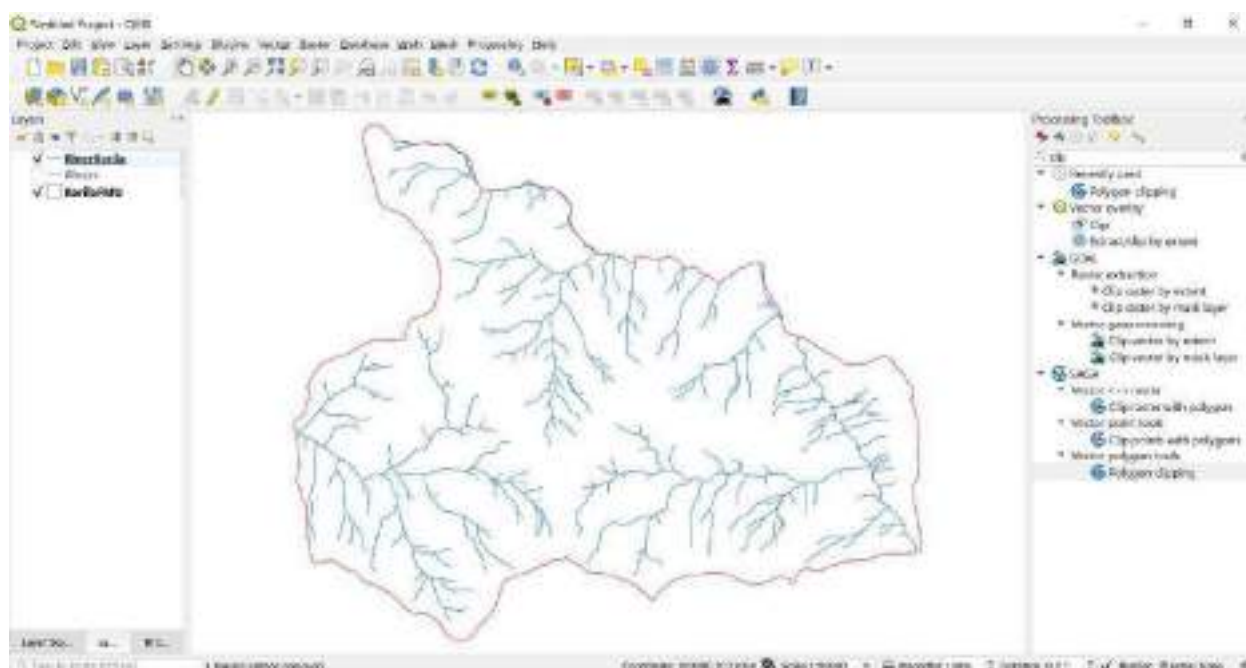
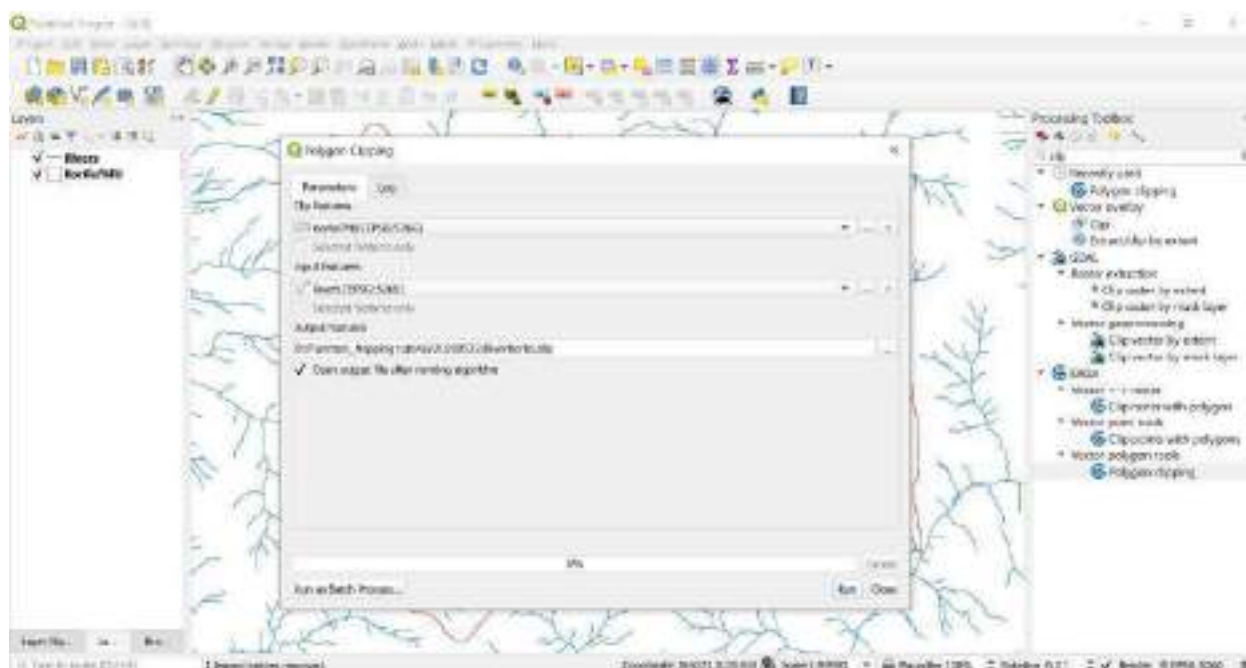
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

- *Open QGIS*
- *Add FMU boundary layer*
- *Add River networks layer*



## Clip with FMU Boundary

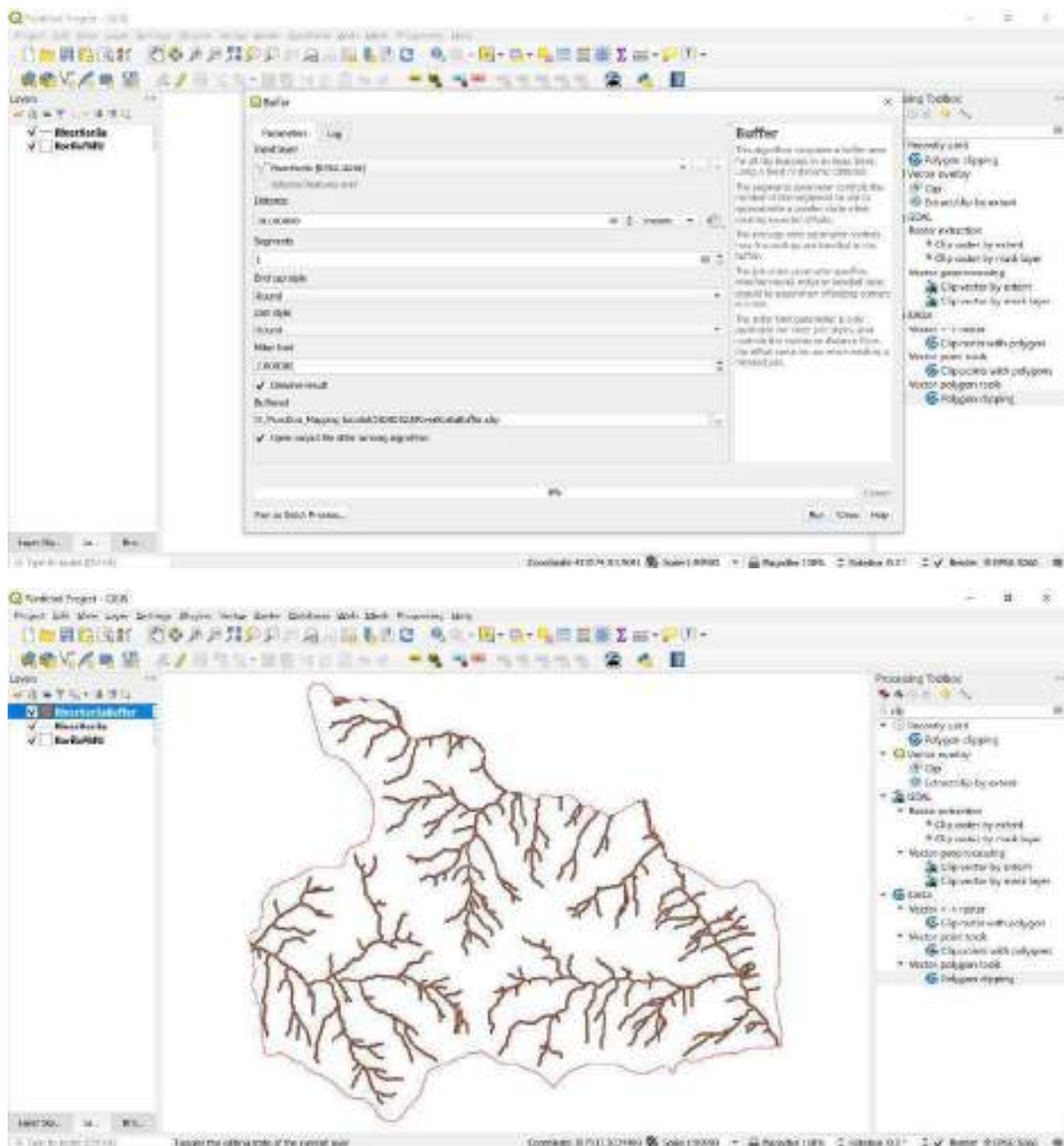
- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select FMU boundary layer*
- *In input features: select River network layer*
- *Save the file with appropriate name in working directory*



Create buffer of 30m around the rivers

- Click Vector > Geoprocessing Tools > Buffer
- In Input layer: Select river layer
- In distance: enter 30
- Check dissolve result
- Rest parameter leave as default
- Save the file with appropriate name in working directory



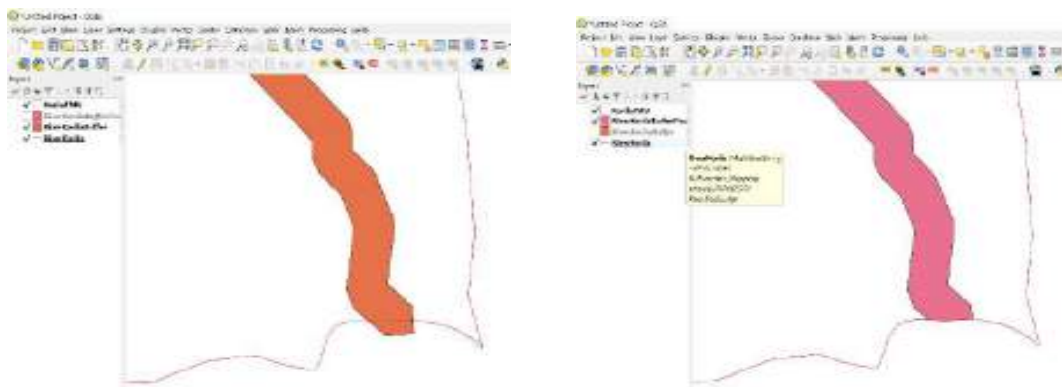


The exported river buffer layer extends beyond FMU boundary. Therefore, we need to extract river buffer layer within FMU boundary

#### Clip with FMU Boundary

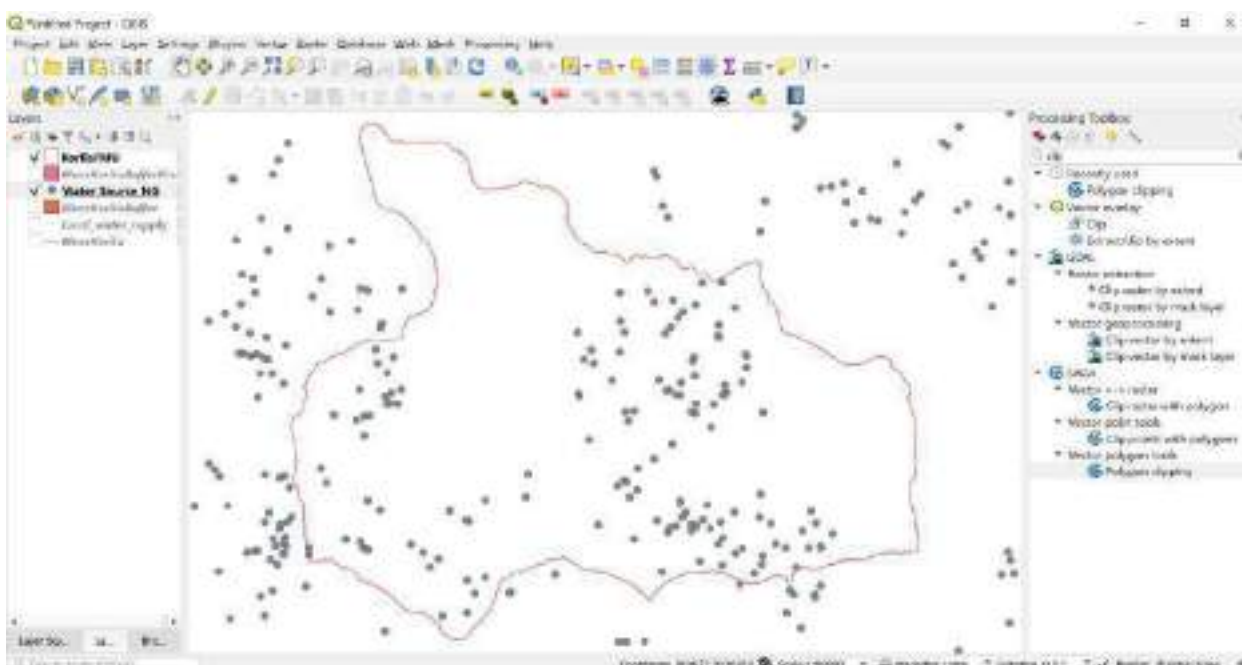
- Type clip in processing toolbox
- Select Polygon clipping from SAGA Tools
- In Clip features: select FMU boundary layer
- In input features: select river buffer layer
- Save the file with appropriate name in working directory





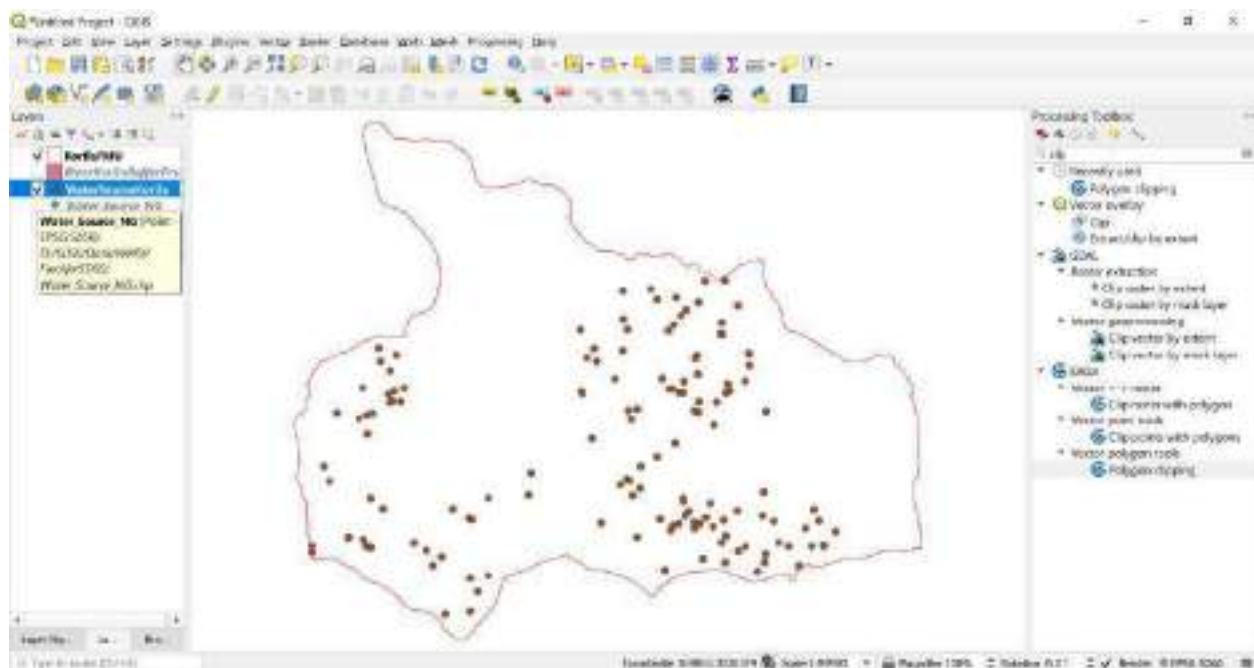
Note: Any stream that is being used as source of local water supply needs to be mapped as local water supply by generating 60m buffer on either side.

- *Add water source point layer*



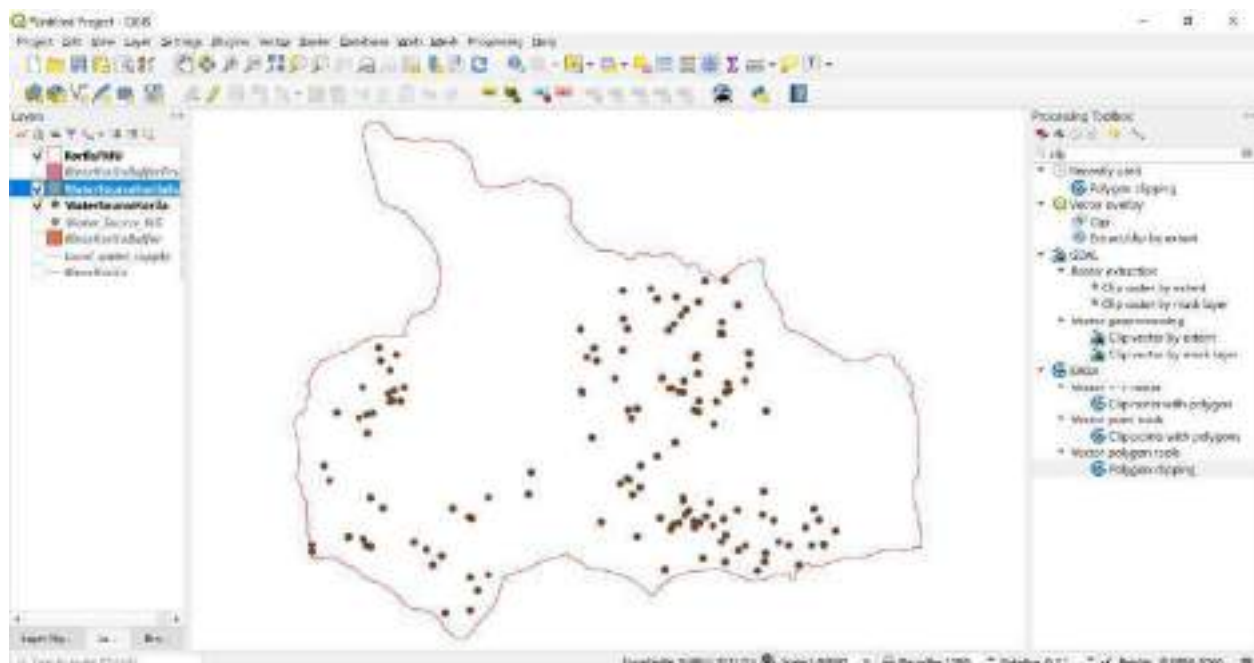
Clip with FMU Boundary

- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select FMU boundary layer*
- *In input features: select water source point layer*
- *Save the file with appropriate name in working directory*



Create buffer of 30m around the water source point

- Click *Vector > Geoprocessing Tools > Buffer*
- In *Input layer*: Select water source point layer
- In *distance*: enter 30
- Check *dissolve result*
- Rest parameter leave as default
- Save the file with appropriate name in working directory



If the generated buffer is extending beyond FMU boundary, it needs to be clipped with FMU boundary

Note: If there is any wetland or watershed area that demands protection form sustainable timber harvesting, then such area can be designated as watershed special management area.

### 1.9.1.3 Social Functions

The local population living in and around the forest landscape depend on forest as a resource for construction timber, firewood and fence posts. They also use the area for collection of NWFP and as cattle grazing ground. To avoid conflicts with commercial logging, the forest area used by the local people must be identified and, if required, a portion of the forest has to be set aside for their exclusive use (Table 1.39). It is of greatest importance, that the identification of the areas used by the local people and the decision on "social functions" is made in a participatory way. Therefore, the identification of social functions is subject of the PRA. There is one problem in defining and mapping social functions: they are not consistent and they depend largely on social framework. Therefore, when mapping the social forest functions, future trends and developments need to be appraised.

Religion plays an important role in Bhutan. Throughout the country, monasteries, *gneys*, meditation houses and other religious objects are located and many of them are in forested areas. To respect the sanctity of these holy places and in order not to disturb people in their religious practice, no forestry operations should take place in the immediate vicinity of religious sites.

Table 1.39. Social functions

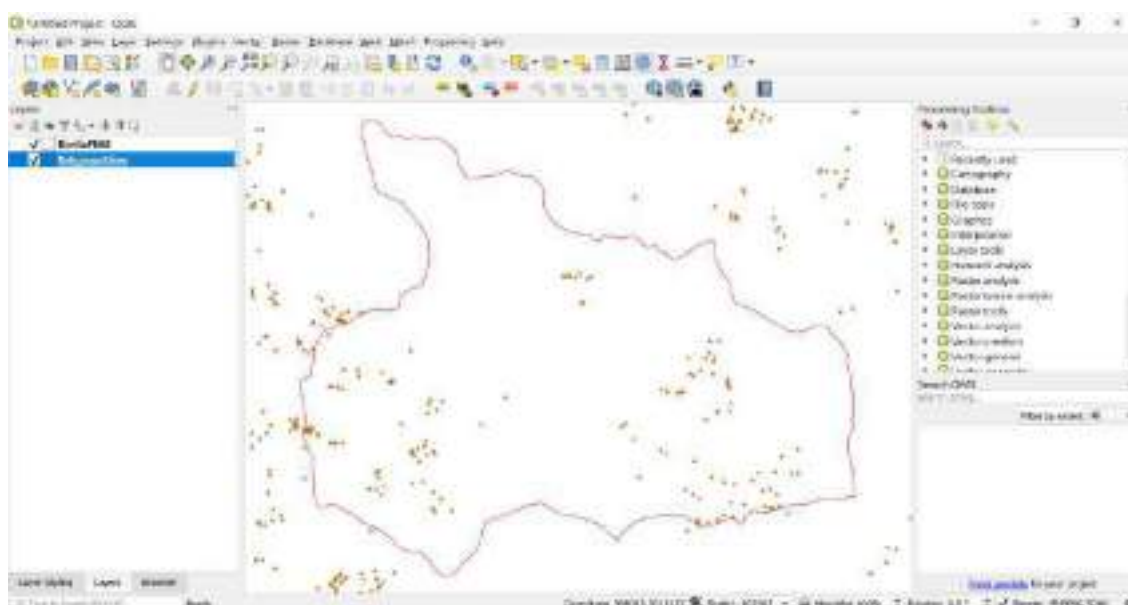
	<b>Social (SocL) (Local Use Only)</b>	<b>Social (SocRS) (Religious Site Protection)</b>
Definition	Forest areas which are, and have been, traditionally used intensively by the local population and which are an integrated and indispensable component of their subsistence should be set aside for Local Use Only.	Religious sites are lhakhangs/goenpas and gneys and all other places used by people to practice religion.
Objective	(1) to provide the local population with sufficient forest products for their subsistence needs in a sustainable way; and (2) to exclude forest areas from commercial logging, where the commercial use of the forest is in contradiction with objective (1).	(1) not to disturb people in their religious practice and to respect the sanctity of these places.
Legal Restrictions	None!	None!
Identification	The definition and mapping of social functions is done during the PRA after the decision has been taken to open a FMU. The procedures for identifying the individual functions shall be prescribed in the PRA manual. Criteria for the identification are: <ul style="list-style-type: none"> <li>•vicinity to settlement or village;</li> <li>•accessibility;</li> <li>•forest type and condition (can the area provide the required product in a sustainable way?)</li> <li>•site capability (production potential)</li> <li>•traditional use and user (any registered rights?)</li> <li>•local demand on wood and NWFP</li> <li>•visibility of boundaries (natural features)</li> <li>•prospective of future social development (i.e. population growth, market structures)</li> <li>•other functions.</li> </ul>	During the process of RRA and PRA all religious sites should be identified and point coordinates collected.

GIS Analysis	<ul style="list-style-type: none"> <li>the local use area boundary agreed during the FMU meeting</li> </ul>	<ul style="list-style-type: none"> <li>100 m buffer on the point coordinates</li> </ul>
Short Description of Management Prescriptions/ Restrictions	<p>No commercial exploitation!</p> <p>Note: Removal of trees shall be considered in the following cases:</p> <ol style="list-style-type: none"> <li>1. Epidemic out-break.</li> <li>2. For silvicultural reasons.</li> </ol>	<p>Strict protection!</p> <p>Buffer zones around religious sites shall have to be exempted from commercial logging. However, silvicultural improvement measures such as planting, weeding, tending and thinning should be planned and implemented if the religious site is located on a Soil Protection area and if the implementation of these measures are required for protecting these objects Only the local forest uses should be permitted which do not disturb the sanctity of the place.</p> <p>Note: Removal of trees shall be considered in the following cases:</p> <ol style="list-style-type: none"> <li>1. Epidemic out-break.</li> <li>On silvicultural reasons.</li> </ol>

#### GIS Steps

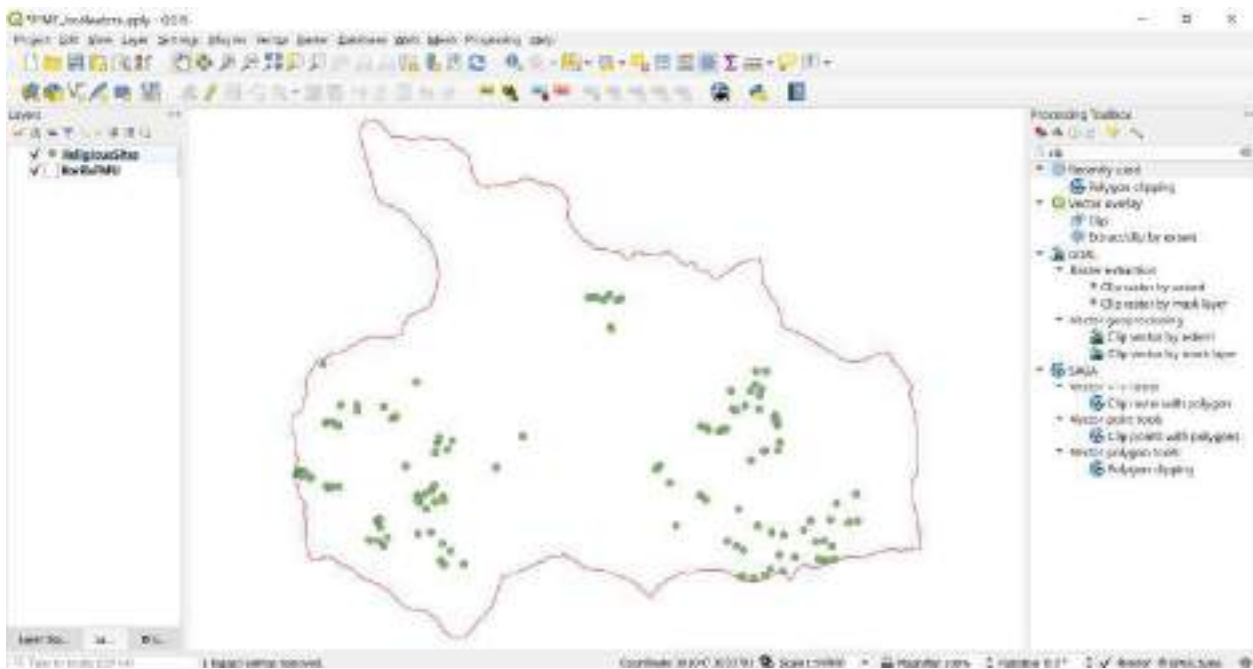
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

- *Open QGIS*
- *Add FMU boundary layer*
- *Add Religious sites layer*



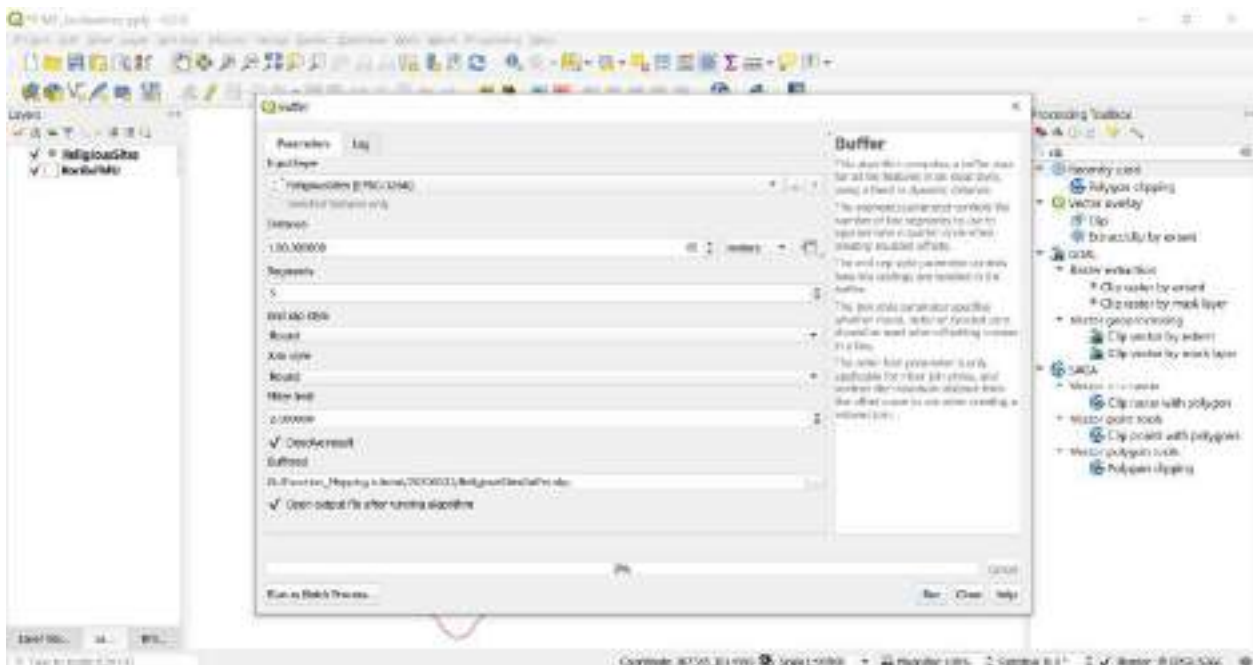
#### Clip with FMU Boundary

- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select FMU boundary layer*
- *In input features: select religious site point layer*
- *Save the file with appropriate name in working directory*

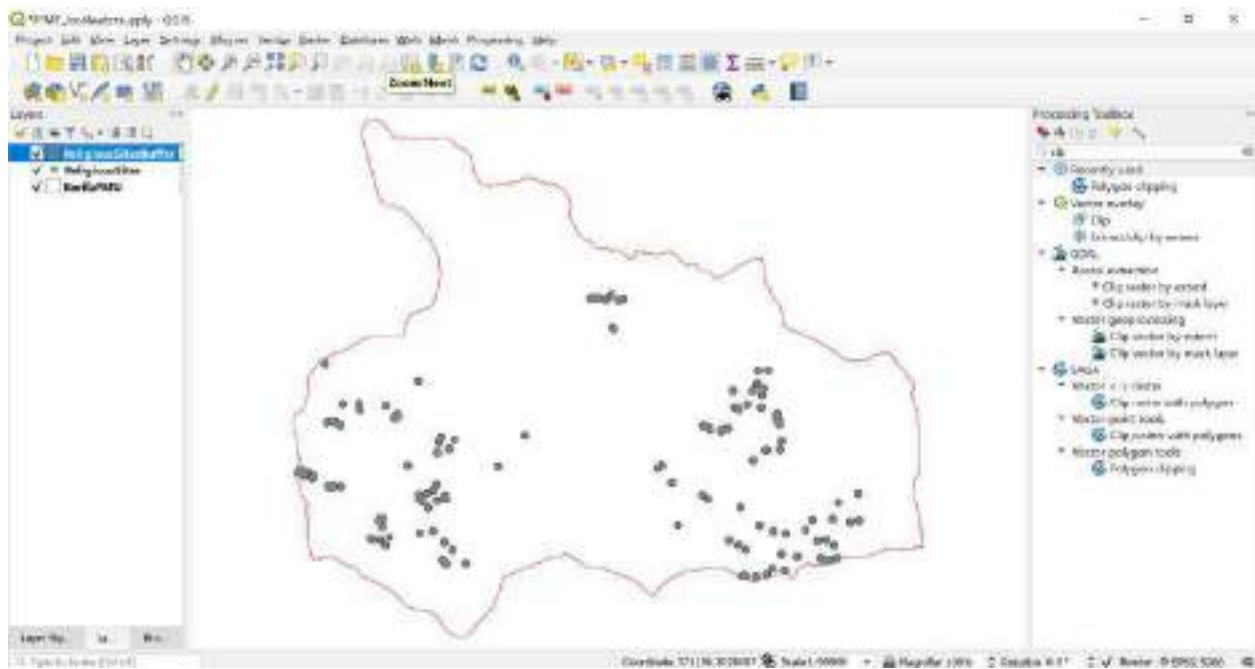


Create buffer of 100m around religious sites

- *Click Vector > Geoprocessing Tools > Buffer*
- *In Input layer: Select water source point layer*
- *In distance: enter 100*
- *Check dissolve result*
- *Rest parameter leave as default*
- *Save the file with appropriate name in working directory*



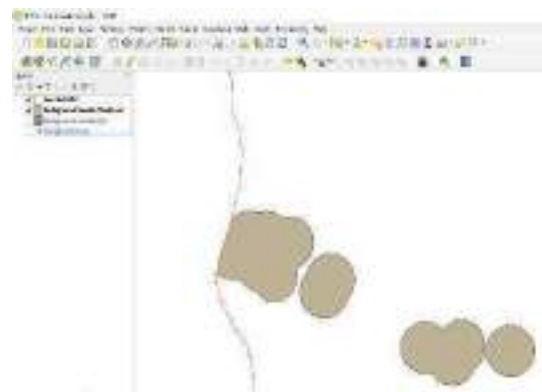
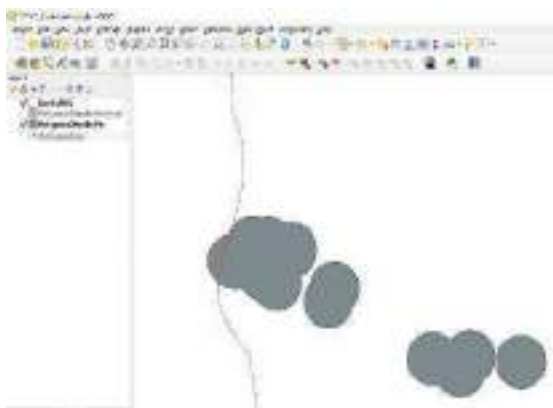




Since the buffer is extending beyond the FMU boundary, clip religious sites buffer with FMU boundary

Clip with FMU Boundary

- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select FMU boundary layer*
- *In input features: select religious site buffer layer*
- *Save the file with appropriate name in working directory*





#### 1.9.1.4 Nature Conservation

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

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

Table 1.40. Nature conservation functions

	Wildlife Protection (NWP)	Wildlife Conservation (NWC)	Biodiversity Protection (NB)
Definition	This function includes all habitats and other areas where <u>rare or endangered mammals and birds</u> occur and where the protection of these animals gains highest priority.	All forests areas <u>rich in species variety and number of wildlife</u> , in particular, mammals and birds.	<p>Biodiversity can be defined as the diversity of plants, animals and other living organisms in all their forms and level of organization, including genes, species, ecosystems and the evolutionary and functional processes that link them. Biodiversity does not entail merely the preservation of a few rare, endangered or interesting species, but rather the protection and conservation of the diversity of species, genetic materials, biophysical processes and ecosystem structures that together determine biological productivity and stability.</p> <p>The <u>diversity</u> of a given ecosystem is defined by the following three components:</p> <ul style="list-style-type: none"> <li>• <b>Composition:</b> Ecosystems are composed of organisms, species, groups of interacting species, genetic diversity within species, the remains of dead organisms, and various inorganic compounds;</li> <li>• <b>Structure:</b> Ecosystem structure arises from the patterns in which the basic building blocks of composition occur. There are two types of structure: physical structure or spatial pattern (i.e. canopy layer, patchiness in distribution of species, etc.) and social structure (relationship of individuals, species, group of species to each other and to the ecosystem as a whole).</li> </ul> <p><b>Function:</b> Function refers to the actions or interrelationships between components of composition and structure.</p>
Objective	(1) to conserve the habitat of protected wild animals and corridors for their movement; and	(1) to minimize or prevent negative impacts due to forest resource use on wildlife habitats and to minimize	(1) to preserve rare and extra-ordinarily rich ecosystems and ecological niches and to protect them from human interference in order to conserve the biological diversity within the concerned FMU.

	(2) to prevent the protected animals from human disturbance.	disturbances due to human impacts.	
Legal Restrictions	<i>According to § 22 (a) of the Forest and Nature Conservation Act of 1995 altogether 23 wild animals are totally protected in Bhutan (Table 1.41).</i>	None!	<i>According to § 22 of Forest and Nature Conservation Act of 1995 the following plants are totally protected (Table 1.41)</i>
Identification	The determination of wildlife protection and conservation areas should be done during EA exercise, which should be carried out in close consultation with NCD, NEC, WWF and RSPN. Useful information can be derived from the FMU inventory and RRA/PRA. Criteria for the identification are: type and number of wildlife species and protection status, actual vegetation and habitat condition, habitat size, and degree of disturbance.		<p>The following areas should be allocated to forest function "Biodiversity Protection" (NB).</p> <ul style="list-style-type: none"> <li>• ecosystems rich in biological diversity (in particular flora and non-vertebrate animals such as reptiles, insects, amphibians);</li> <li>• rare ecosystems (i.e. swamp forests, gallery forests, alpine shrubs);</li> <li>• ecosystems and areas with a high percentage of protected flora; and</li> <li>• forest areas which should be conserved because of their extra-ordinary composition or structure.</li> </ul> <p>NB-areas are generally smaller than Wildlife Conservation areas and may range between 1 and 100 (or more) hectares.</p>
GIS Analysis	All areas where protected wildlife species occur.	Areas identified as biological corridors and all <u>areas rich in wildlife</u> , both in species and in number. Especially breeding areas, watering places, etc.	All areas rich in biological diversity
Short Description of Management Prescriptions/Restrictions	Strict protection! Within wildlife refuge areas commercial logging is strictly prohibited. Local forest use is only permitted if the habitat quality and structure is not significantly changed and disturbance to the protected animals is not long lasting and kept to a minimum. Road construction within wildlife refuge areas should be avoided as much as possible.	Only management restrictions! Forest operations within Wildlife Conservation zones should minimize disturbance to understory vegetation, in particular bamboo, and to residual trees. Fruit and fodder trees for wild animals have to be excluded from exploitation. Small pasture areas or gaps have to be left open and should not be reforested. Logging operations should	Strict protection! <u>Commercial and local forest use are strictly prohibited</u> . This refers also to the collection of NWFP and other minor forest products. If possible, these areas should be exempted from grazing. No road construction within NB areas.

	<p><b>Note:</b> Removal of trees shall be considered in the following cases:</p> <ol style="list-style-type: none"> <li>1. Epidemic outbreak.</li> <li>2. On silvicultural reasons.</li> </ol>	<p>leave behind some undisturbed forest patches irregularly distributed within a coup.</p> <p>At least one snag tree per ha of big diameter has to be left in order to provide arboreous living animals with tree cavities.</p>	
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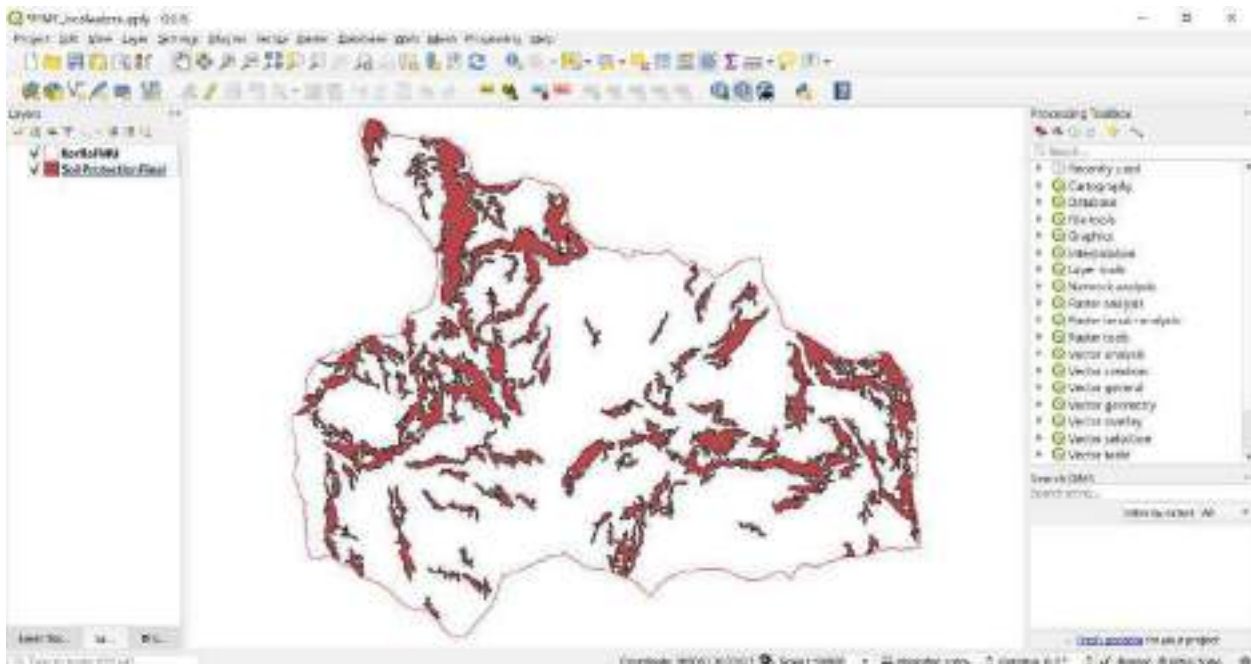
Table 1.41 List of totally protected wild animals and Plants as per FNCA 1995

List of totally protected wild animals			
No.	Common Name	Scientific Name	
1.	Asian Elephant	<i>Elephas maximus</i>	
2.	Clouded Leopard	<i>Neofelis nebulosa</i>	
3.	Golden Langur	<i>Presbytis geei</i>	
4.	Musk Deer	<i>Moschus chrysogaster</i>	
5.	Pangolin	<i>Manis crassicaudata</i>	
6.	Pigmy Hog	<i>Sus sylvanicus</i>	
7.	Snow Leopard	<i>Panthera uncia</i>	
8.	Takin	<i>Budorcas taxicolor</i>	
9.	Tiger	<i>Panthera tigris</i>	
10.	Wild Buffalo	<i>Bubalus bubalis</i>	
11.	Black-Necked Crane	<i>Grus nigricollis</i>	
12.	Monal Pheasant	<i>Lophophorus impejenus</i>	
13.	Peacock Pheasant	<i>Polyplectron bicalcaratum</i>	
14.	Raven	<i>Corvus corax</i>	
15.	Rufus-Necked Hornbill	<i>Aceros nepalensis</i>	
16.	Golden Mahseer	<i>Tor tor</i>	
17.	Spotted Deer	<i>Axis axis</i>	
18.	Gaur	<i>Bos gaurus</i>	
19.	Leopard	<i>Panthera pardus</i>	
20.	Leopard Cat	<i>Felis bengalensis</i>	
21.	Himalayan Black Bear	<i>Selenarctos thibetanus</i>	
22.	Red Panda	<i>Ailurus fulgens</i>	
23.	Serow	<i>Capriicornis sumatraensis</i>	
List of totally protected plants			
No.	Local Name	Common Name	Scientific Name
1.	Agar/agaru	Eagle Wood/Indian Aloe Wood	<i>Aquilaria malaccensis</i>
2.	Yaetsa-guenboop	Chinese caterpillar	<i>Cordyceps sinensis</i>
3.	Pang-gen metog		<i>Gentiana crassuloides</i>
4.		Snow down lily	<i>Lloydia yunnanensis</i>
5.	Tsher-ngeon	Blue poppy	<i>Meconopsis grandis</i>
6.	Kirang-shing	Yew	<i>Taxus baccata</i>
7.	Bhreeng-gee-ra-dza	Ginseng	<i>Panax pseudo-ginseng</i>

If there is any threatened and protected flora, fauna and avi-fauna is present within the FMU boundary, their habitat should be mapped out. If there are no such threatened and protected species, mapping this function may not be necessary. Similarly, in this example FMU, there are no such species. In such cases, soil protection function can be an overlapping function. Soil protection function can be also mapped as wildlife protection function.

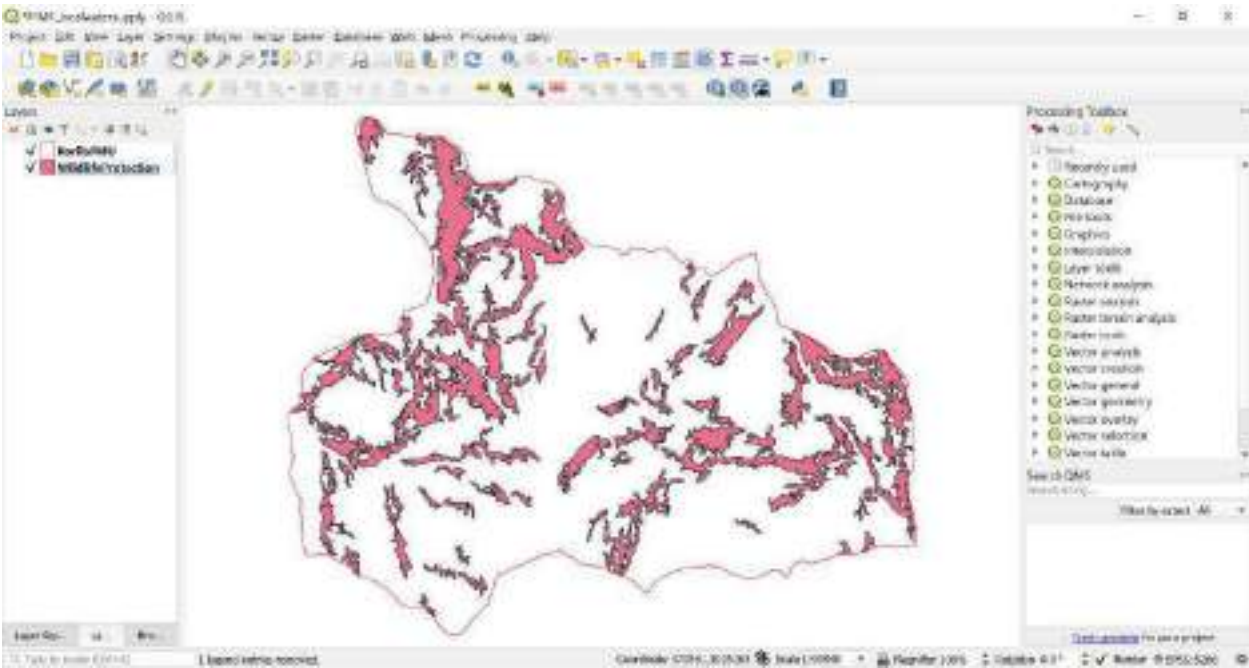
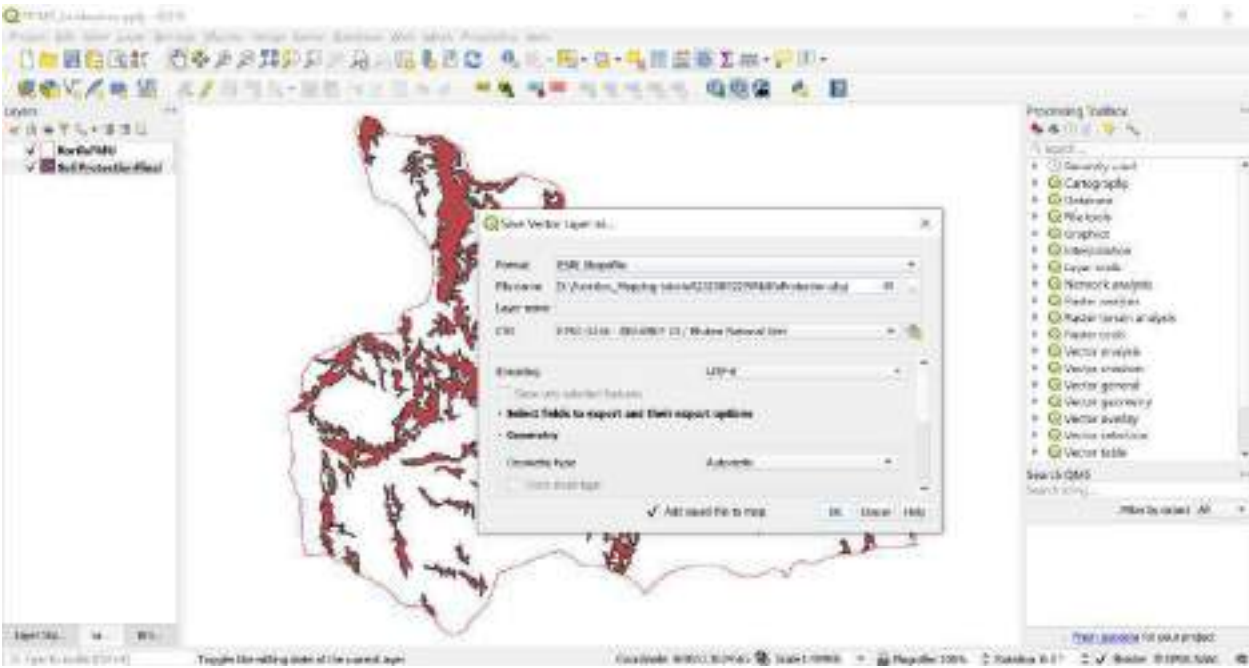
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

- *Open QGIS*
- *Add FMU boundary layer*
- *Add Soil Protection layer*



Export this soil protection layer as wildlife protection layer

- *Right click on filtered vector reclassified slope file > Export > Save Features As*
- *Save the file with appropriate name in working directory*



### 1.9.1.5 Road Buffer

Bhutan being a mountainous country, motorable roads are often constructed on steep slope. In order to protect the road from falling boulders, soil erosion, land and snow slides, and surface run-off the forest lying on either side of the road should be kept undisturbed.

Table 1.42. Road Buffer Function

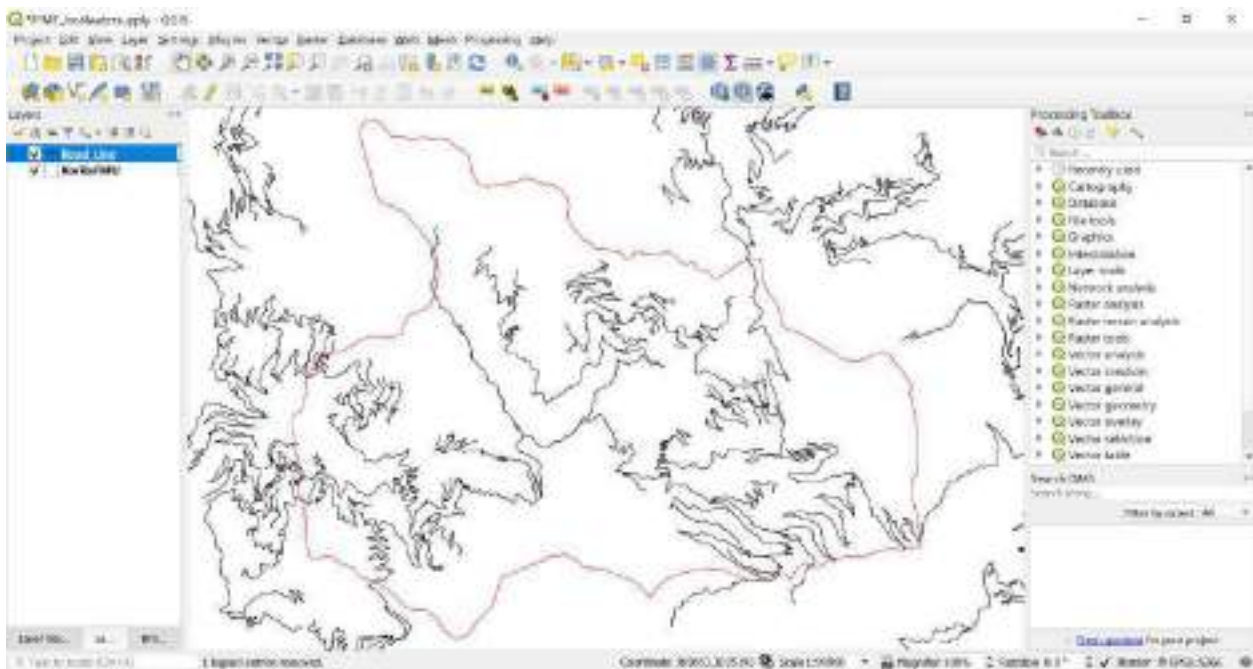
Road Buffer (RB)	
Definition	A road buffer is the zone along a road where the implementation of forest activities may have direct negative impact on the road itself or on the security of the traffic.
Objective	to protect the road from rock fall, land and snow slides, surface runoff of precipitation and erosion and to safeguard traffic.
Legal Restrictions	According to § 14 a (i) of the Forest and Nature Conservation Act (1995) "no permit shall be issued to fell and take any timber within 600 feet (200 m) uphill and 300 feet (100 m) downhill of motorable roads <u>except forest roads</u> ."
Identification	Segregate between public motorable road and forest road
GIS Analysis	<ul style="list-style-type: none"> <li>• National Highway: 180 m buffer on either side of the road</li> <li>• Dzongkhag road: 30 m buffer on either side of the road</li> <li>• Farm road: 30 m buffer on either side of the road</li> <li>• Access road: 30 m buffer on either side of the road</li> <li>• Forest road: 20 m buffer on either side of the road</li> </ul>
Short Description of Management Prescriptions/ Restrictions	<p><u>Commercial logging within road buffer zones is prohibited, including felling and removal of trees for local use.</u> However, trees which are a source of danger for the road, or the traffic on it, shall have to be felled as soon as possible. This refers namely to dead or decayed trees, or exposed single trees which may break or fall during storms or heavy winds. The collection of NWFP such as fruits, medicinal herb, mushrooms etc. for the local use may be permitted as well as the collection of dead wood and fallen branches for firewood.</p> <p>Note: Removal of trees shall be considered in the following cases:</p> <ol style="list-style-type: none"> <li>1. Epidemic out-break.</li> <li>2. On silvicultural reasons</li> </ol>

#### GIS Steps

This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to used QGIS version 3.12 and above.

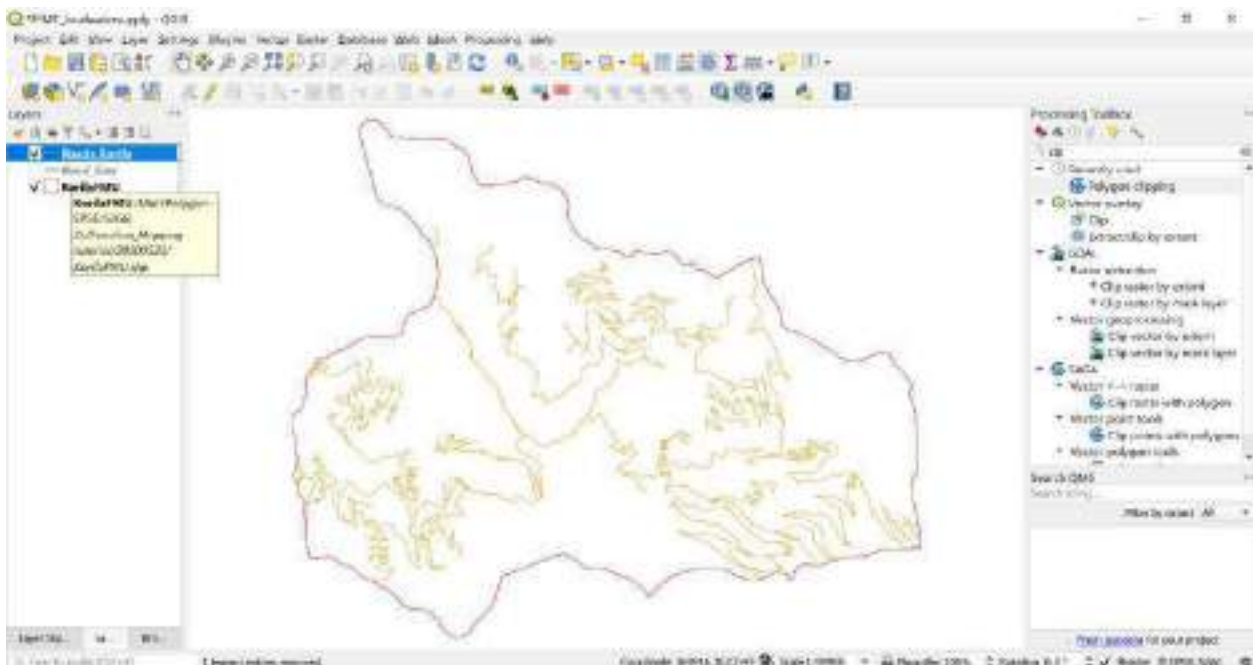
- *Open QGIS*
- *Add FMU boundary layer*
- *Add Road network layer*





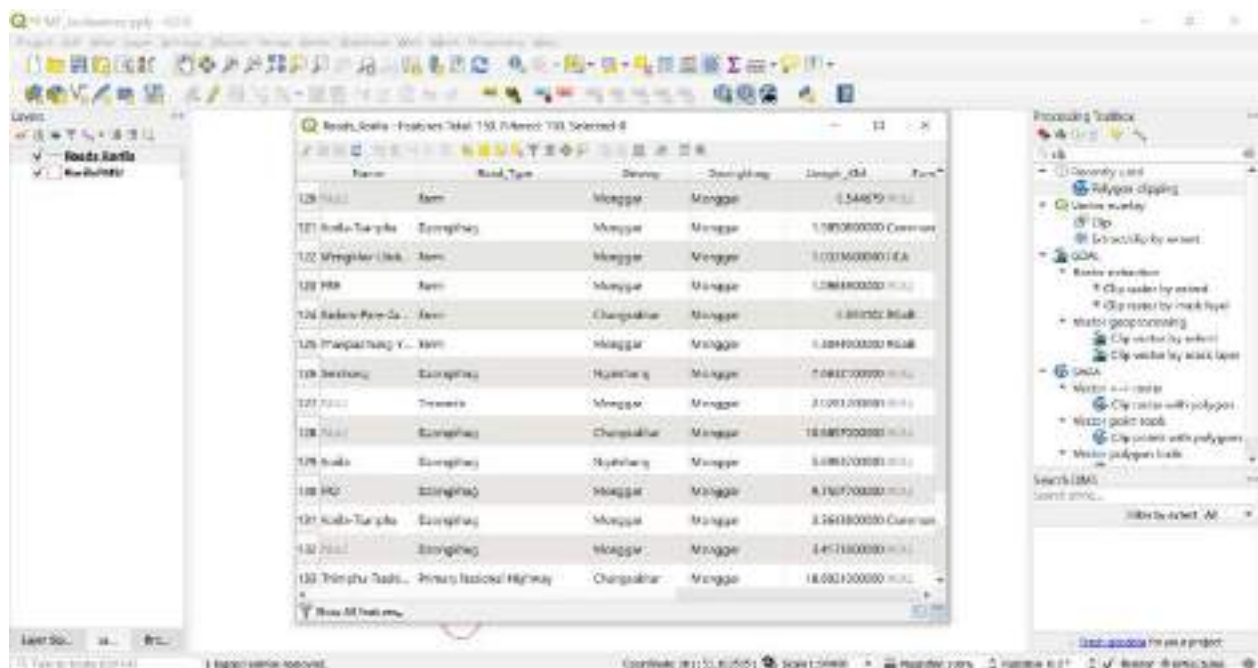
#### Clip with FMU Boundary

- Type clip in processing toolbox
- Select Polygon clipping from SAGA Tools
- In Clip features: select FMU boundary layer
- In input features: select road network layer
- Save the file with appropriate name in working directory



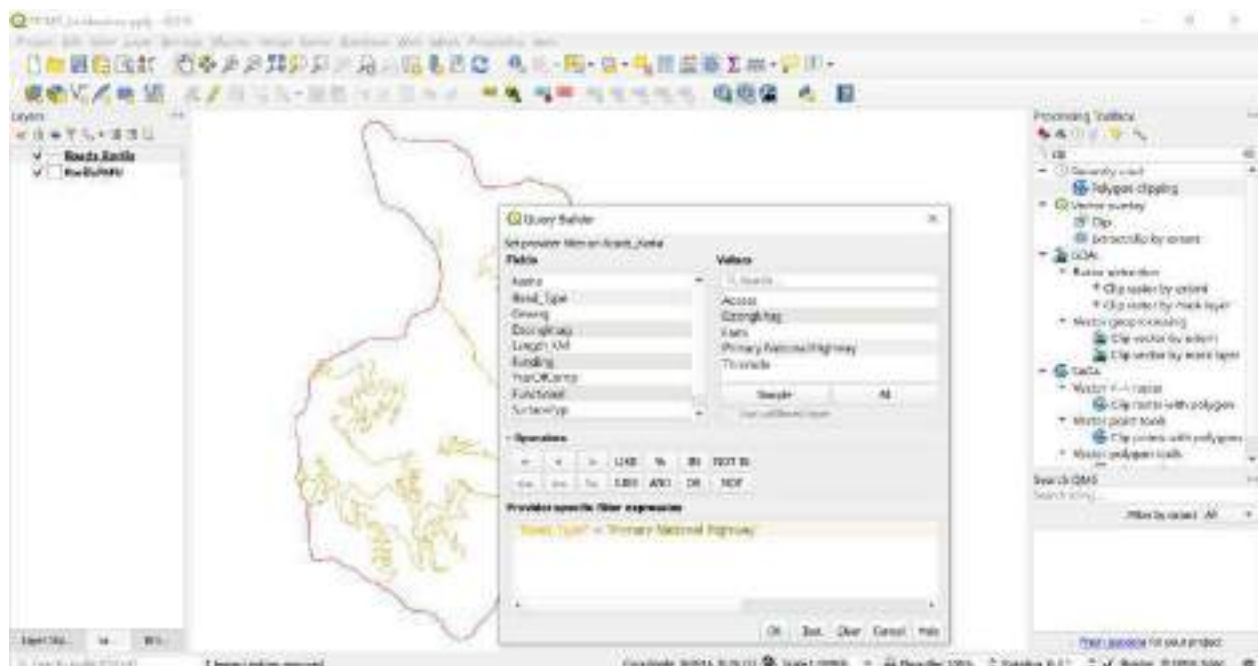
Open attribute table and look at the column Road\_Type. There are different types of road

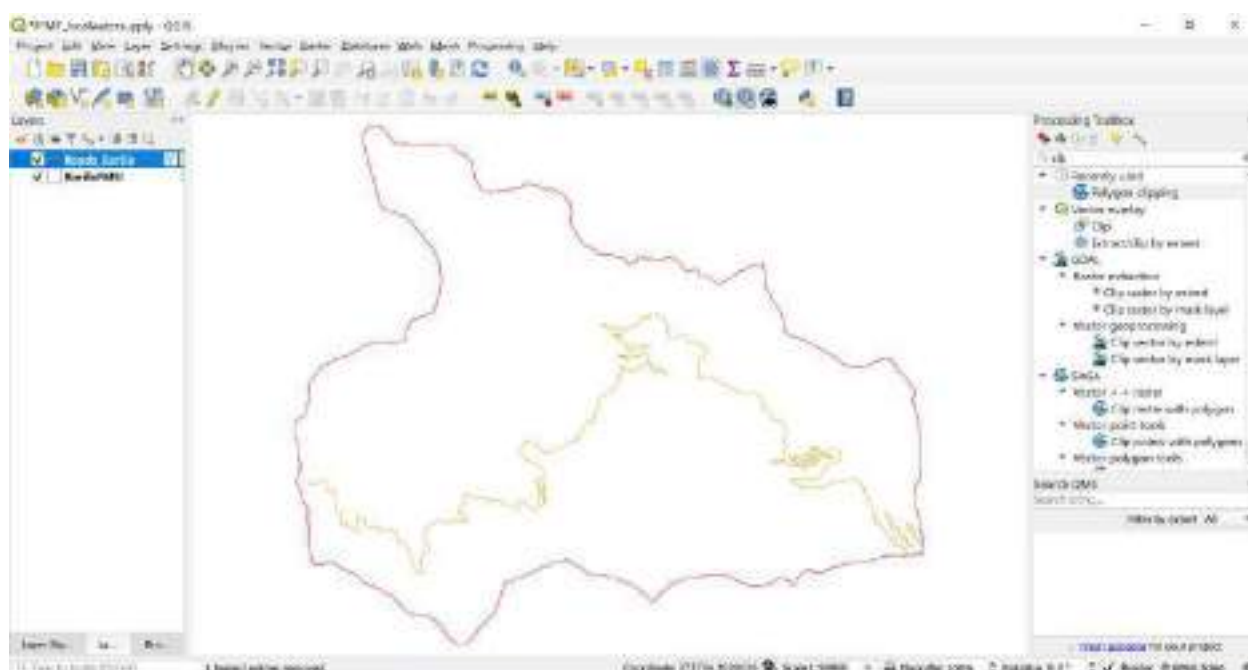
- Right click on Road layer > Click Open attribute table



Select Primary National Highway through filtering process

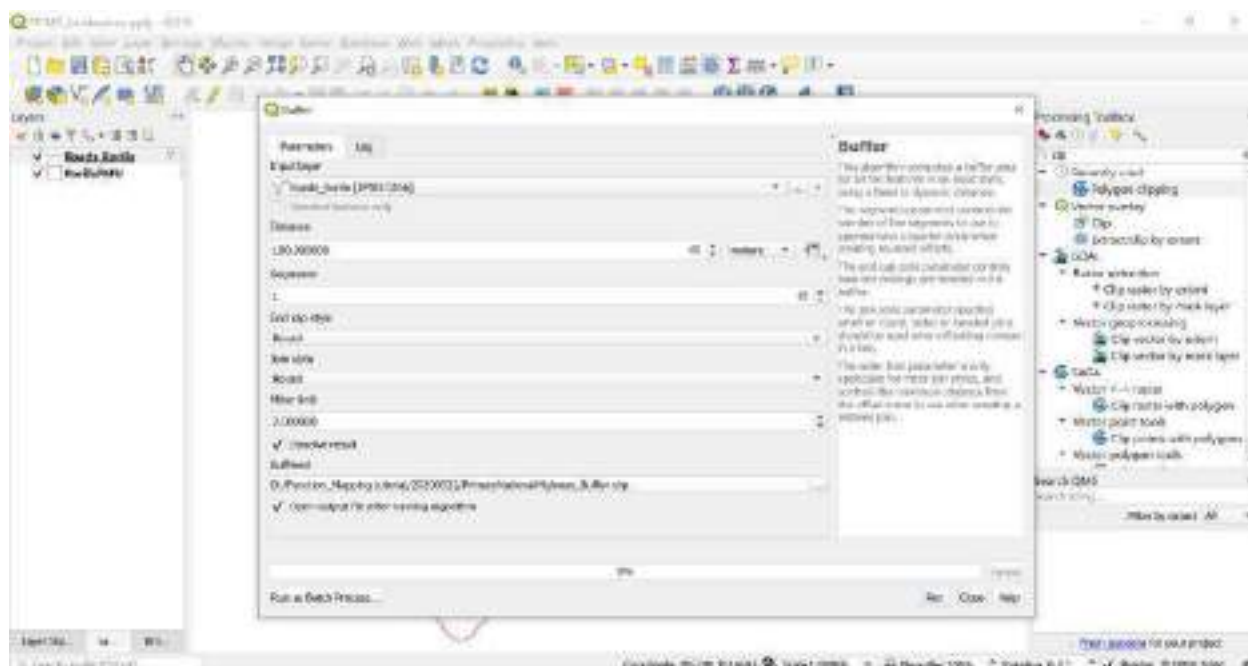
- Right click road network layer > Filter
- Enter expression as shown in the figure
- Double click Road\_Type > Click = sign > click All (this shall display road types present in attribute table) > double click Primary National Highway > ok

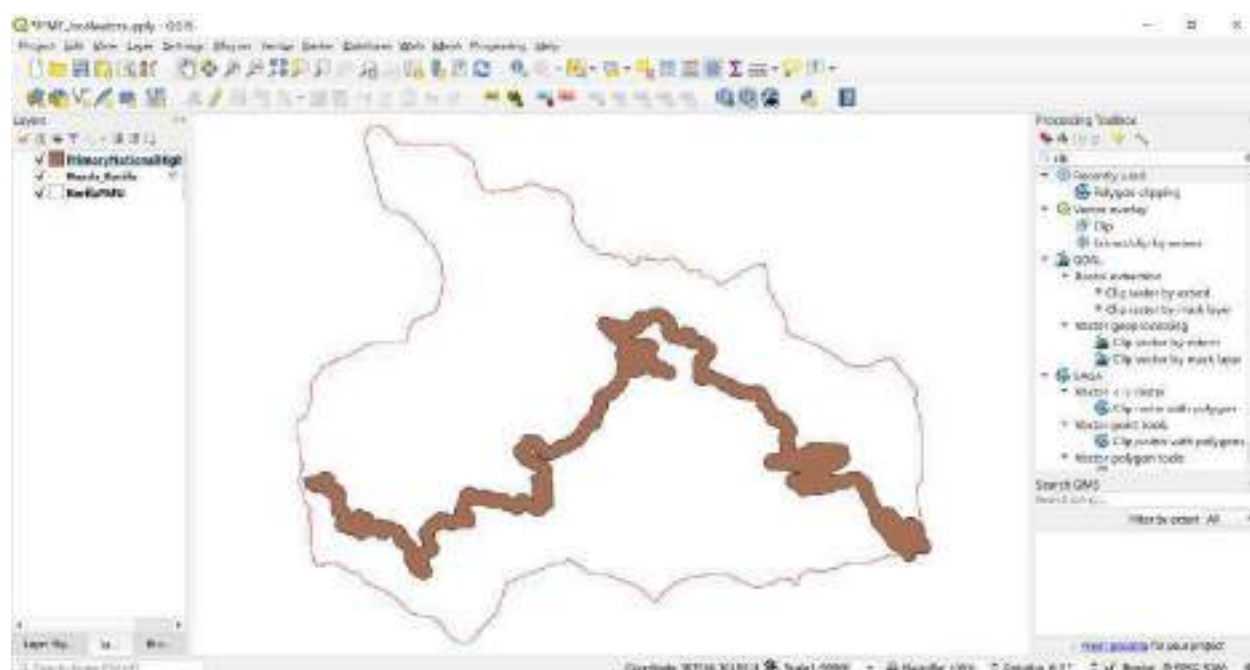




Create buffer of 180 m on either side of Primary National Highway

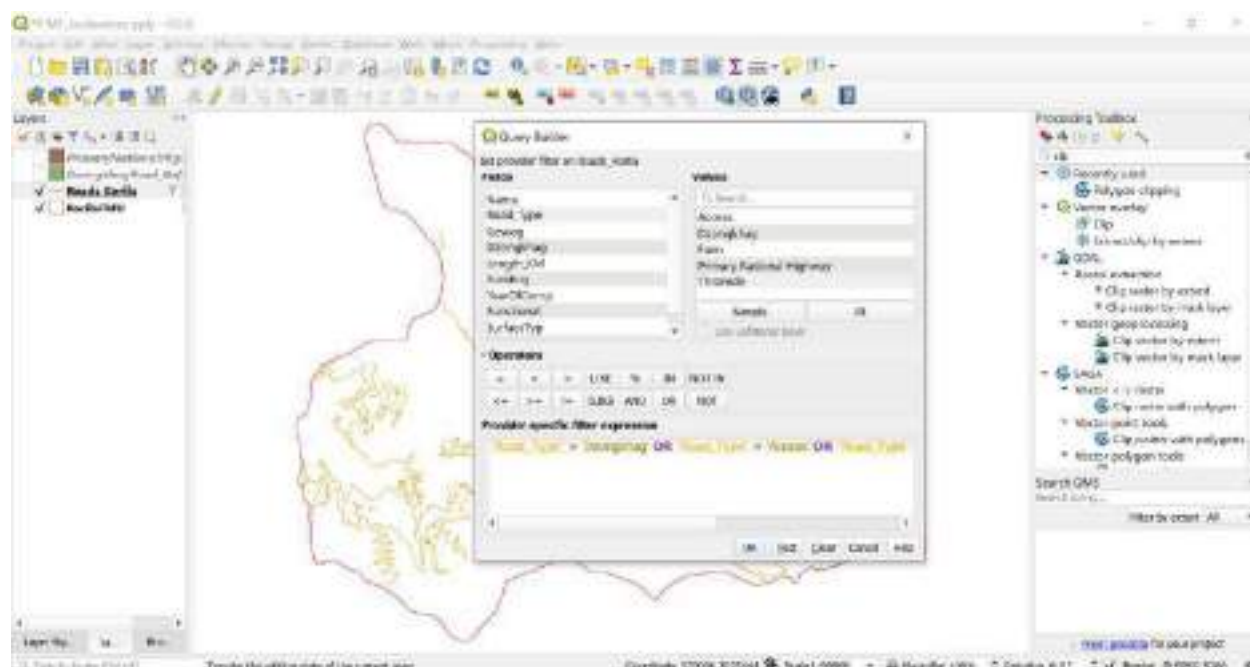
- *Click Vector > Geoprocessing Tools > Buffer*
- *In Input layer: Select filtered Primary National Highway layer*
- *In distance: enter 180*
- *Check dissolve result*
- *Rest parameter leave as default*
- *Save the file with appropriate name in working directory*



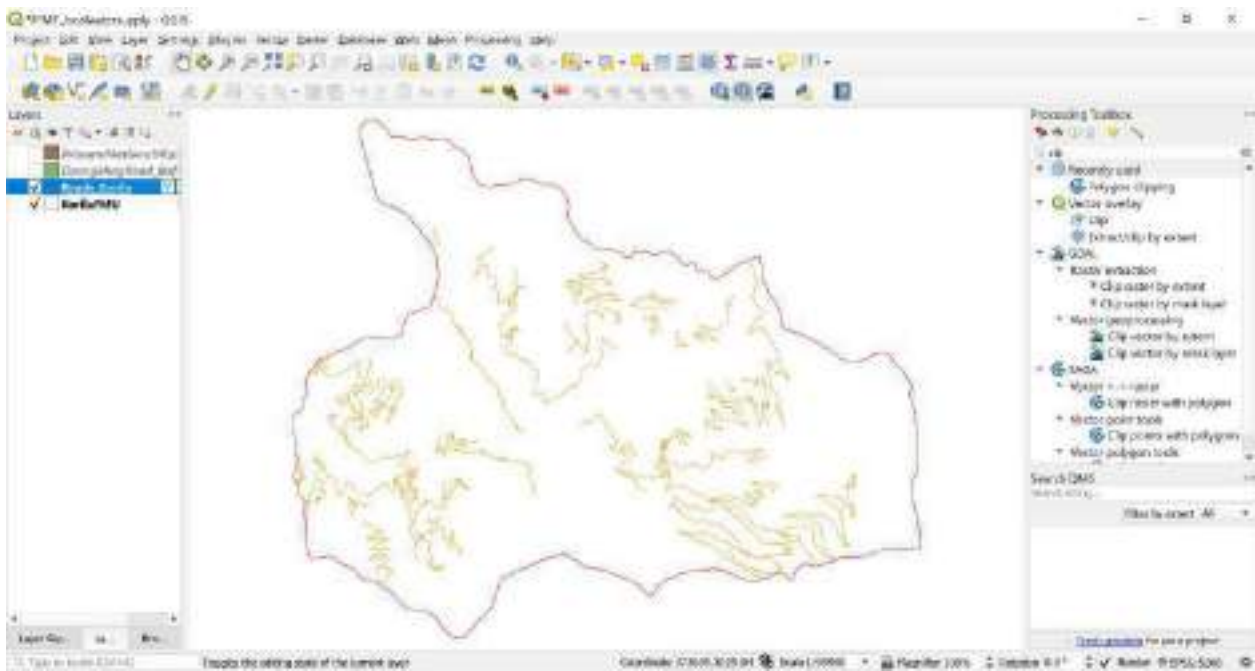


Select Dzongkhag Road, Farm Road, Access Road and Thromde Road

- Right click road network layer > Filter
- Click Clear the selection
- Enter expression following expression:  
`"Road_Type" = 'Access' OR "Road_Type" = 'Dzongkhag' OR "Road_Type" = 'Farm' OR "Road_Type" = 'Thromde'`
- Click Ok

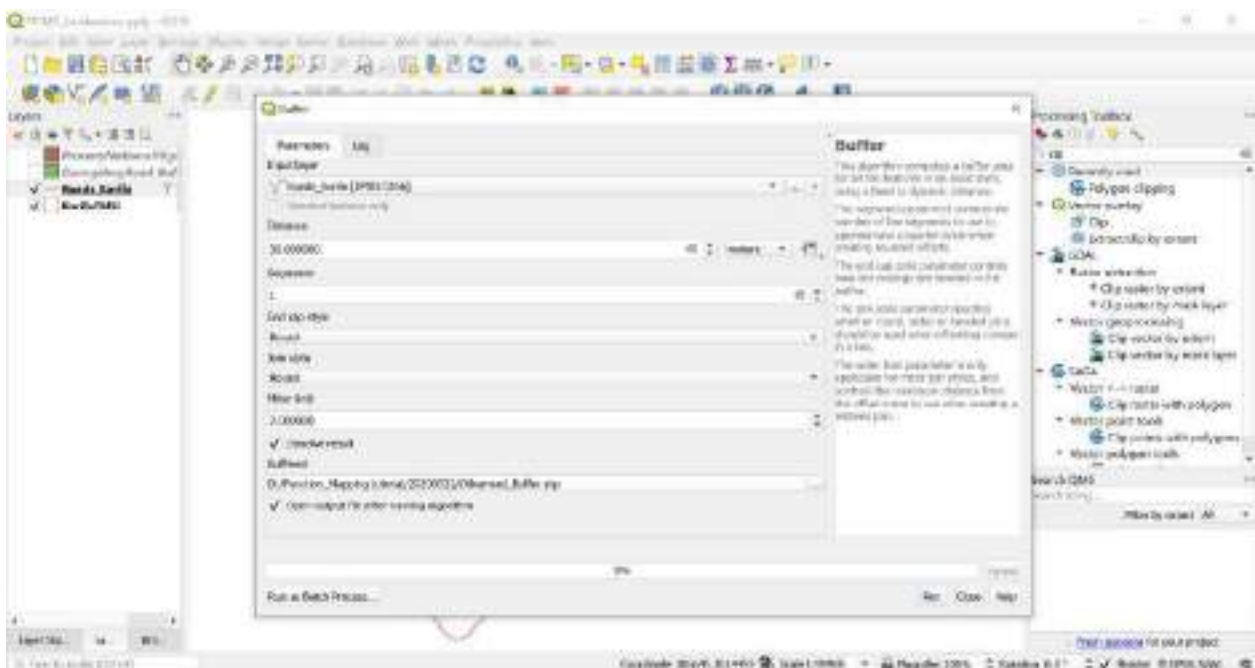


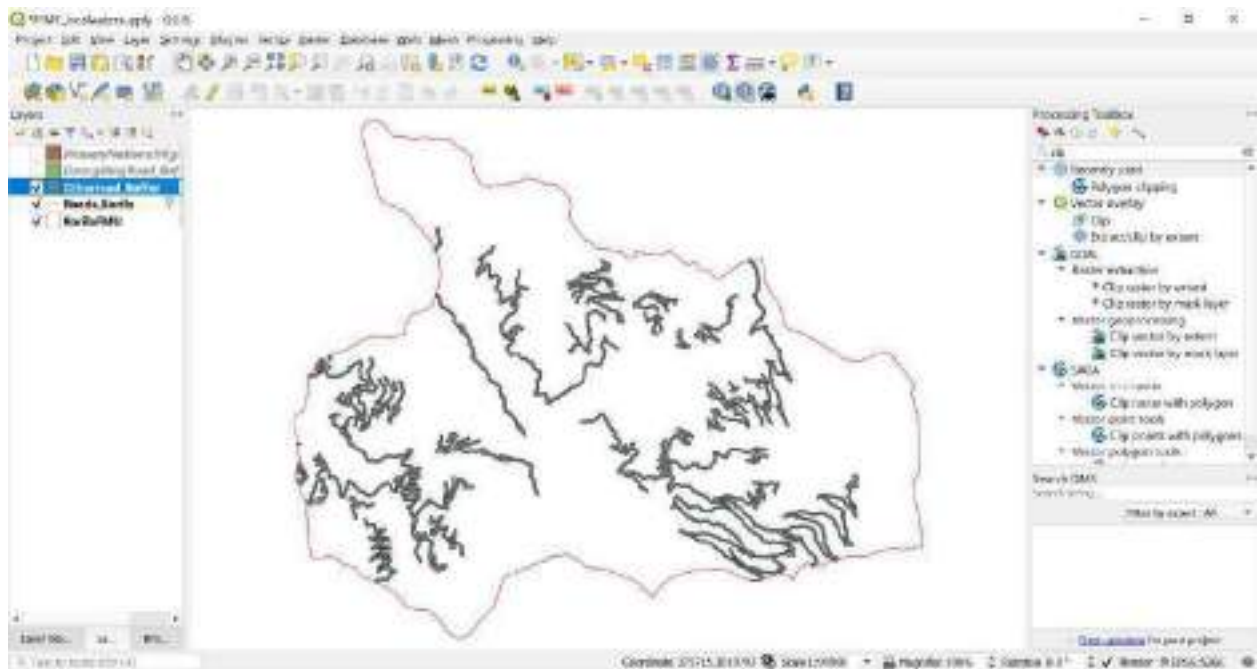




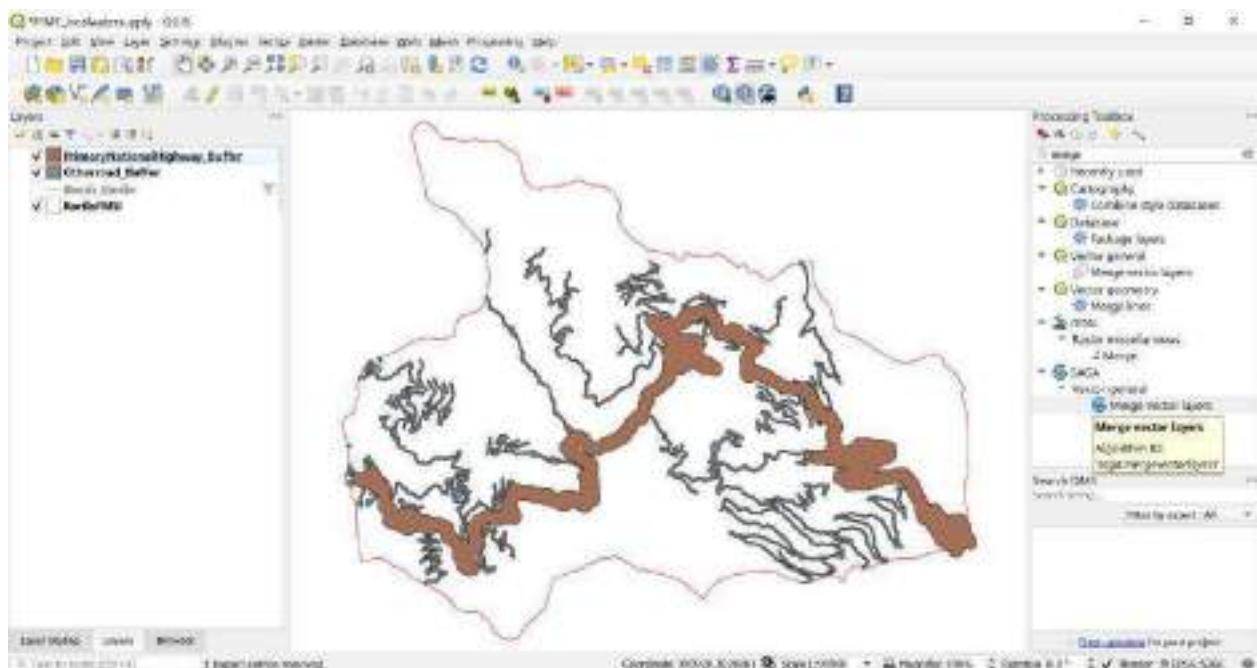
Create buffer of 30 m on either side of Dzongkhag, Farm, Access and Thromde road

- Click Vector > Geoprocessing Tools > Buffer
- In Input layer: Select filtered Primary National Highway layer
- In distance: enter 30
- Check dissolve result
- Rest parameter leave as default
- Save the file with appropriate name in working directory



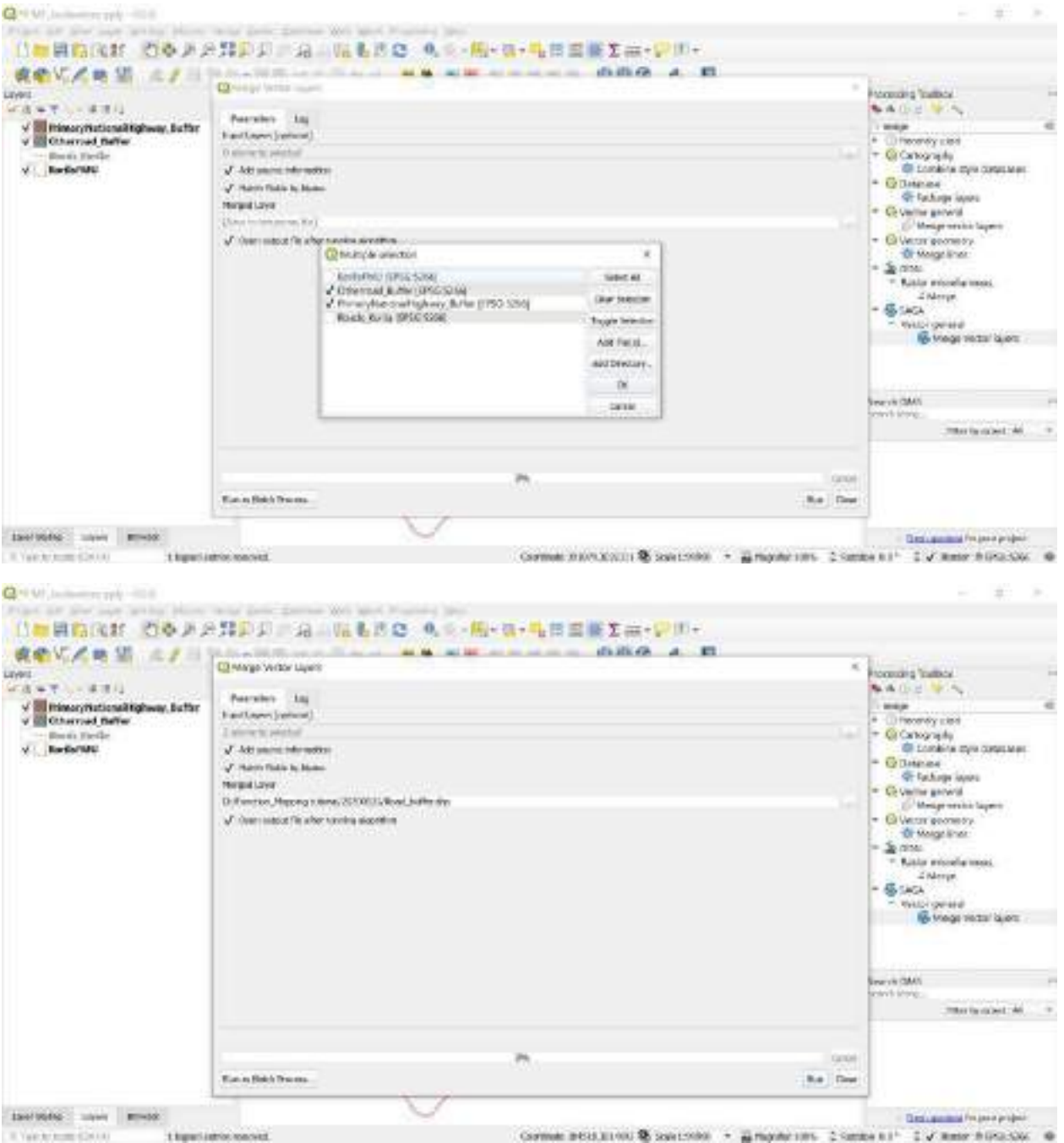


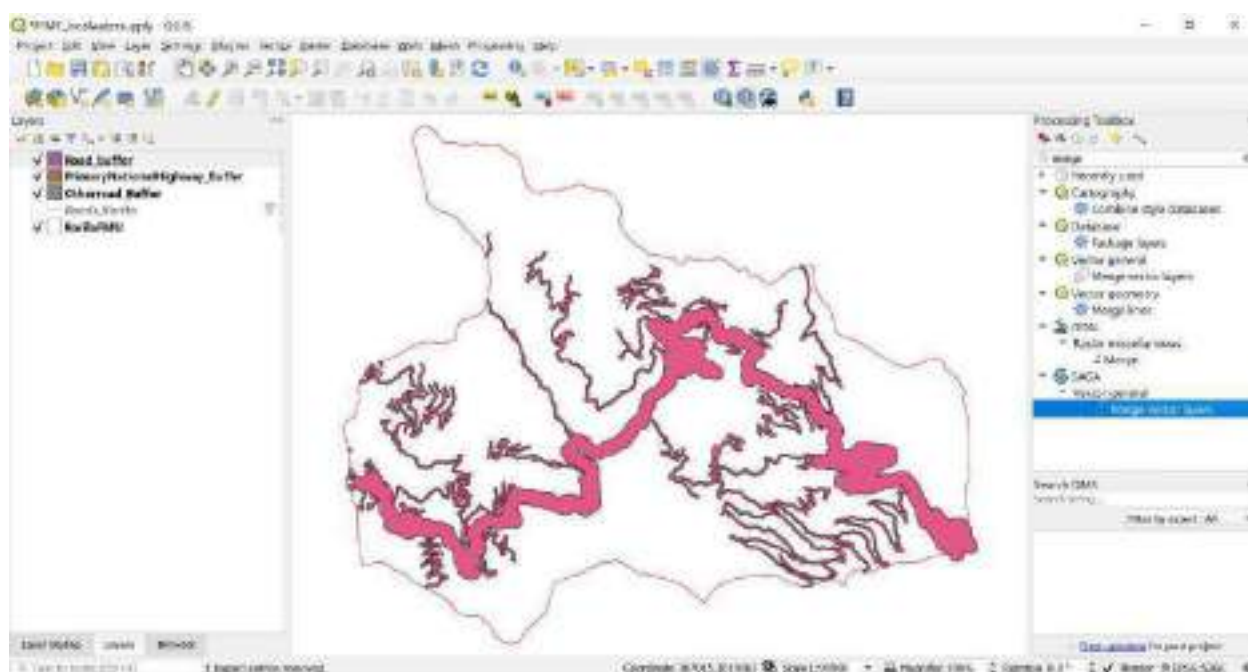
Now there are two different road buffer layers, we need to merge it together.



- *Type merge in processing toolbox*
- *Navigate to SAGA and select Merge vector layers*
- *In Input Layers: Select the file you want to merge (PrimaryNationalHighway\_Buffer and Otherroad\_Buffer)*
- *Rest parameter leave as default*
- *Save the file with appropriate name in working directory*

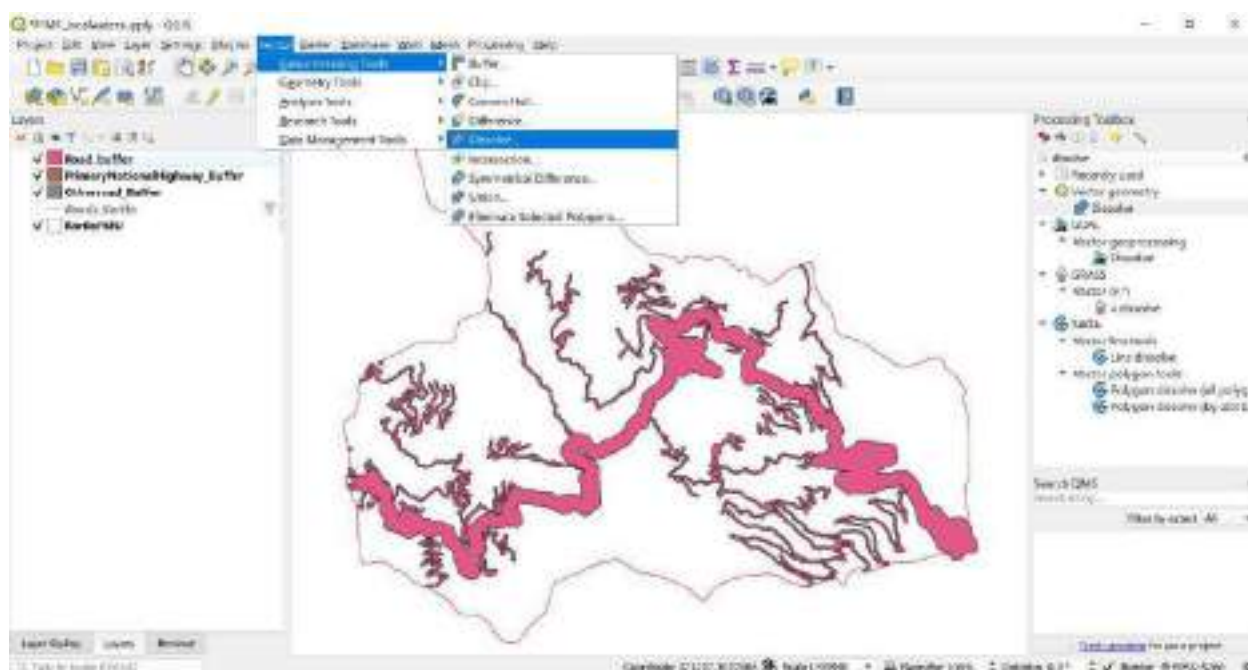




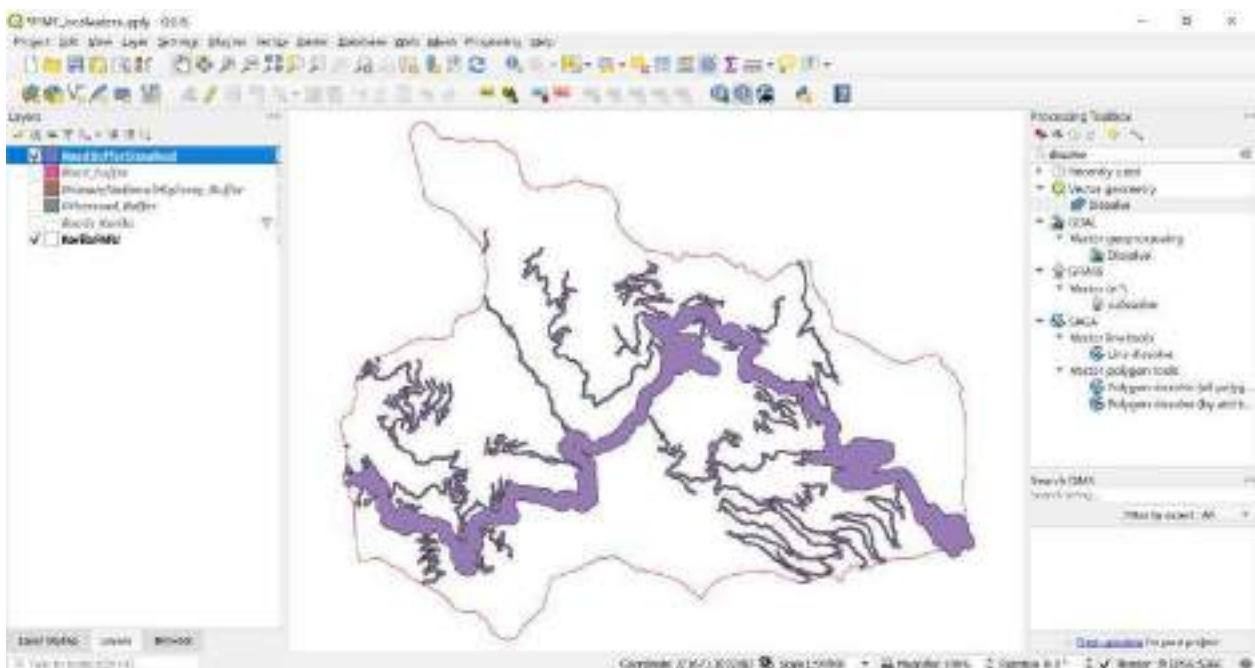
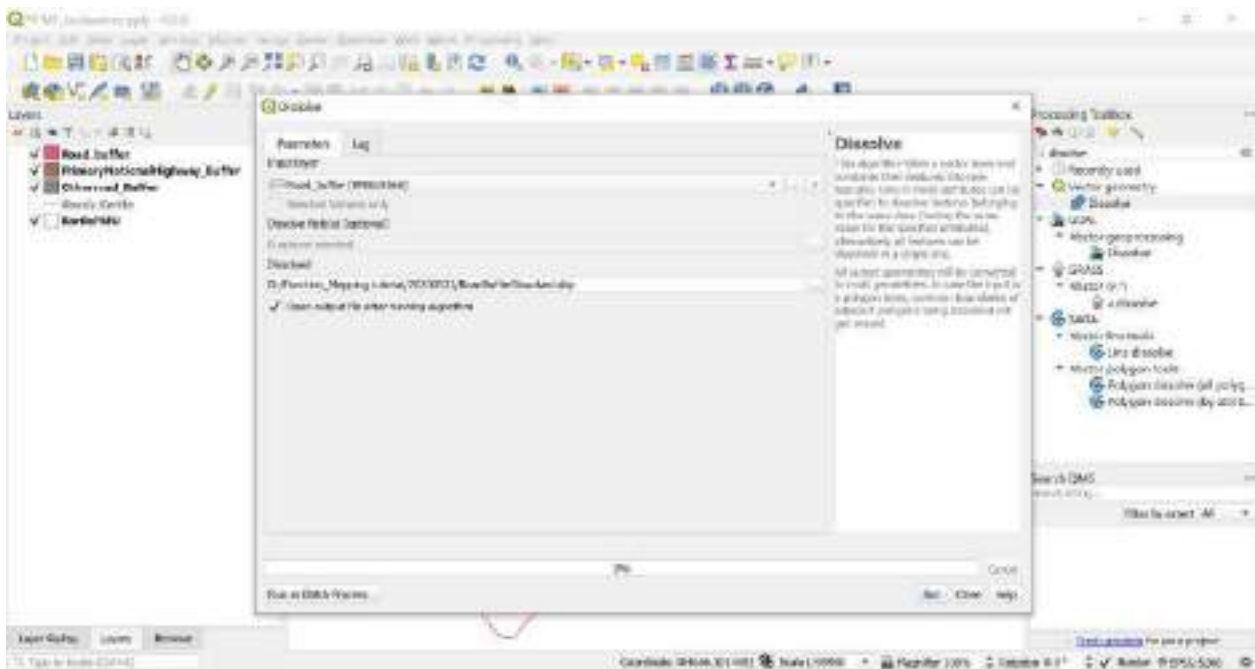


Dissolve merged layers

- *Click Vector > Geoprocessing Tools > Dissolve*



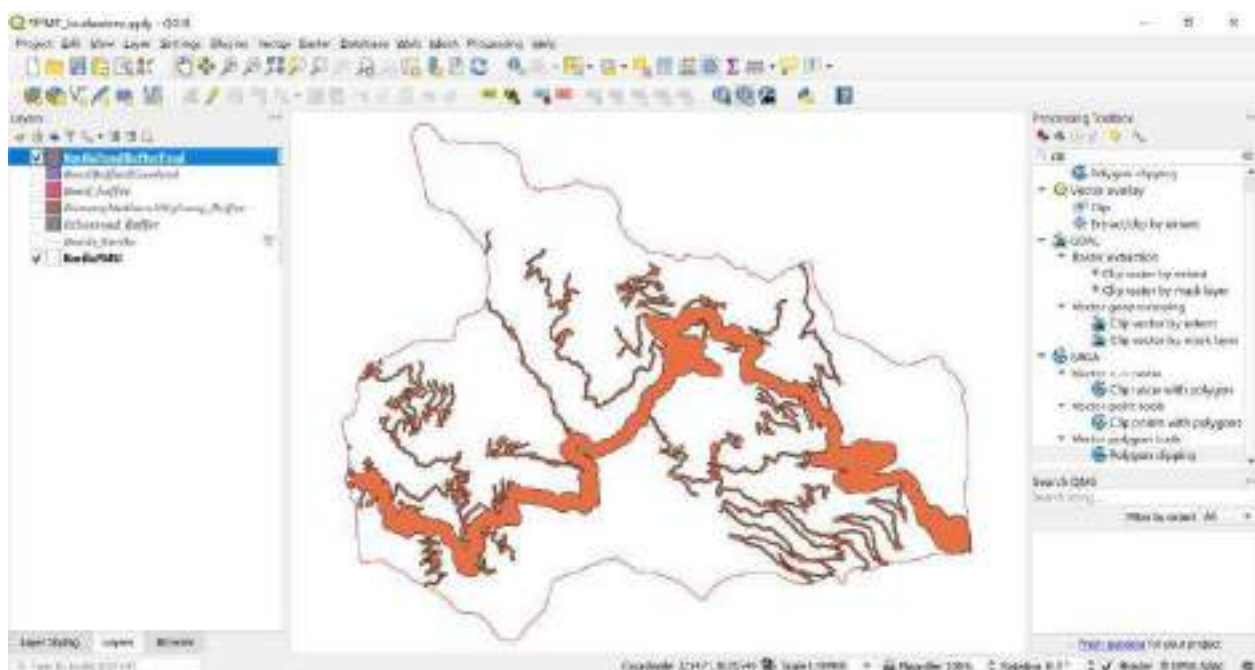
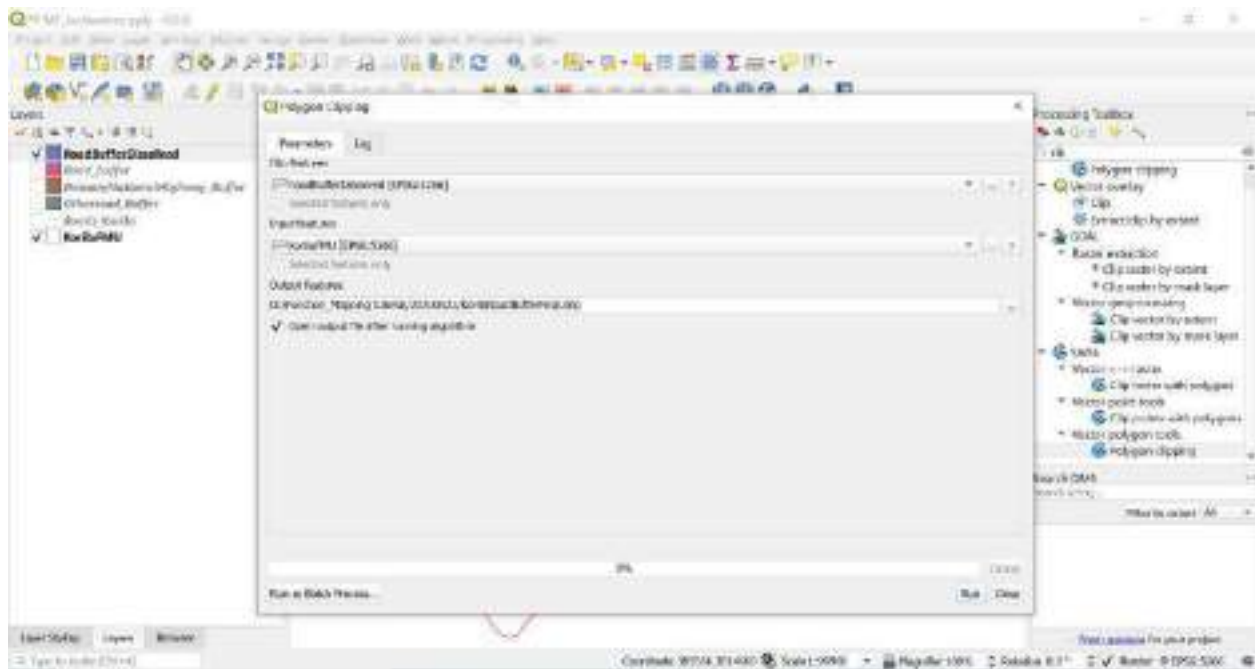
- *In input layer: Select the layer to be dissolved*
- *Save the file with appropriate name in working directory*



Dissolved road buffer extends beyond FMU boundary

Clip with FMU Boundary

- Type clip in processing toolbox
- Select Polygon clipping from SAGA Tools
- In Clip features: select FMU boundary layer
- In input features: select dissolved road buffer layer
- Save the file with appropriate name in working directory



### 1.9.1.6 Production function

This refers to the stable forest landscape from where timber can be sustainably produced without affecting the ecological, environmental and social functions.

Production function (Pf)		Research and Development (PR)
Definition	Forest area where timber production can be carried out sustainably	Forest area set aside for research
Objective	to produce timber on sustainable basis	To study the impact of timber harvesting and climate change
Legal Restrictions	None!	Limited harvesting shall be adopted

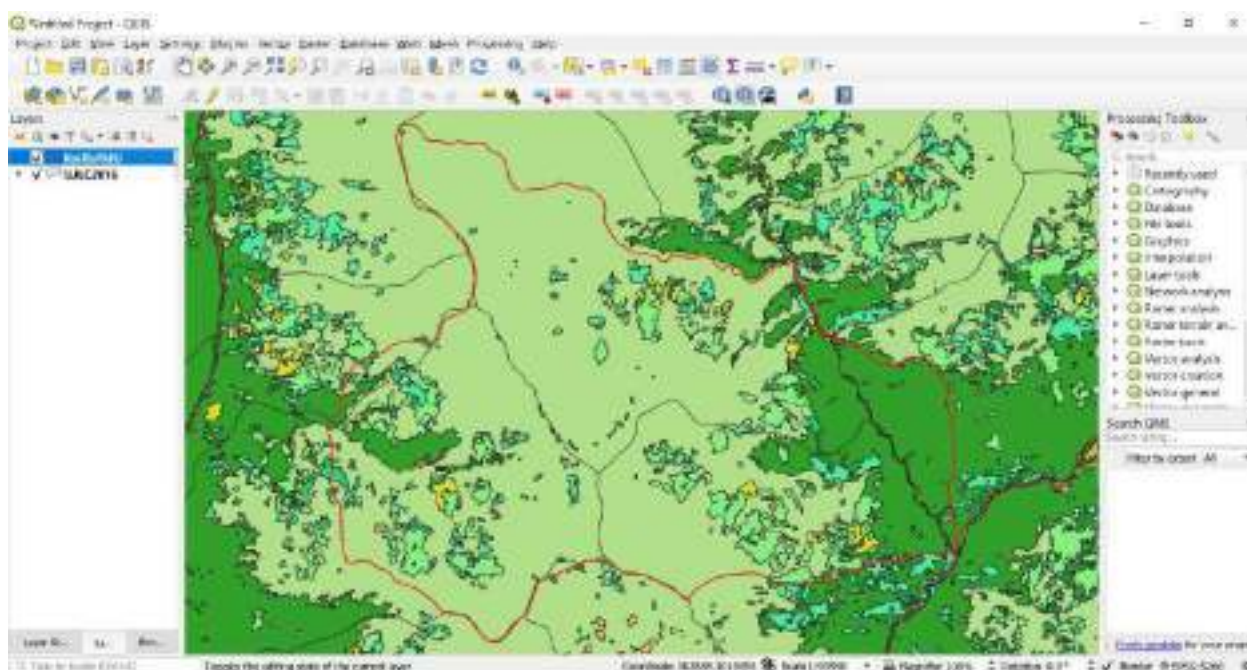


Identification	Suitable forest area with high growing stock which is economically and technical feasible for timber harvesting and extraction	Ideally undisturbed forest area shall be set aside.
GIS Analysis	Forested area left out after mapping of soil protection, riparian reserve protection, special watershed management area, local water supply protection, local use area, religious site protection, wildlife protection, biodiversity protection, road buffer and non-forest area.	Area mapped as identified for research and development
Short Description of Management Prescriptions/ Restrictions	<ul style="list-style-type: none"> <li>As per the prescribed silvicultural system in accordance to the forest type</li> </ul>	<ul style="list-style-type: none"> <li>As per research objectives</li> </ul>

### GIS Steps

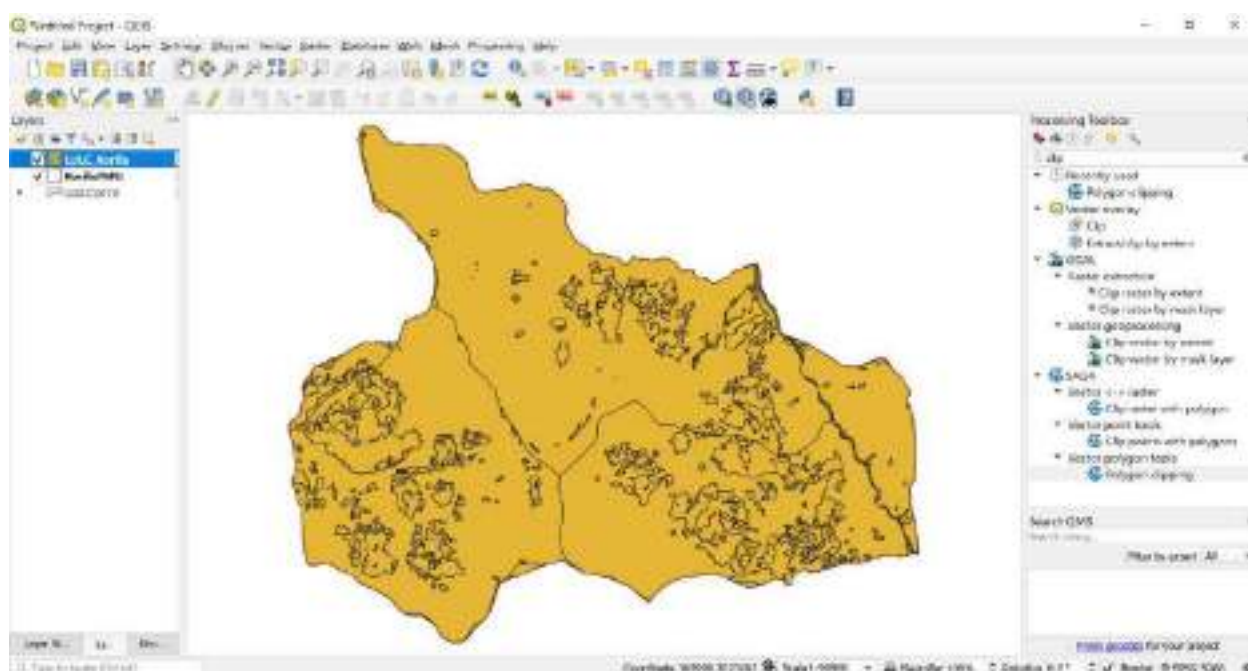
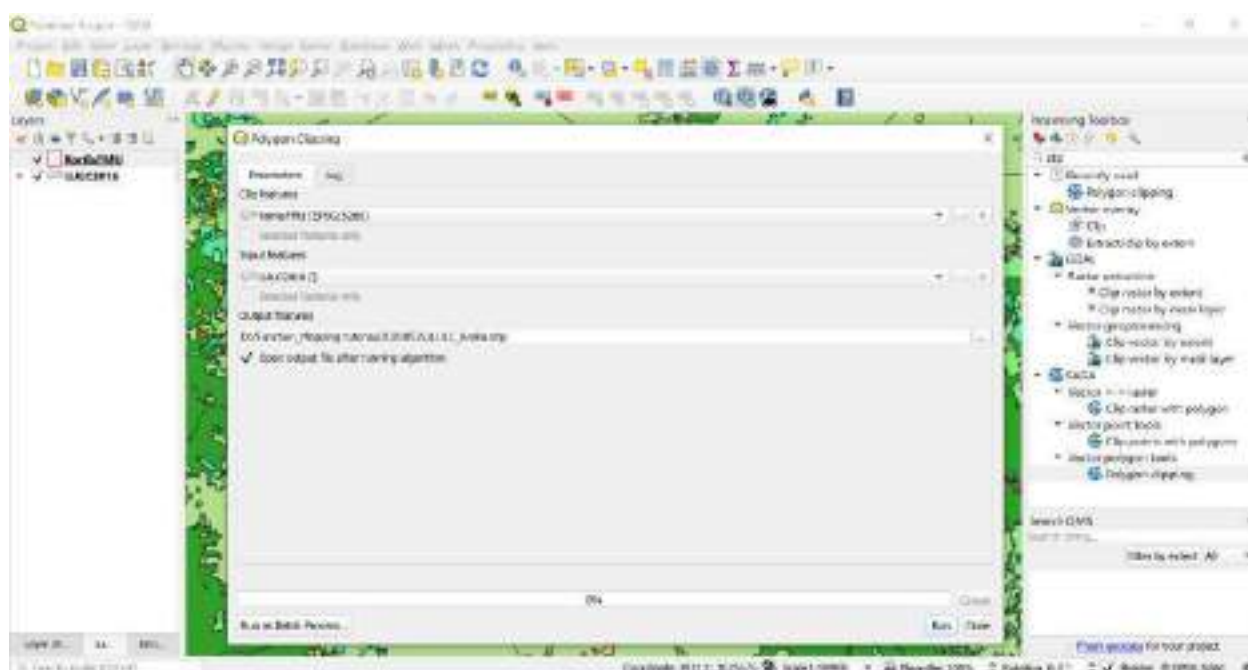
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to used QGIS version 3.12 and above.

- *Open QGIS*
- *Add FMU boundary layer*
- *Add Land use and land cover (LULC) layer*



### Clip with FMU Boundary

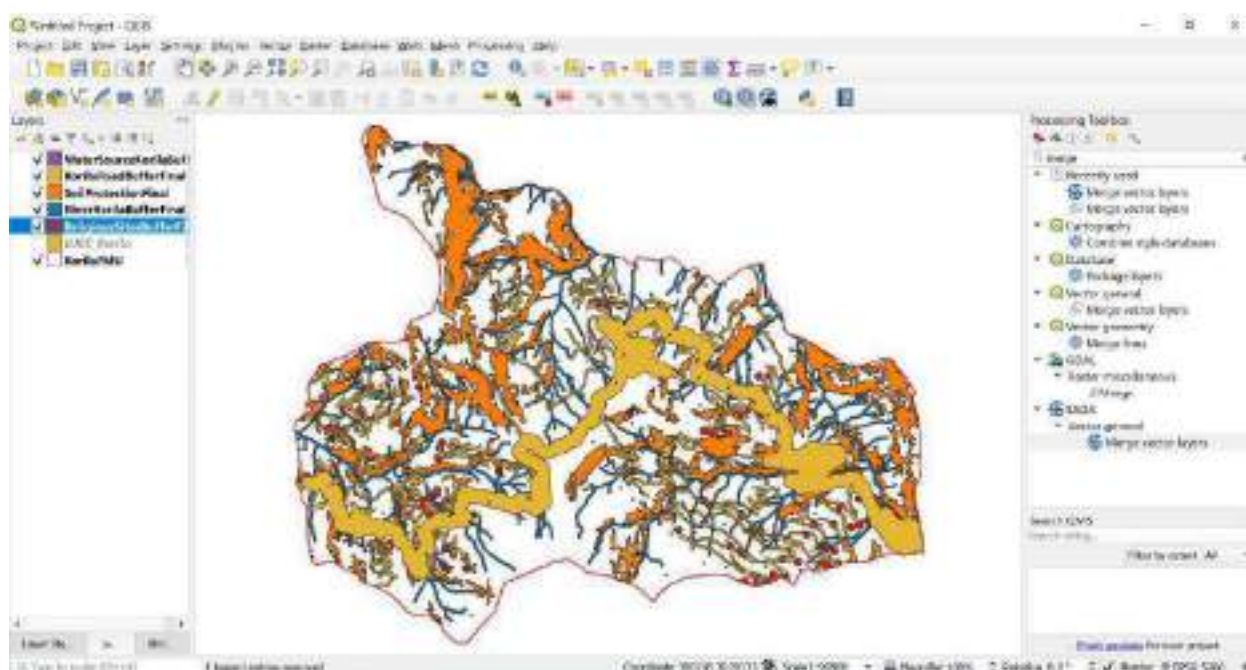
- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select FMU boundary layer*
- *In input features: select LULC layer*
- *Save the file with appropriate name in working directory*



Soil protection layers, water and watershed conservation layer, religious sites protection layers, nature conservation layers, and road buffer needs to be considered as protected areas where sustainable timber harvesting is restricted.

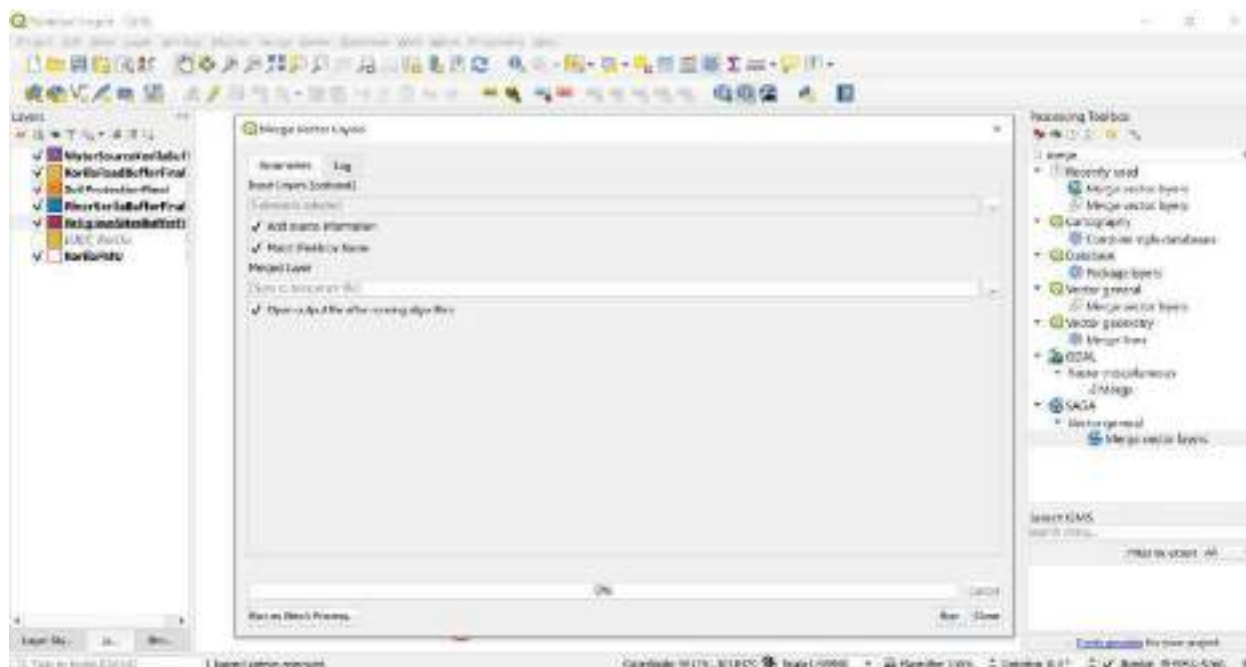
- *Add soil protection layers*
- *Add riparian reserve buffer layer*
- *Add local water supply buffer layer*
- *Add religious site buffer layer*
- *Add road buffer layer*

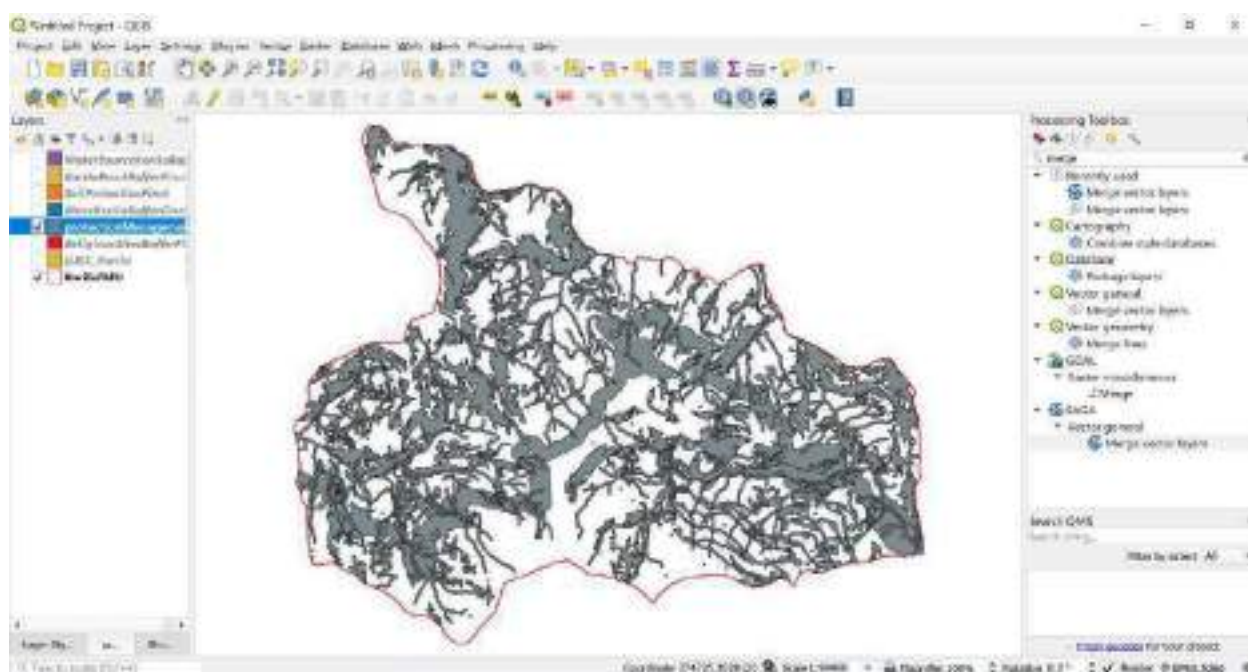




Merge all the layers as one

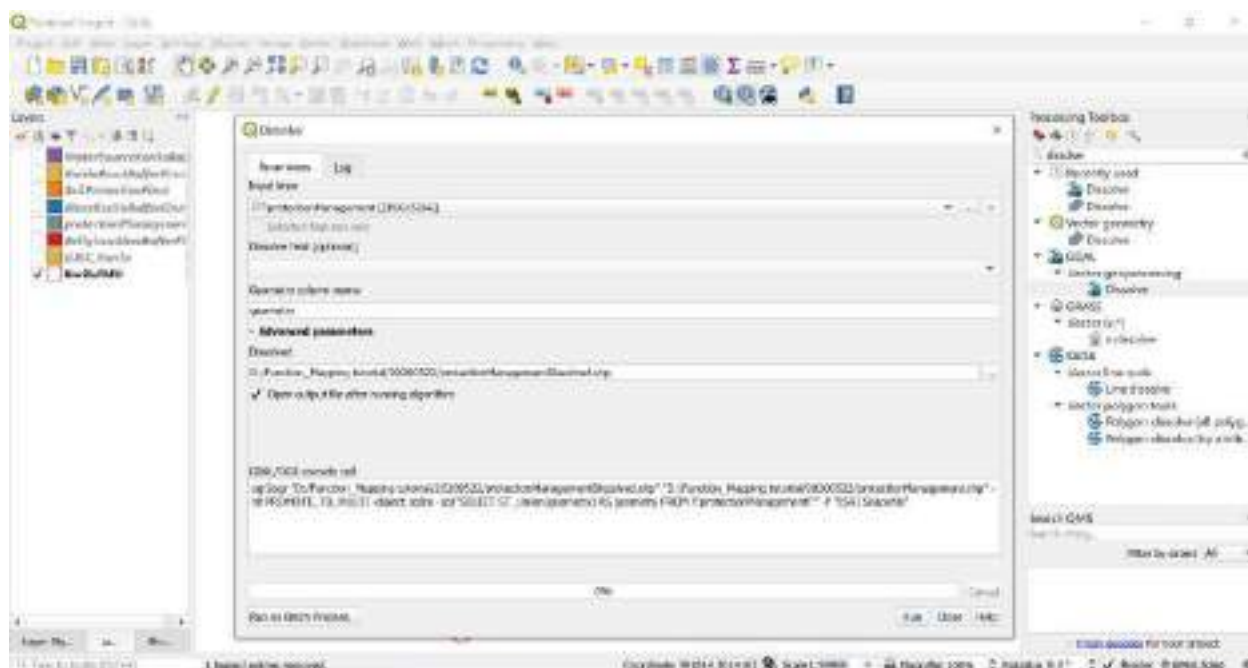
- *Navigate to SAGA and select Merge vector layers*
- *In Input Layers: Select the file you want to merge (Soil protection layers, Riparian reserve buffer layer, Local water supply buffer layer, Religious site buffer layer and road buffer layer)*
- *Rest parameter leave as default*
- *Save the file with appropriate name in working directory*

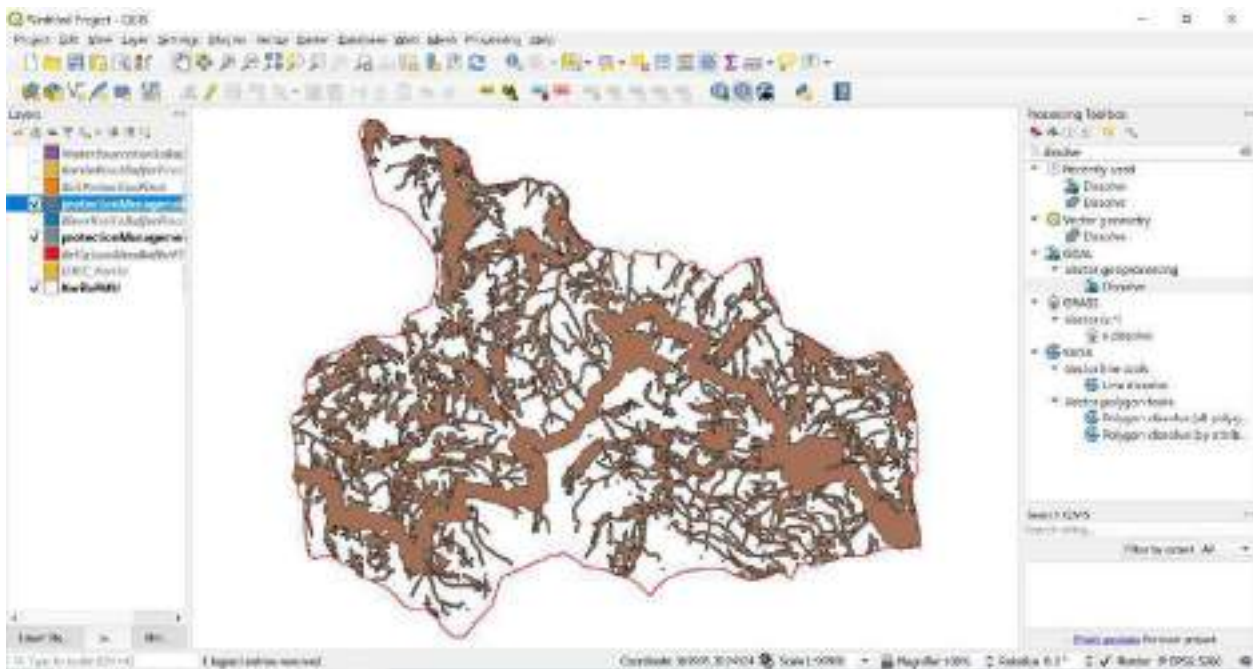




### Dissolve merged layers

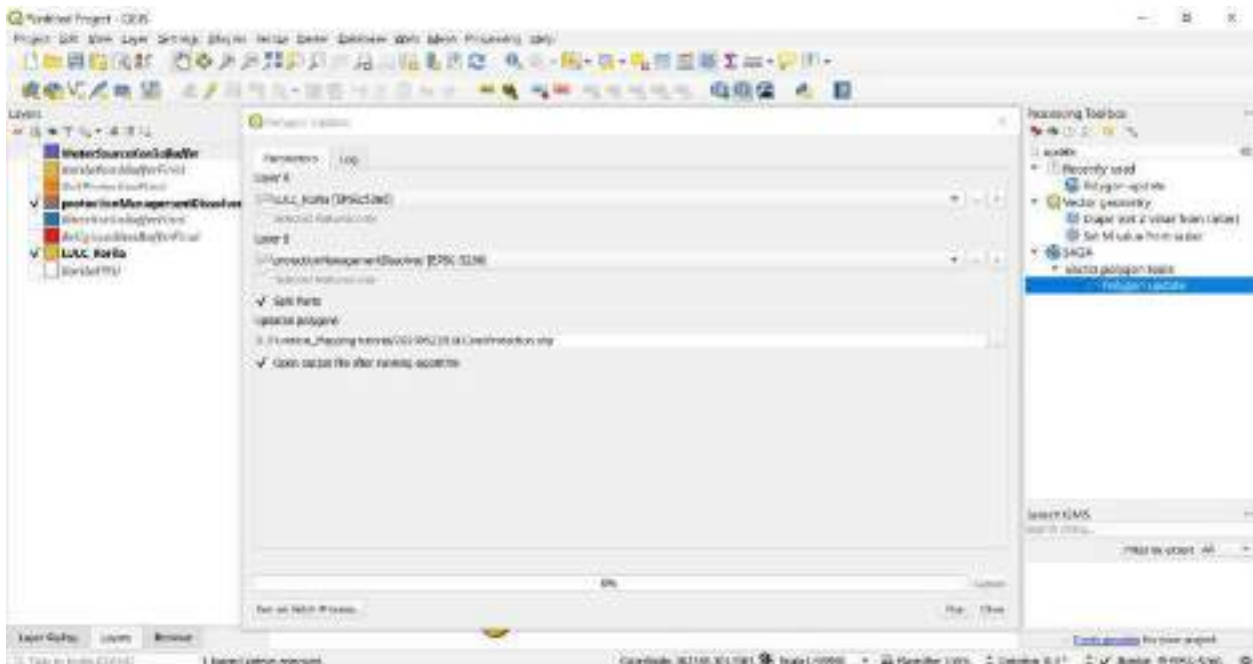
- *Type dissolve in Processing Toolbox*
- *Navigate to GDAL tool and select Dissolve > double click to open the toolbox*
- *Input layer: Select merged protection layers*
- *Save the file with appropriate name in working directory*



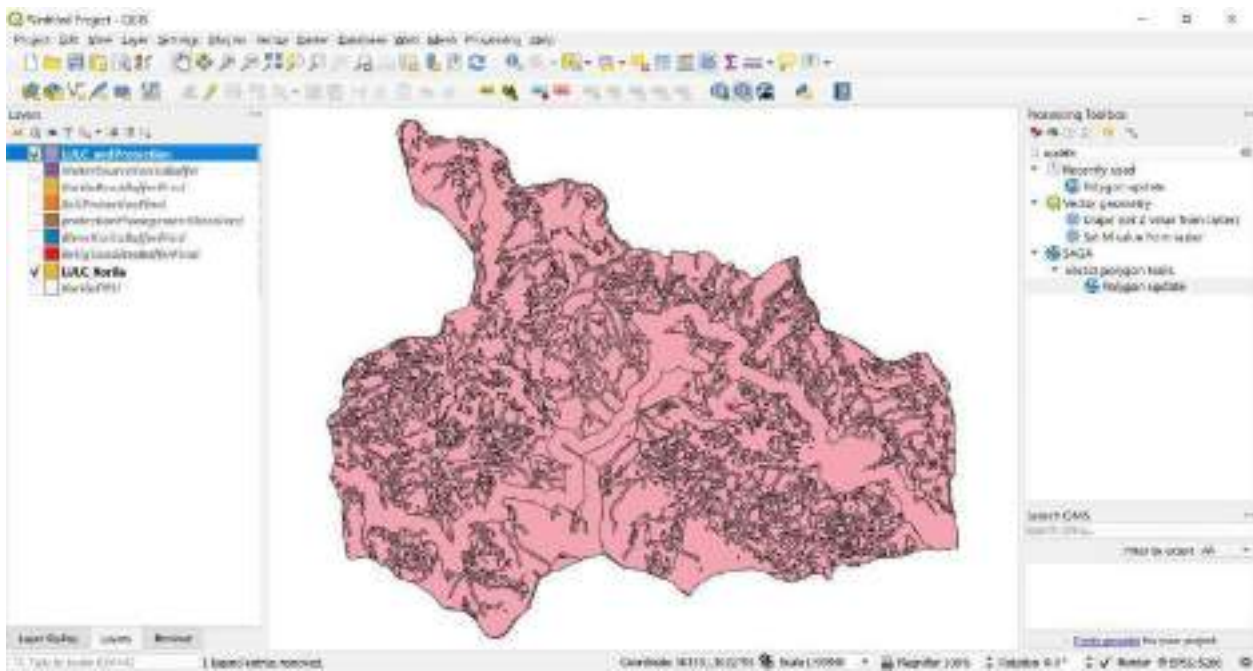


Protected area needs to be updated in LULC

- *Type update in Processing Toolbox > select polygon update tool > double click to open the tool*
- *In Layer A: select LULC of FMU*
- *In Layer B: select merged protection layers*
- *Save the file with appropriate name in working directory*

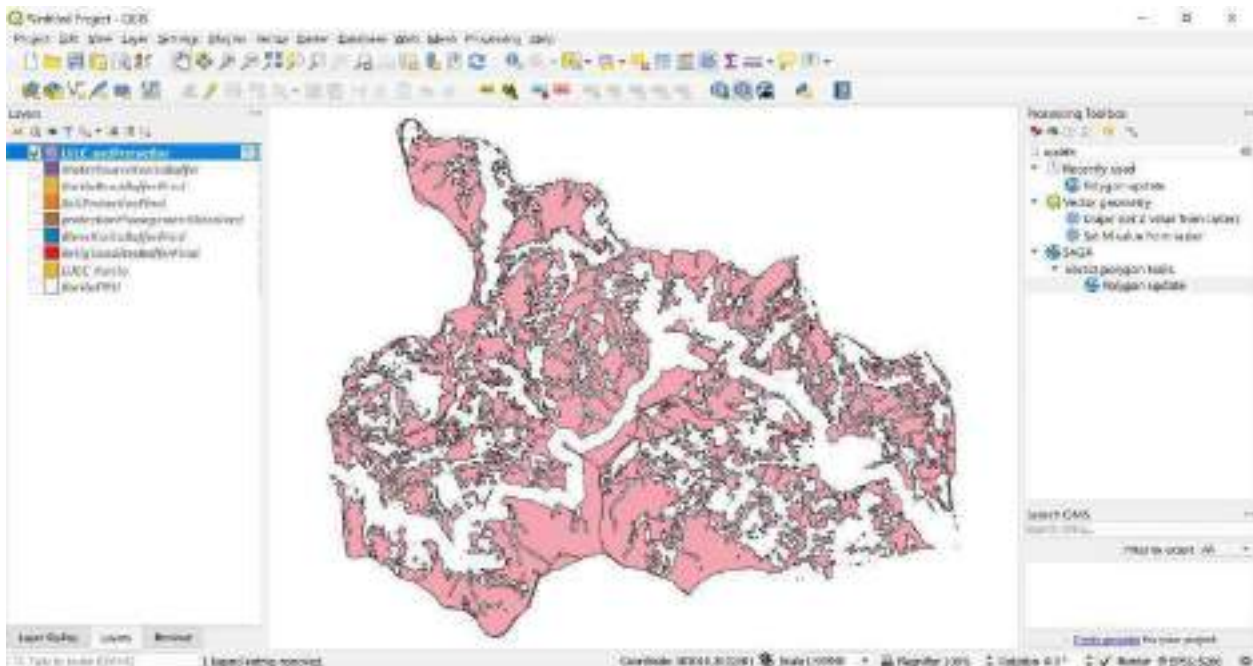






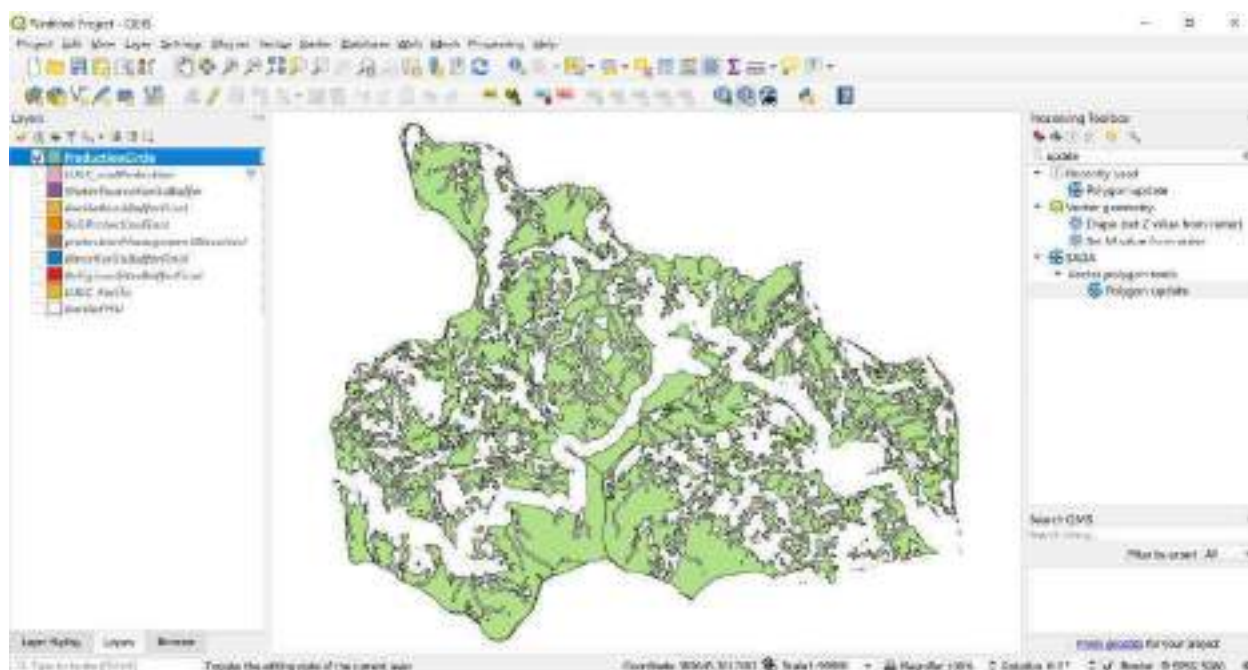
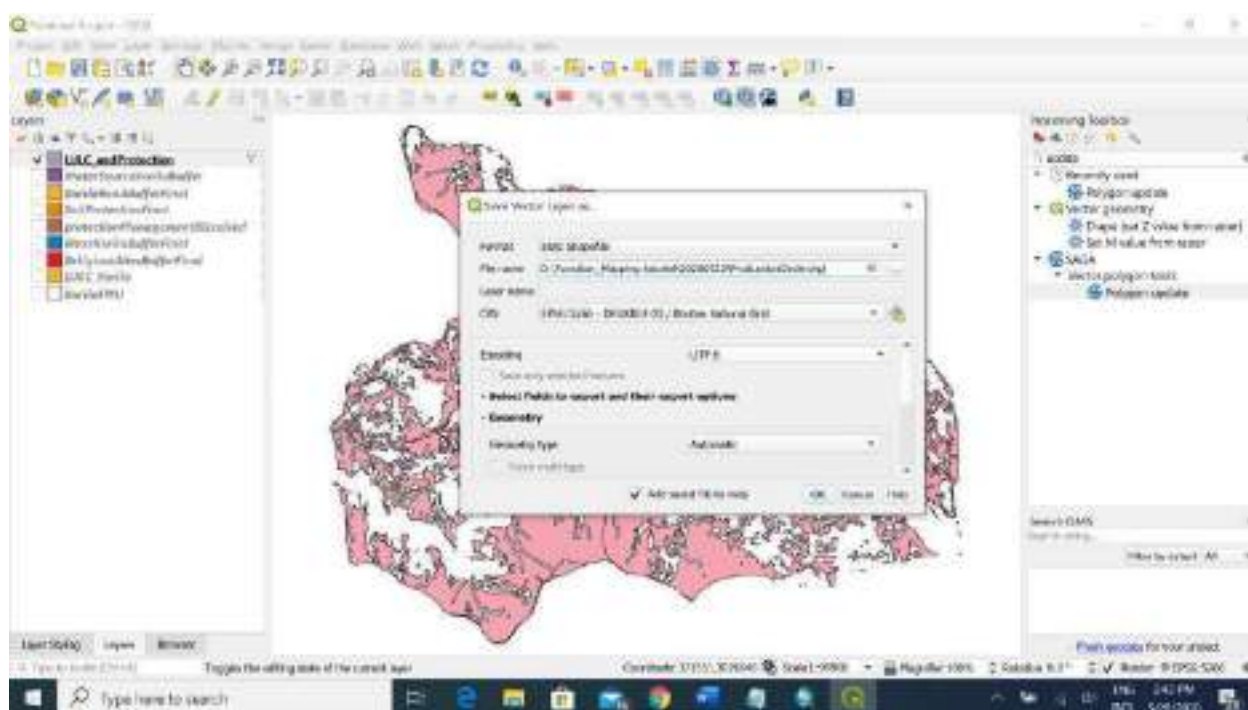
Select only forest area as production area

- *Right updated LULC(LULC\_andProtection) > Filter*
- *Enter expression following expression:  
"CLASS" = 'Forests'*
- *Click Ok*



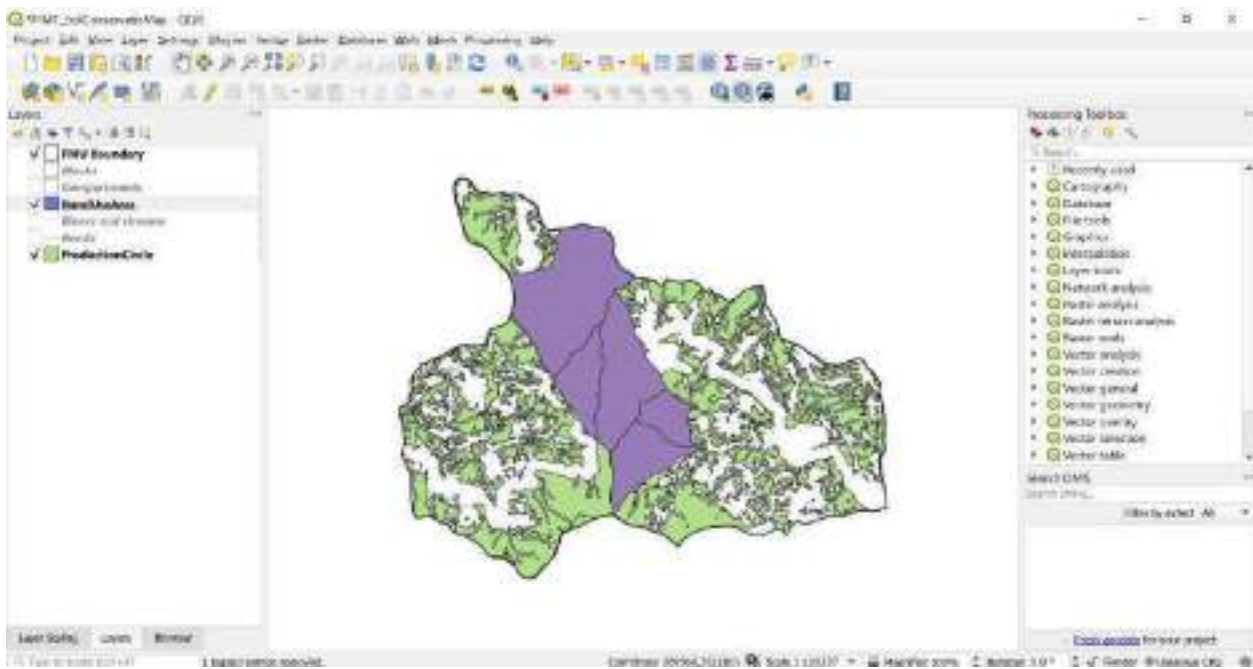
Export the filtered layer and save it as production layer

- *Right click on filtered layer > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *Save the file with appropriate name in working directory*



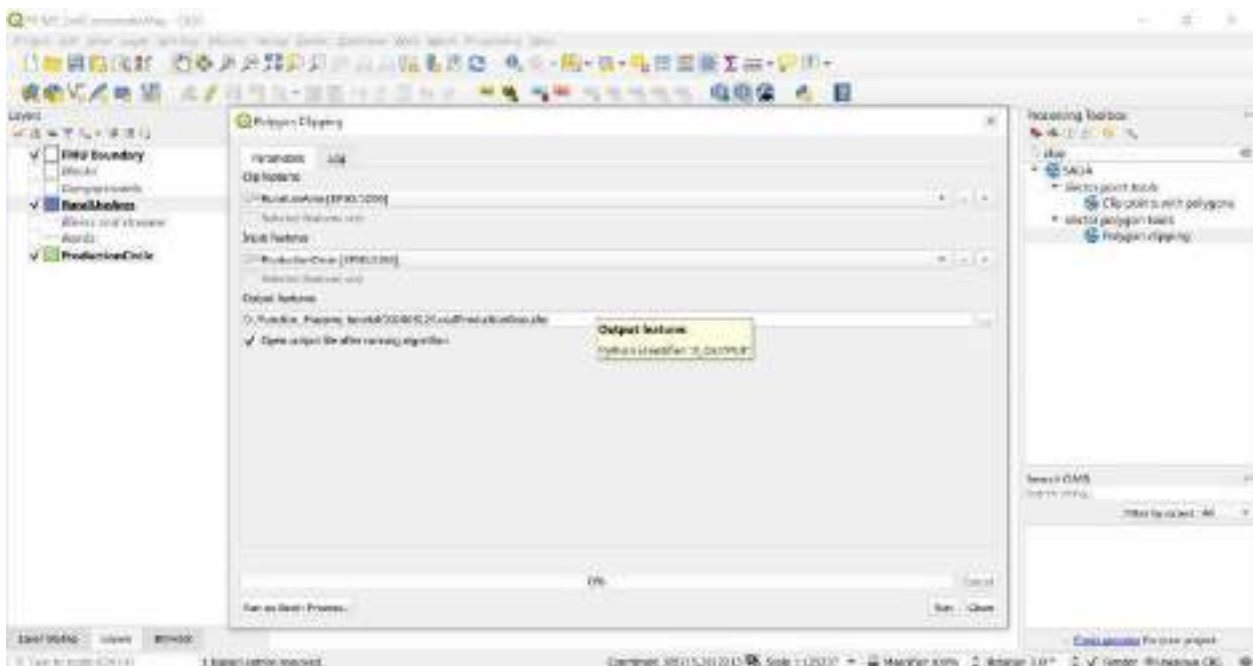
Production area need to be divided into commercial use and local use

- Add production layer
- Add local use area layer

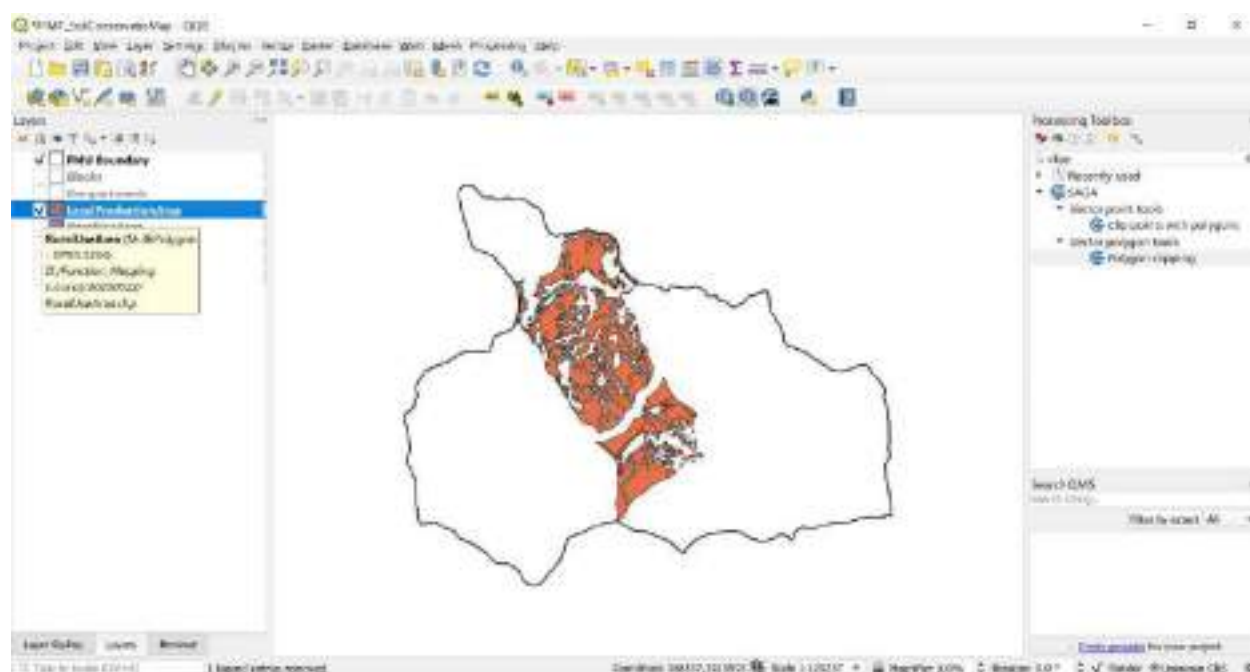


Clip the production layer with local use area

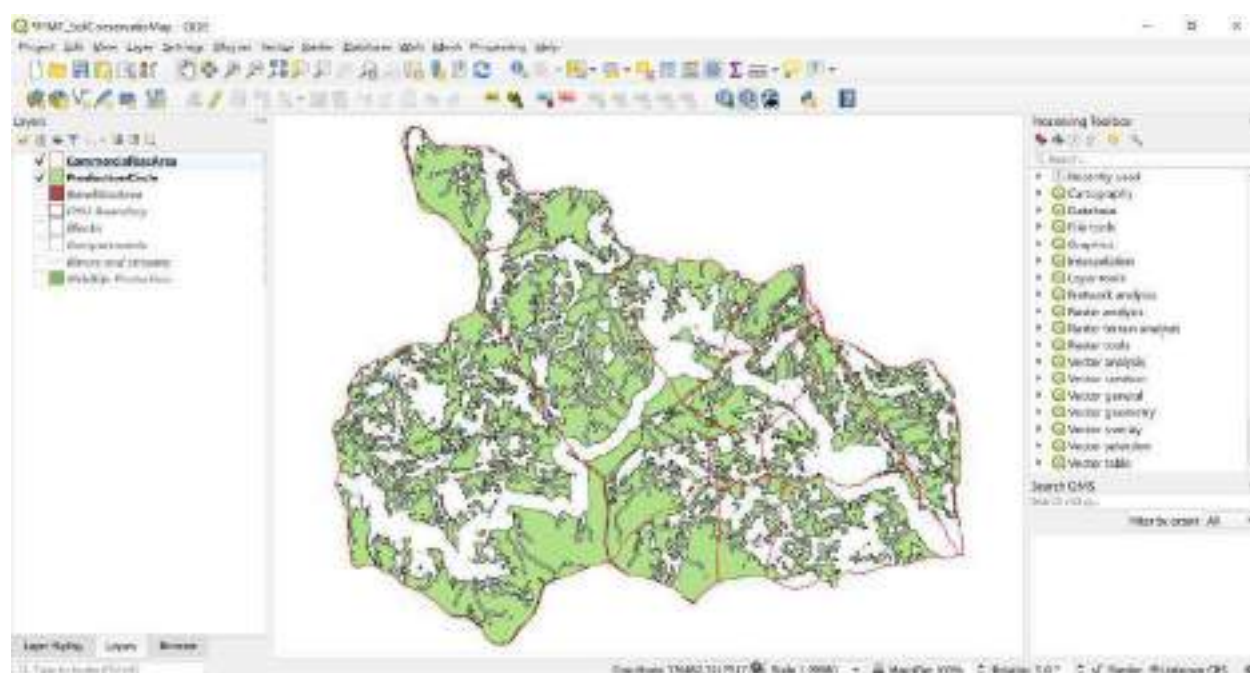
- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select local use area layer*
- *In input features: select production layer*
- *Save the file with appropriate name in working directory*





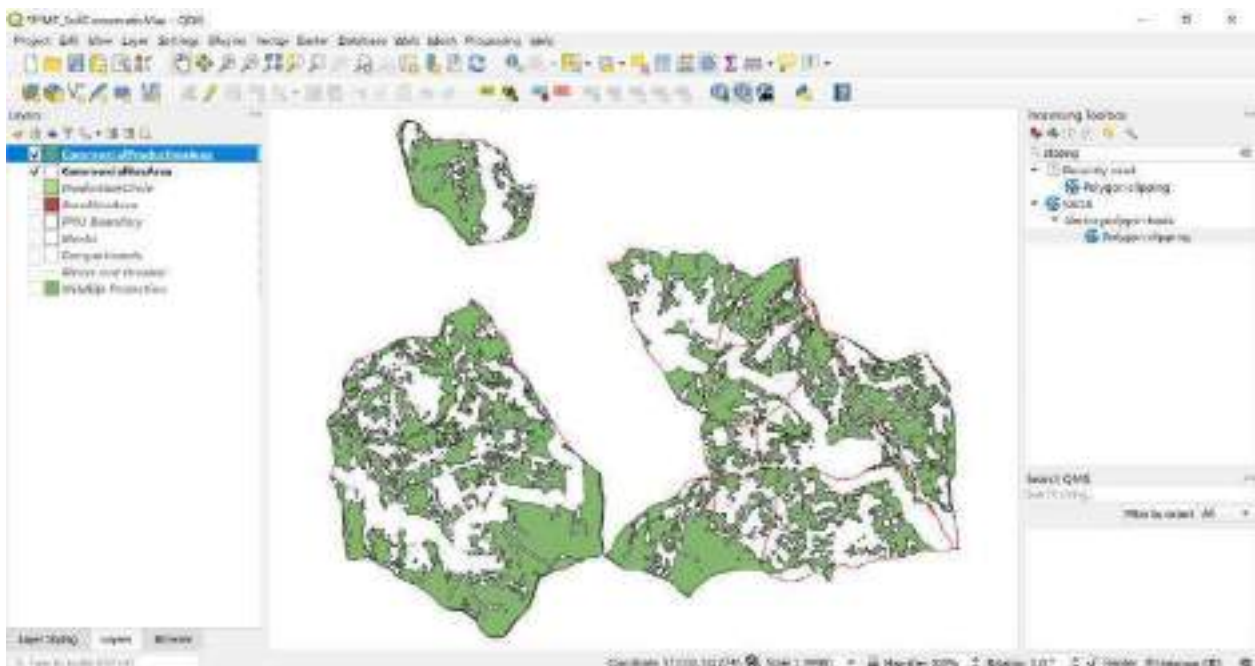
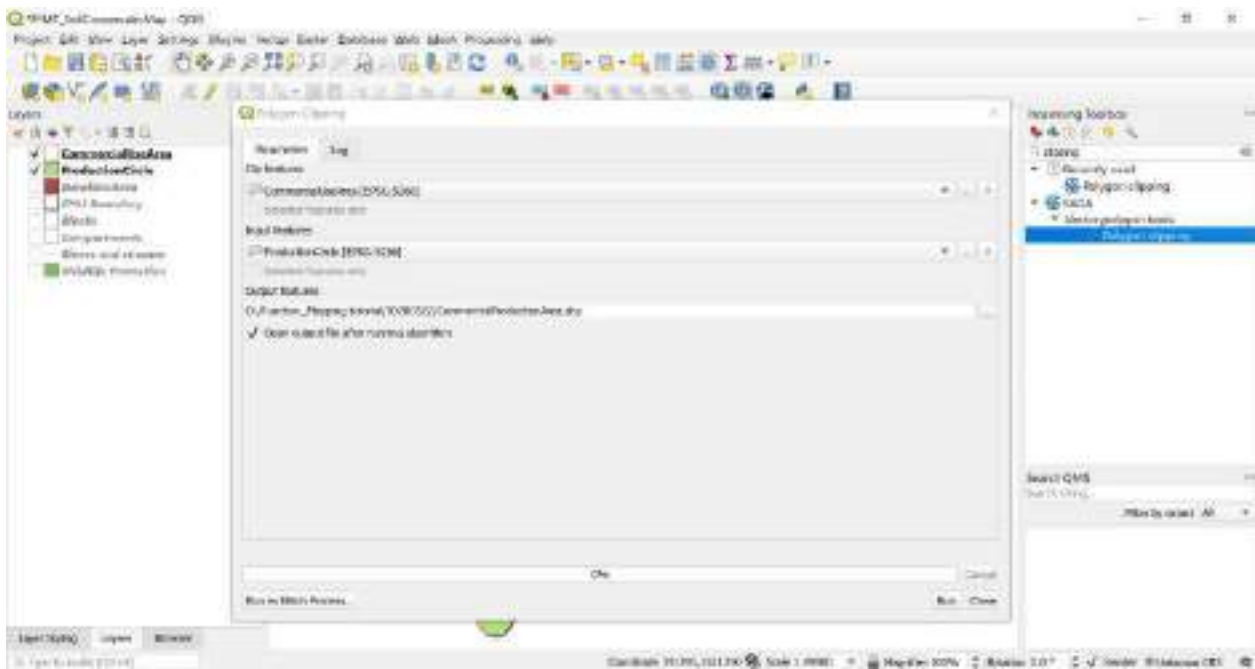


- *Add production layer*
- *Add commercial use area layer*



Clip the production layer with Commercial use area

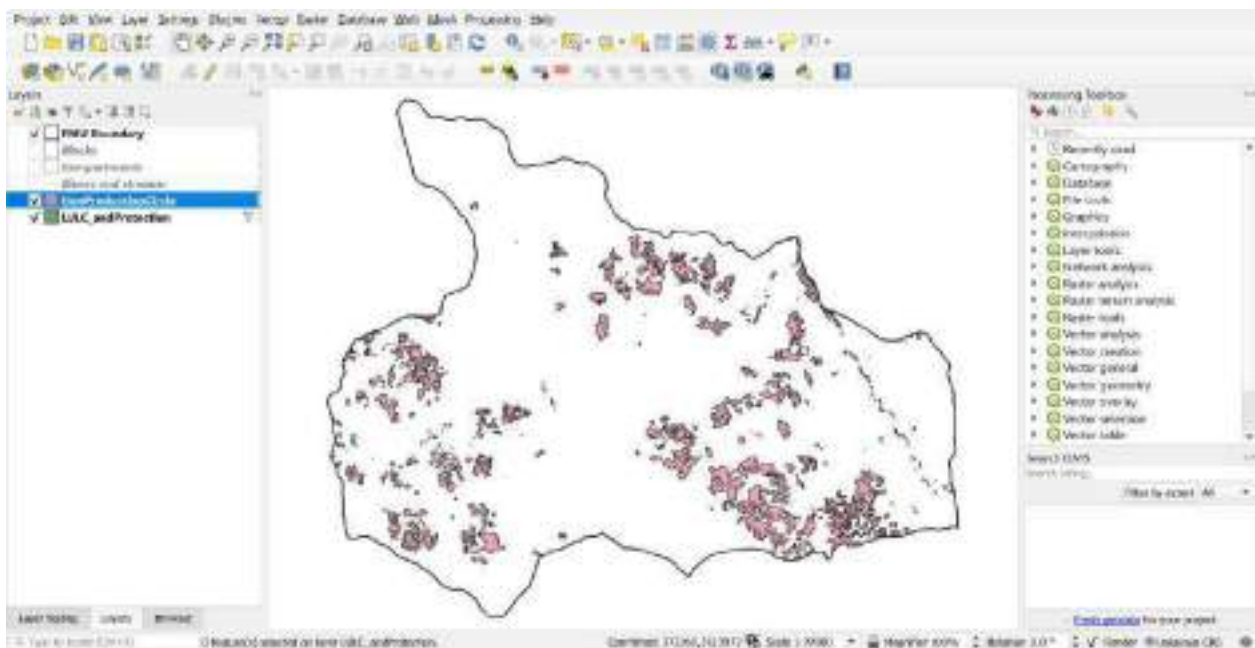
- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select Commercial use area layer*
- *In input features: select production layer*
- *Save the file with appropriate name in working directory*



Apart from production layer, non-production layer also needs to be created, this layer comprises of any area apart from forest and protection layer.

- *Select only non-production area (Area other than forests and protected layer)*
- *Right updated LULC(LULC\_andProtection) > Filter*
- *Enter expression following expression:*  
*"CLASS" = 'Built up' OR "CLASS" = 'Cultivated Agriculture' OR "CLASS" = 'Landslides' OR*  
*"CLASS" = 'Meadows' OR "CLASS" = 'Shrubs' OR "CLASS" = 'Water Bodies'*
- *Click Ok*

- *Right click on filtered layer > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *Save the file with appropriate name in working directory*



### 1.9.2. Preparation of Forest Function Maps

This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to used QGIS version 3.12 and above.

### 1.9.2.1 Soil Conservation Function Map

## Open QGIS

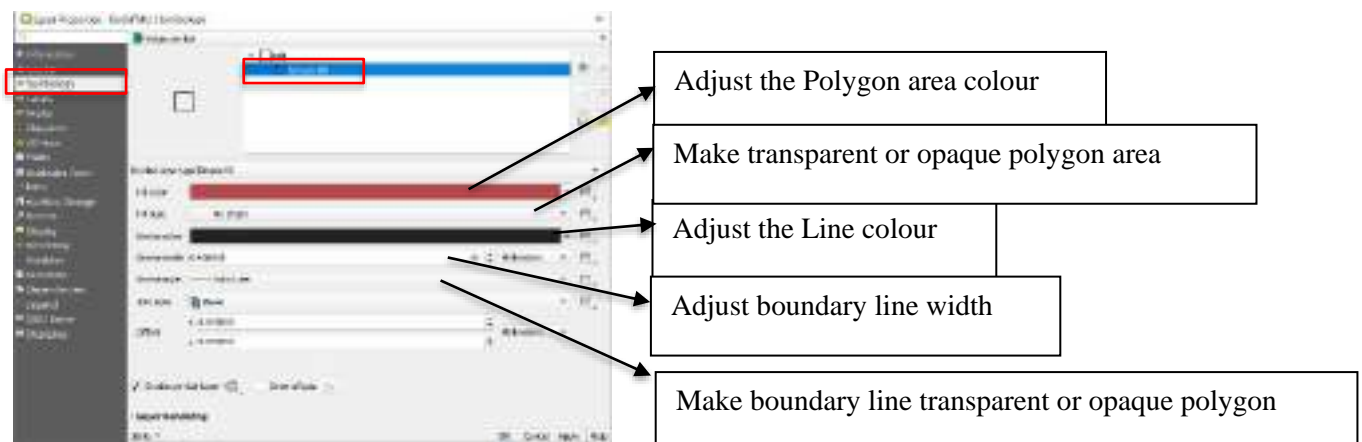
Add following layers:

- *FMU Boundary, Blocks and Compartment layer*
- *Rivers layer*
- *Soil Protection layer*
- *Soil Conservation layer*

### Modify the colour of layers

For polygon layer

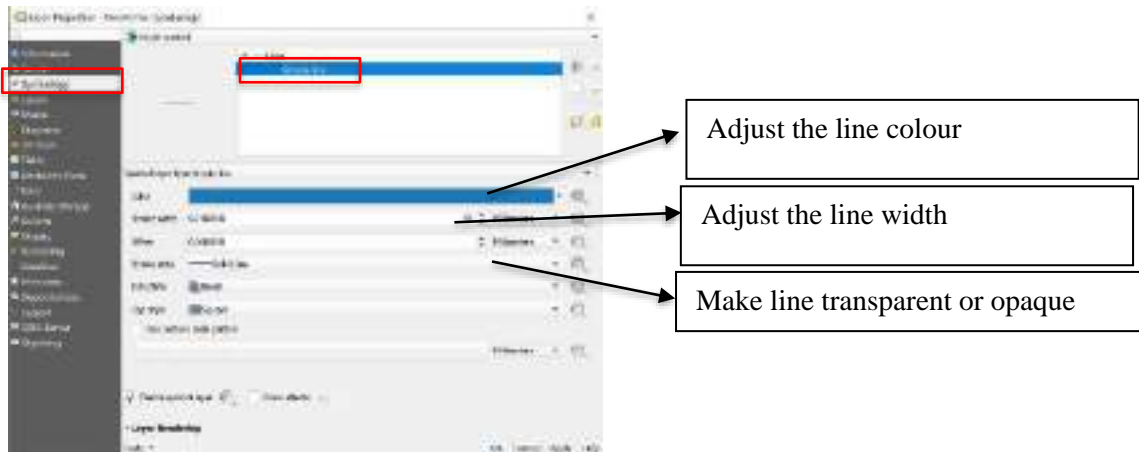
- *Right click polygon layer > Properties > Symbology > Simple fill*





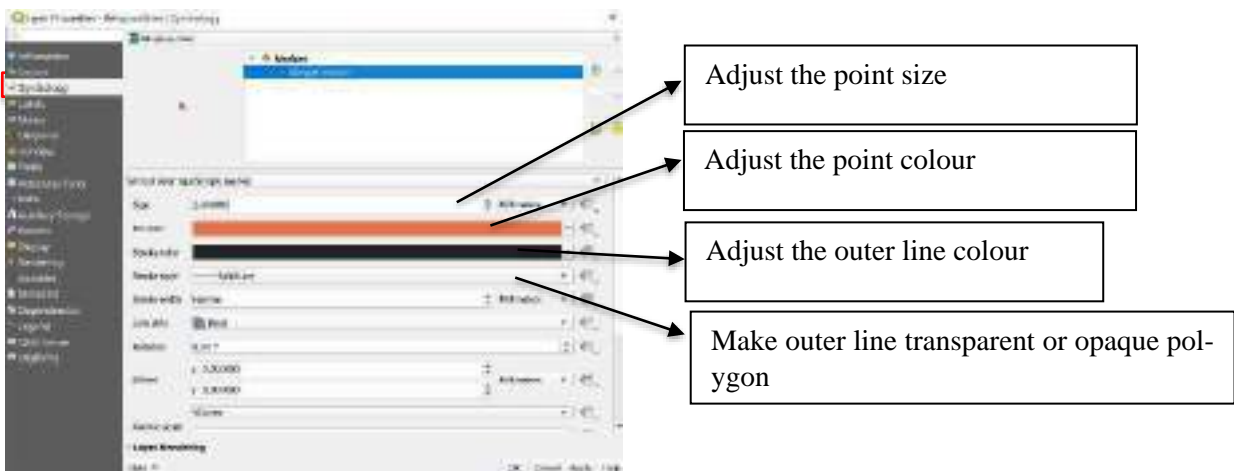
For Line layer

- *Right click line layer > Properties > Symbology > Simple line*

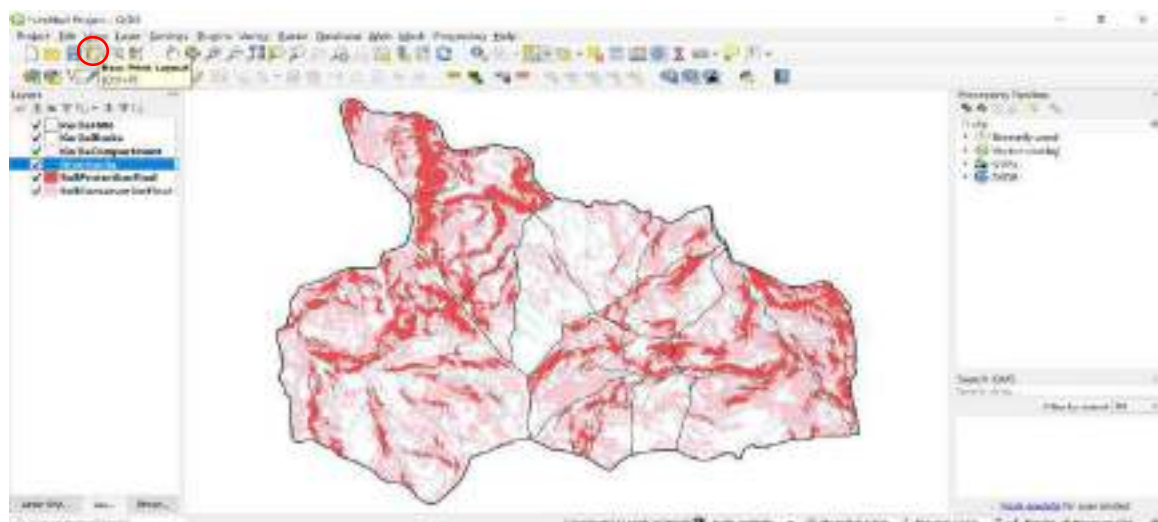


For Point layer

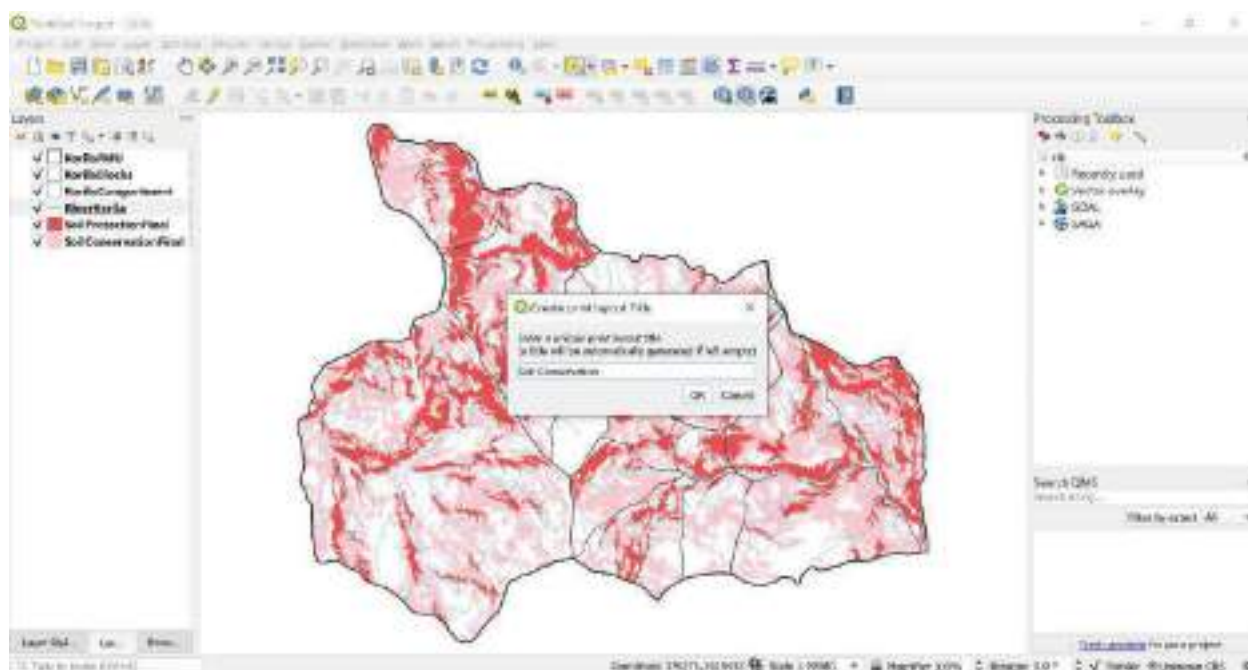
- *Right click point layer > Properties > Symbology > Simple marker*



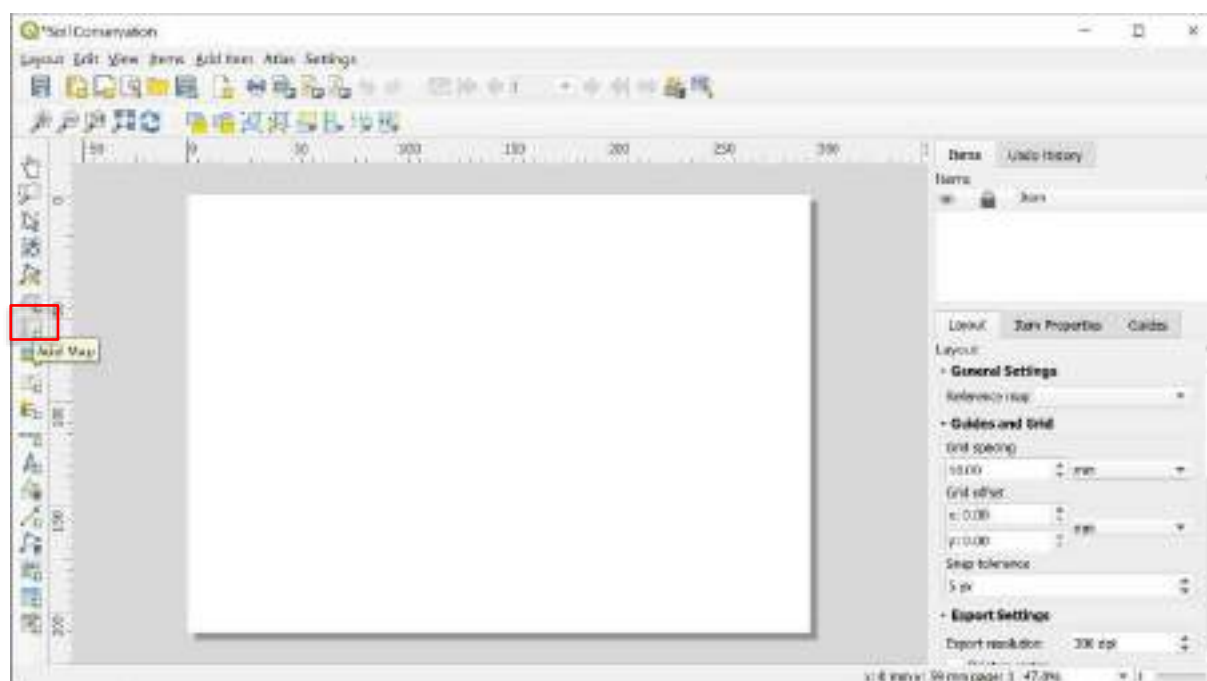
Open New Print Layout



- *Type soil conservation as print layout title > ok*

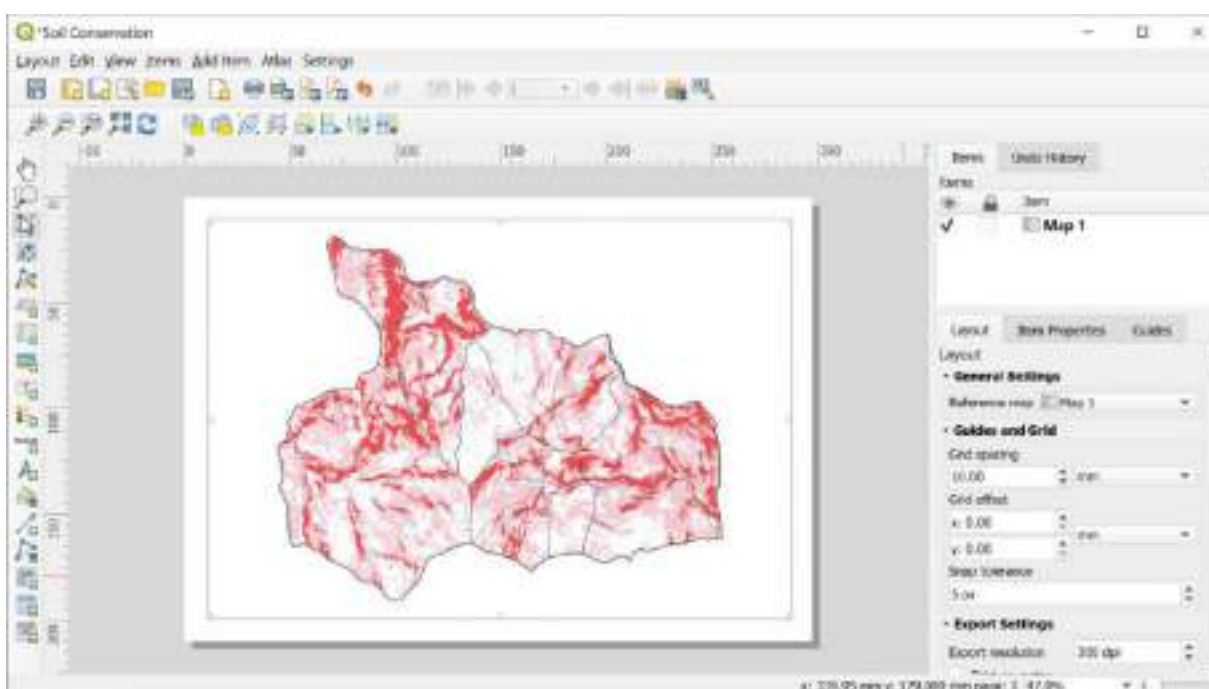
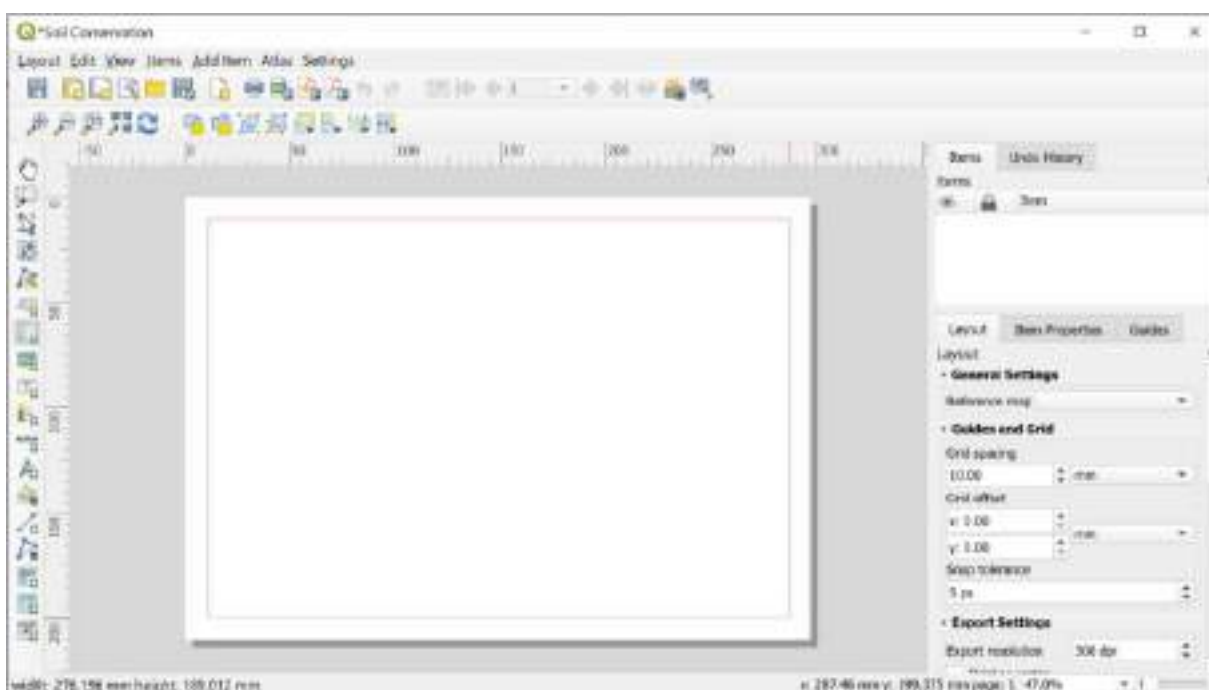


➤ *Click on Add Map*

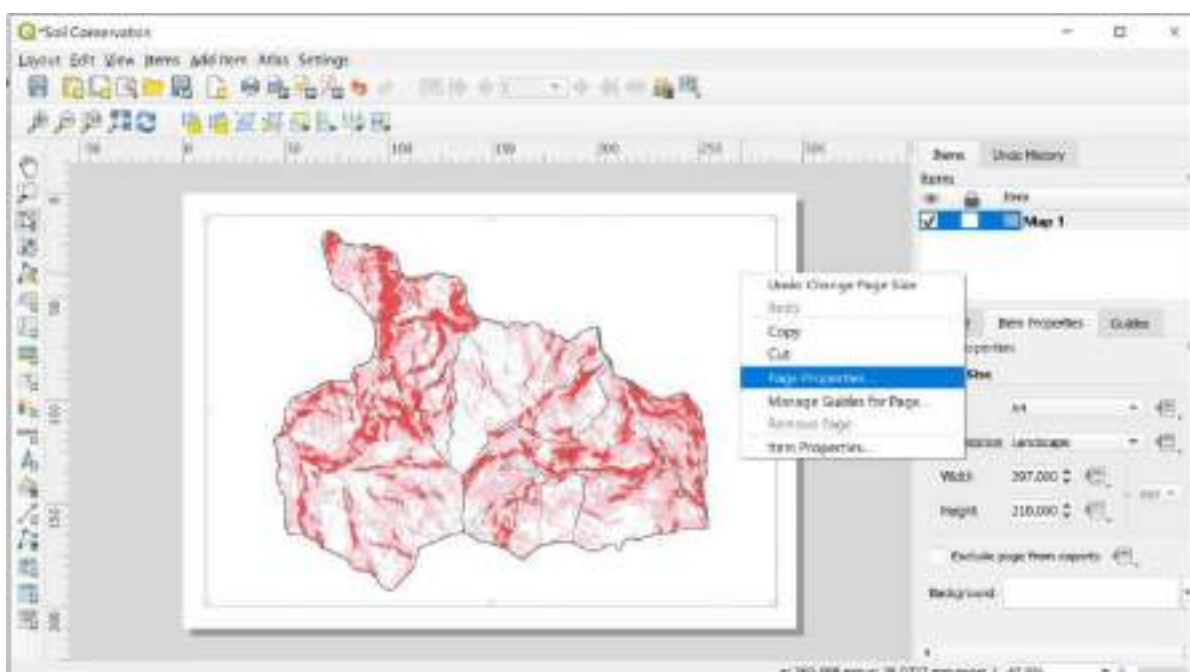


➤ *Move the mouse on page > left click on mouse > drag the mouse to form box on the page*



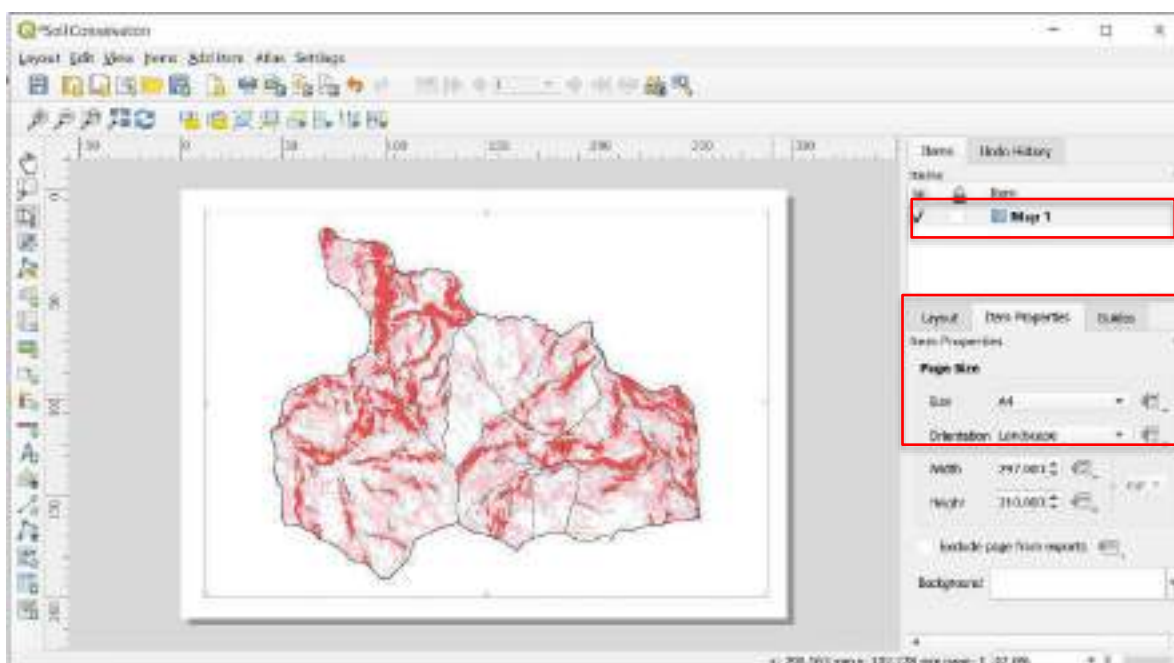


- Right Click on the page > click page properties



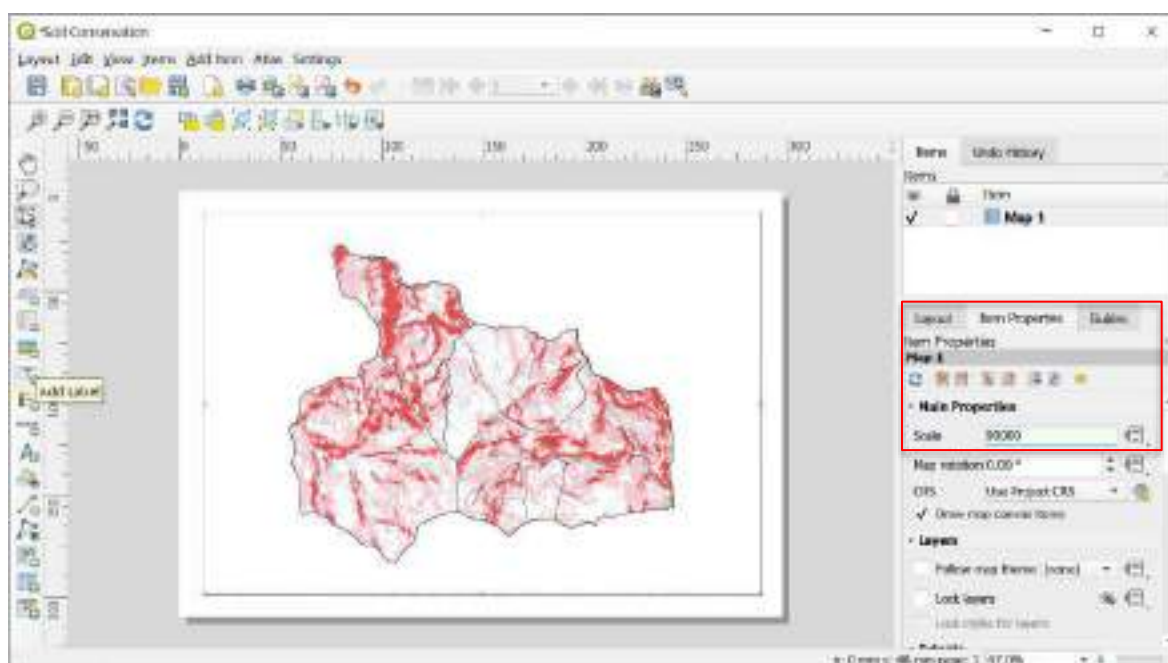
In the item properties

- Click Map 1 > click Item Properties
- Change the page size to A4
- Orientation to Landscape (this depends on shape of FMU)



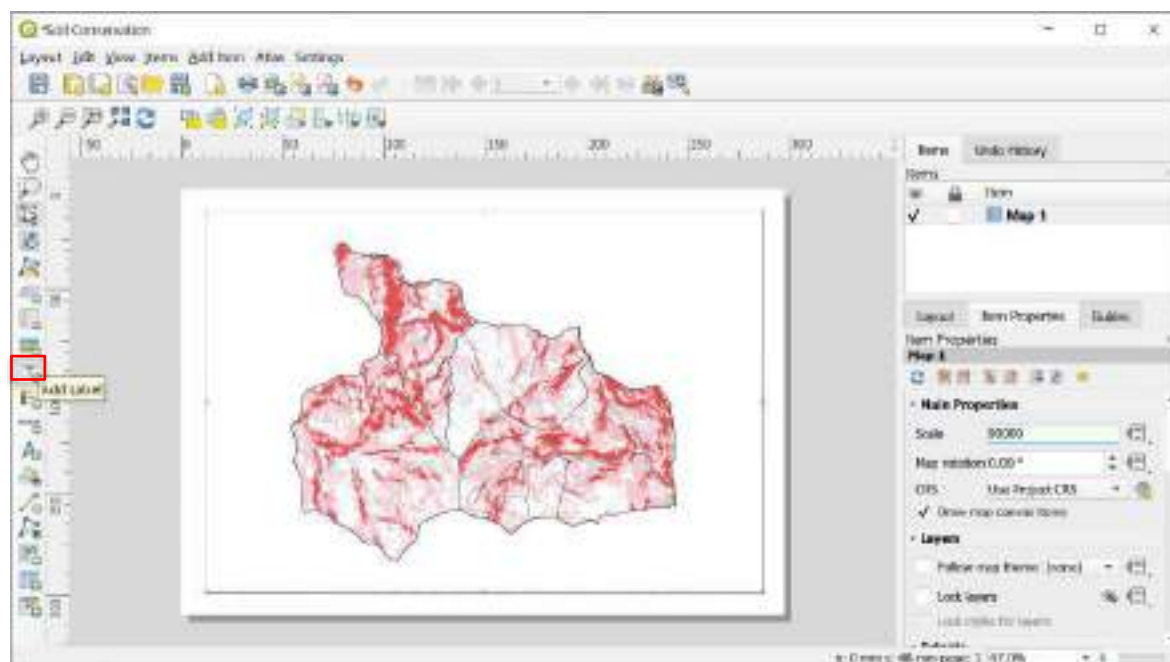
Change the scale of map

- Click Map 1 > click Item Properties > Click Map 1 > Click Main Properties > Scale
- Change to appropriate scale.

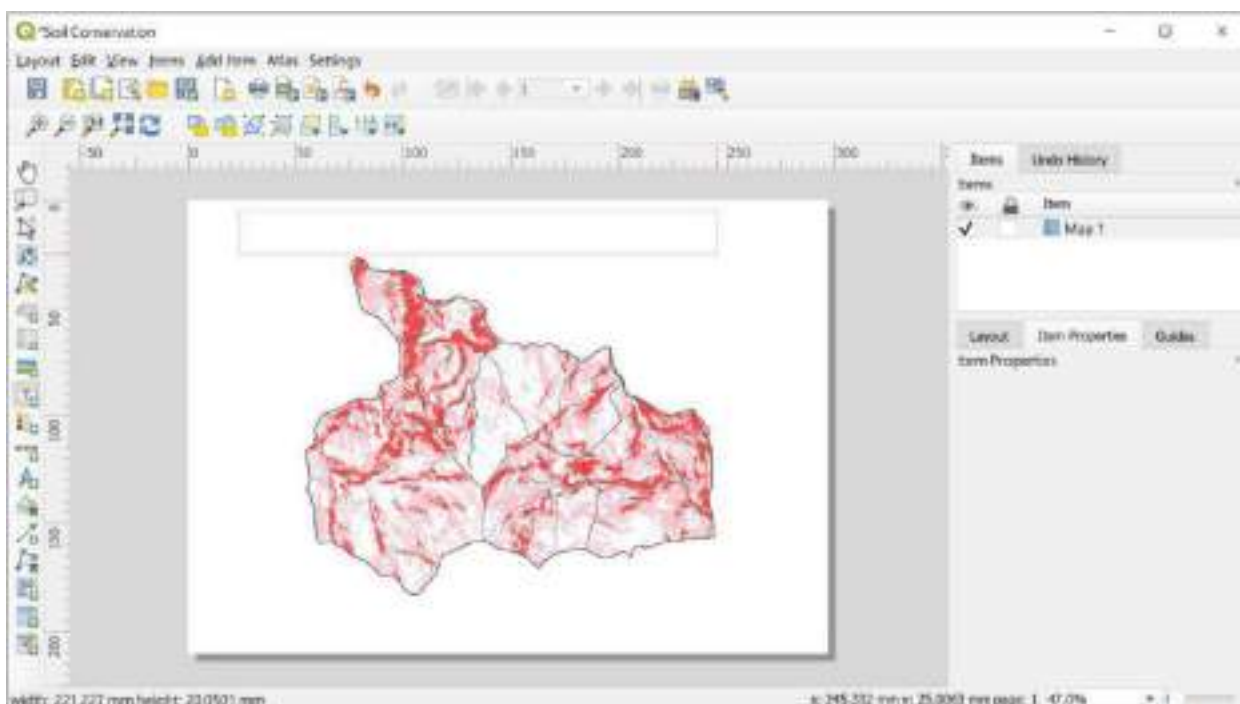


Insert the title of the map

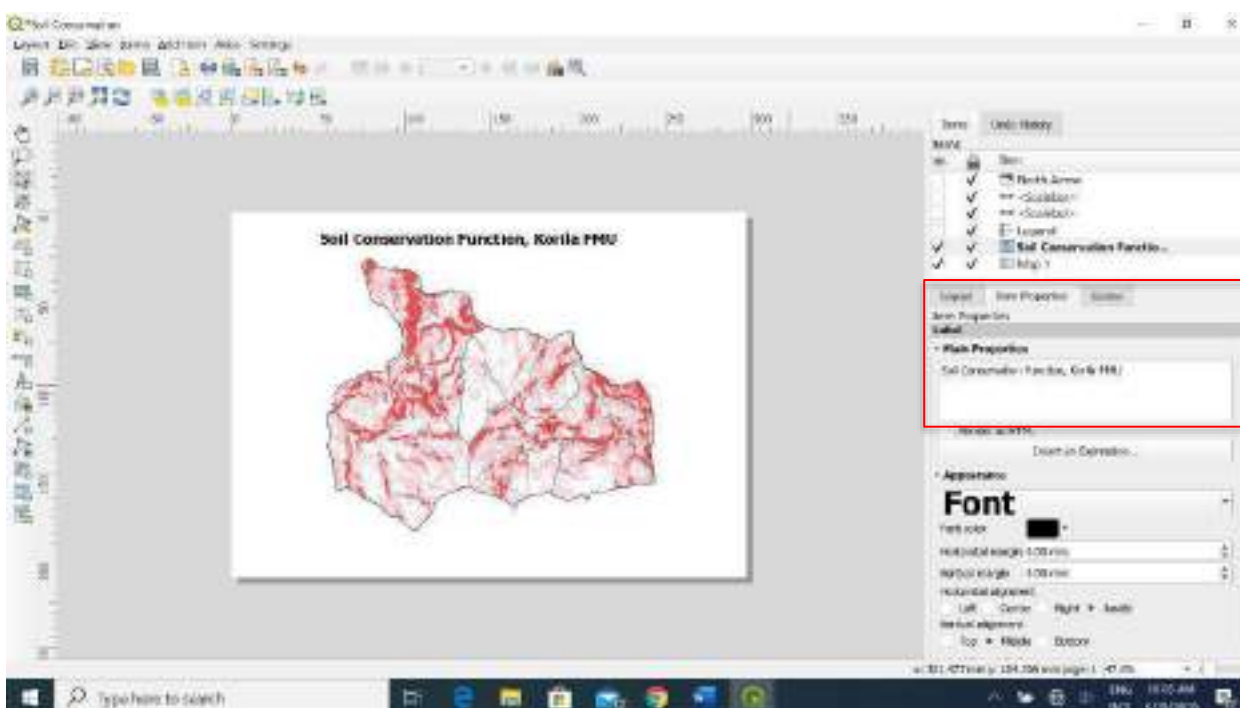
- *Click add label*



- *Move the mouse on page > left click on mouse > drag the mouse to form box on the page to fit the title*



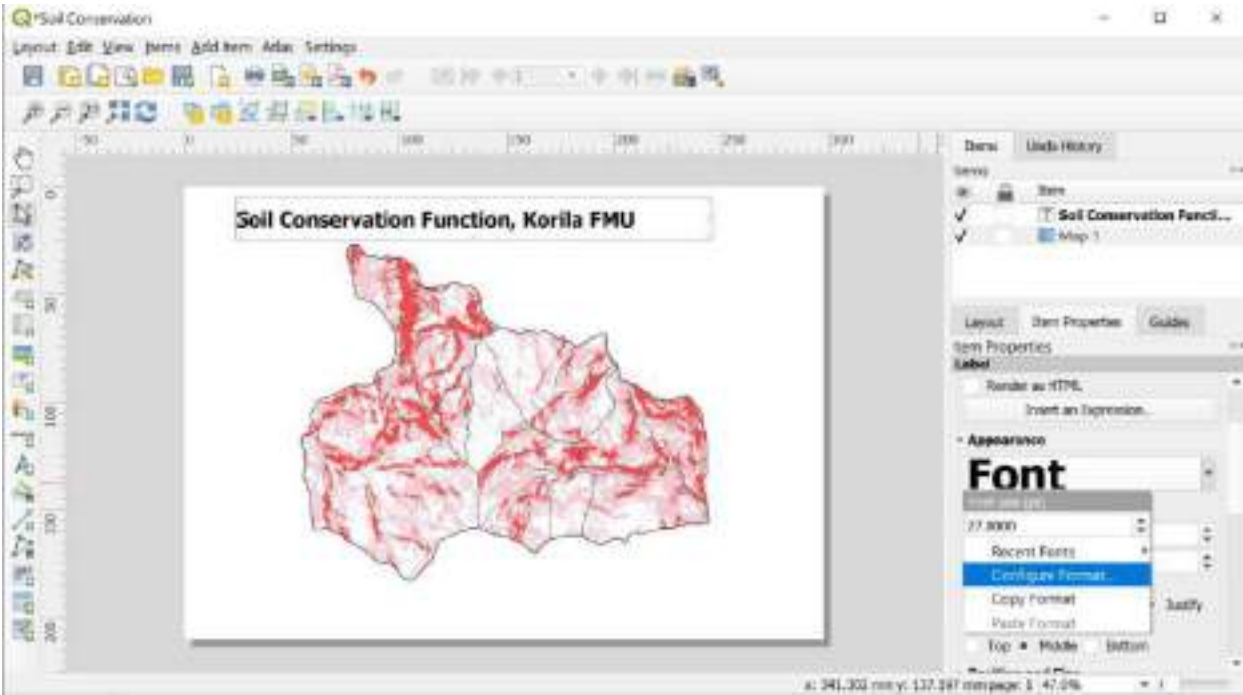
➤ *In the Item Properties box > type appropriate title*



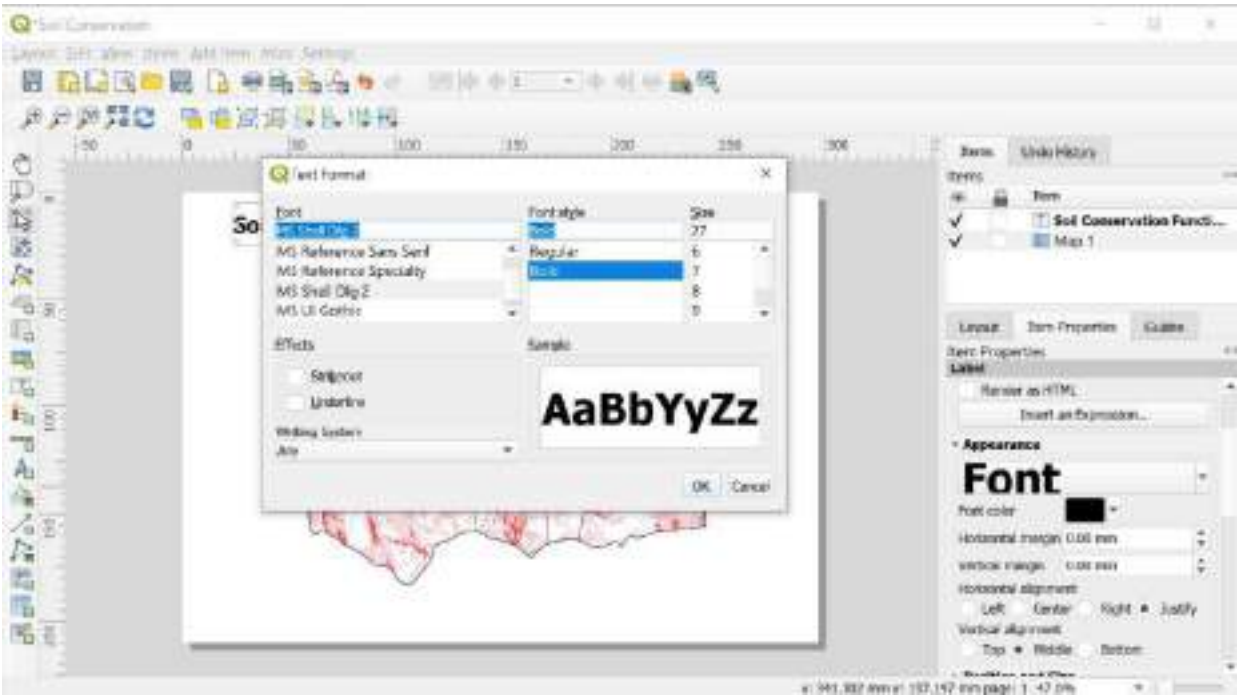
To change the font and size of title

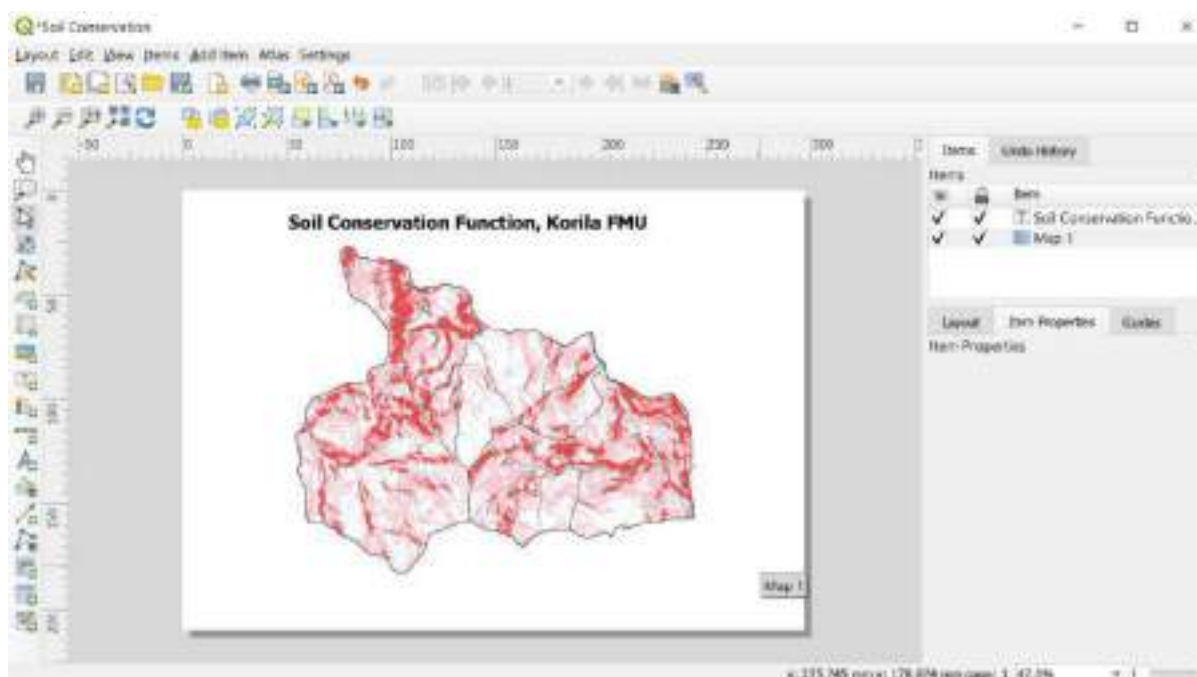
➤ *Click Font > configure format*





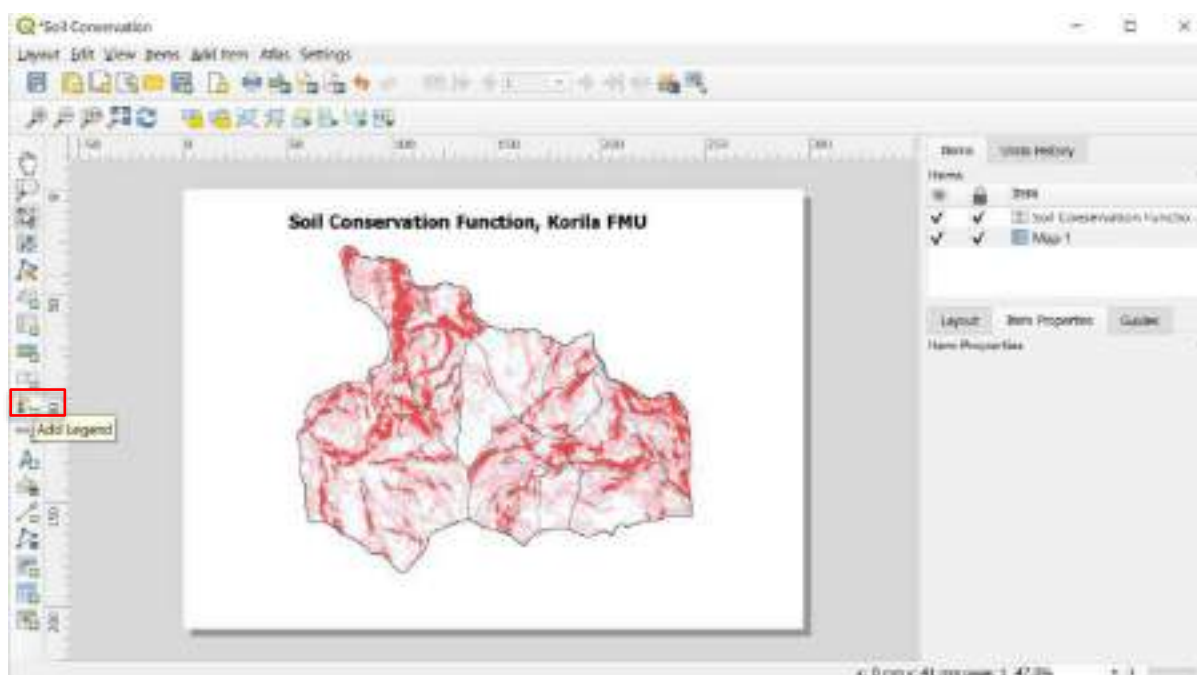
➤ Change the font and size accordingly





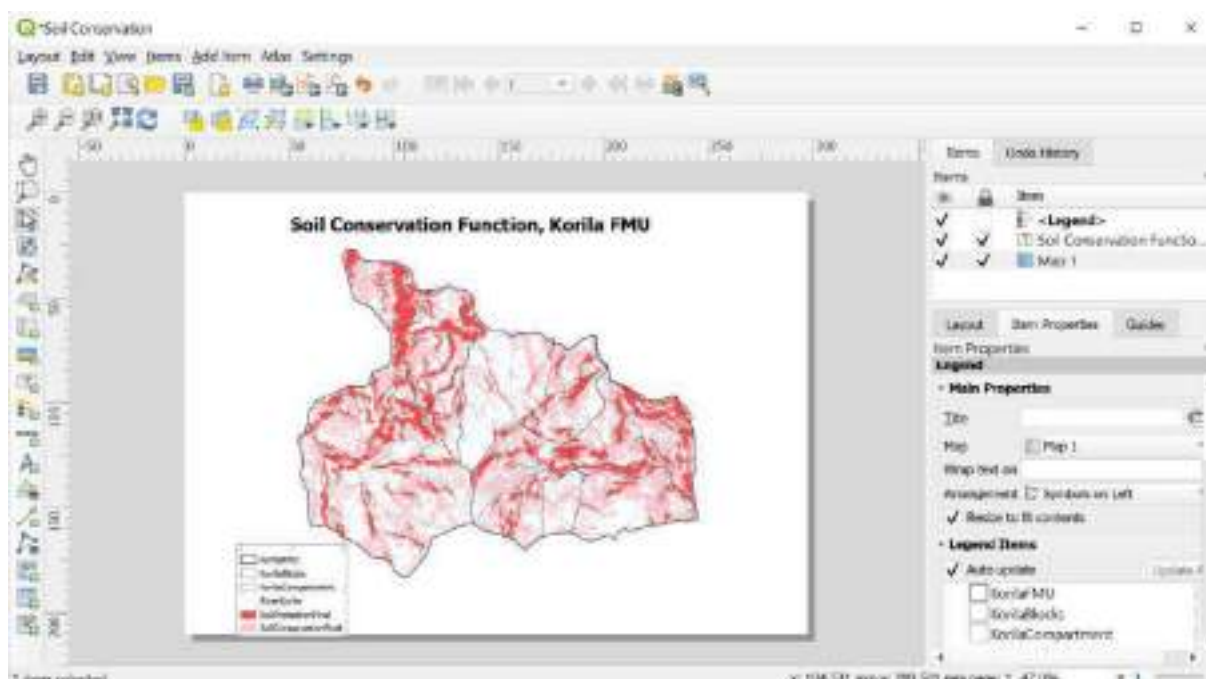
Add legend on the map

- Click Add Legend

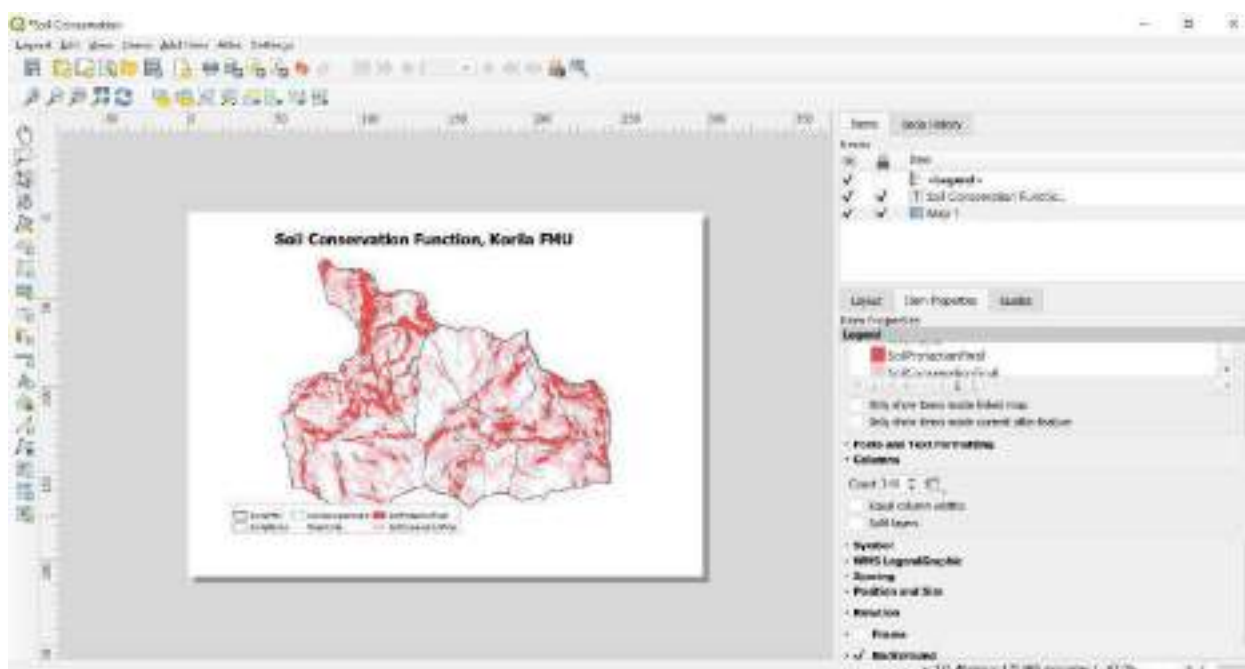


- Move the mouse on page > left click on mouse > drag the mouse to form box on the page to fit the legend

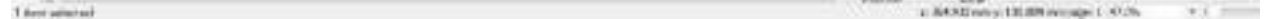


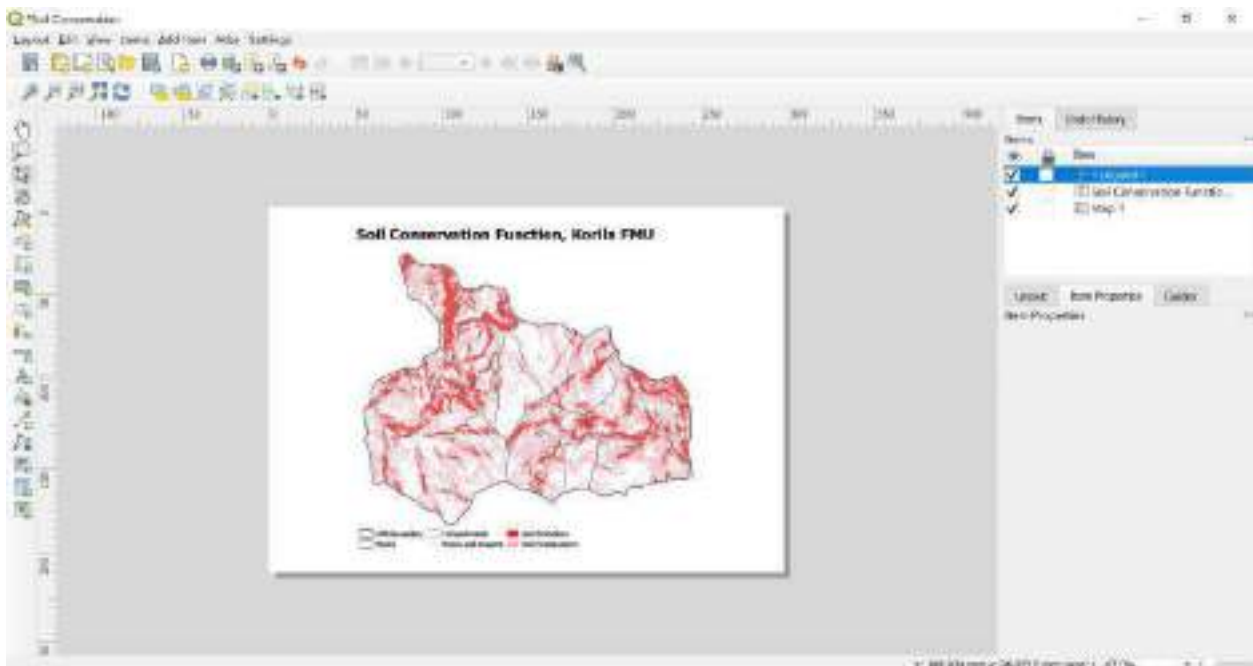


- *In the item box > Click on legend > Click Item Properties > Click Column > Insert the appropriate number of columns required for displaying the legend*



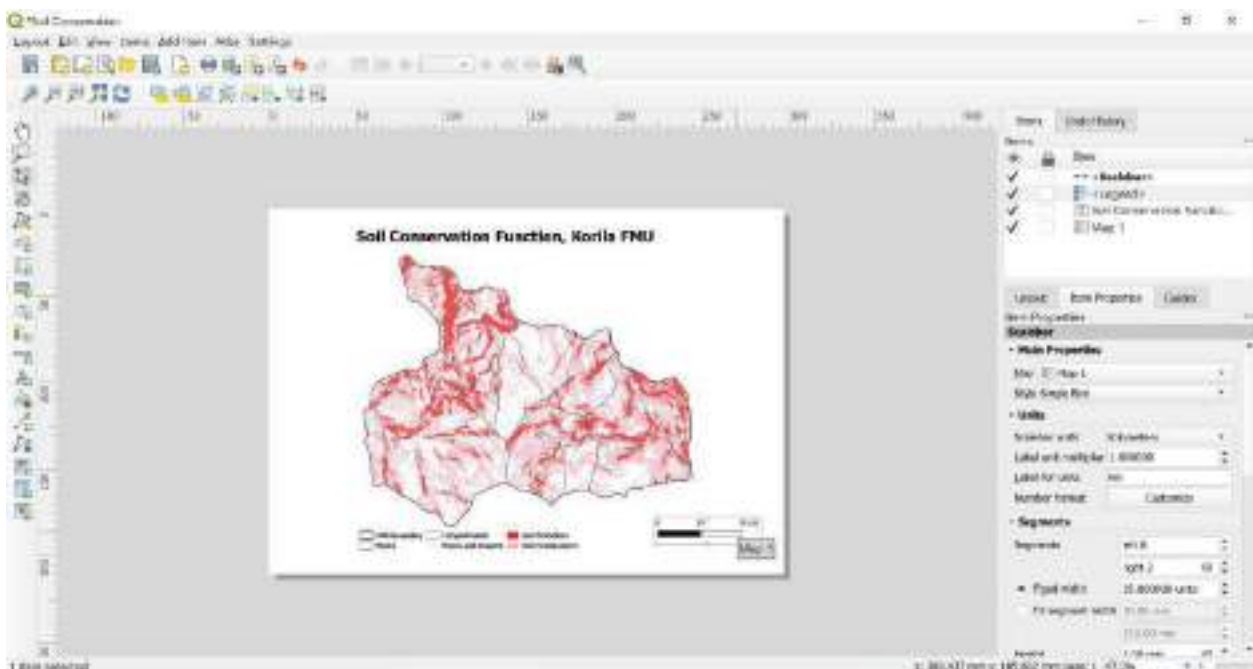
- *Drag and place the legend in the desired position*





Add scale on the map

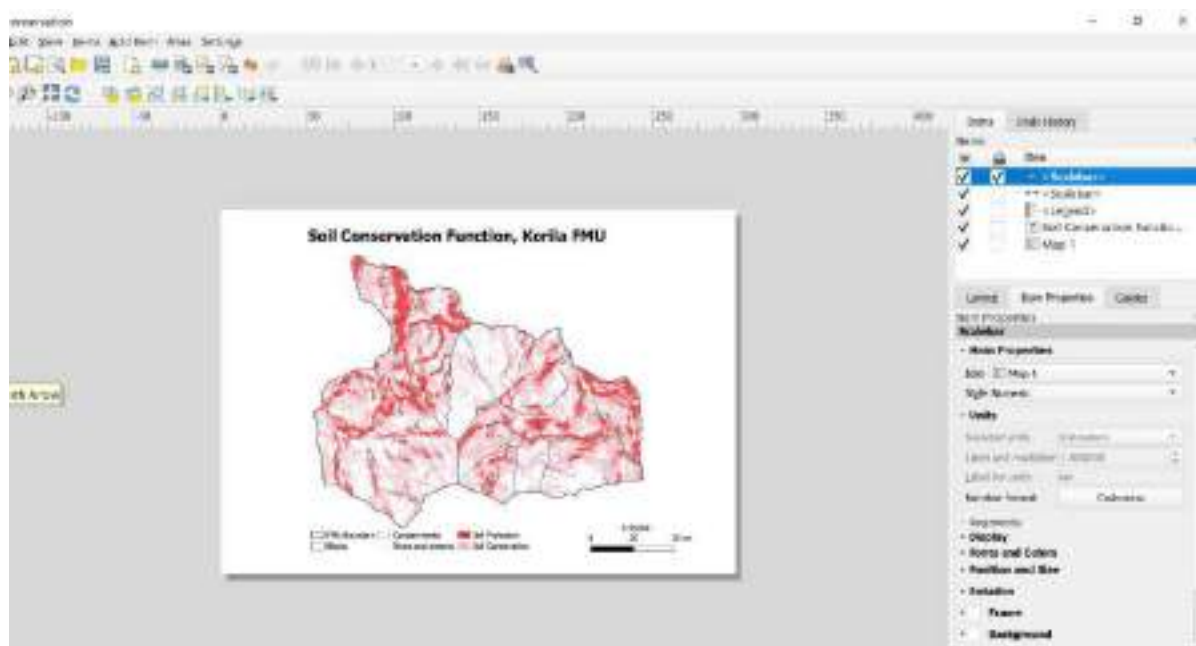
- Click on Add scale bar
- Move the mouse on page > Left click on mouse > drag the mouse to form box on the page to fit scale



Scale can be change to bar or numeric scale

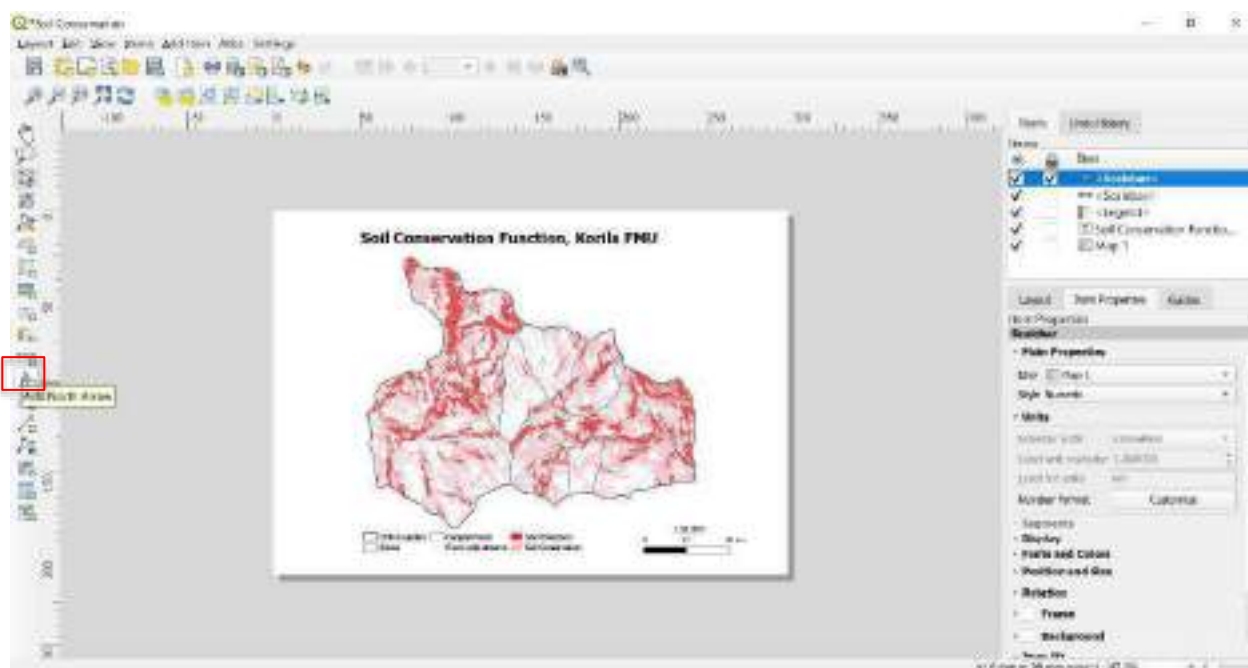
- In the item box > Click on Scalebar > Click Item Properties > Click Scalebar > Click Main Properties > Style > Change scale to bar scale or numeric scale

It is also possible to have both bar scale and numeric scale on a map

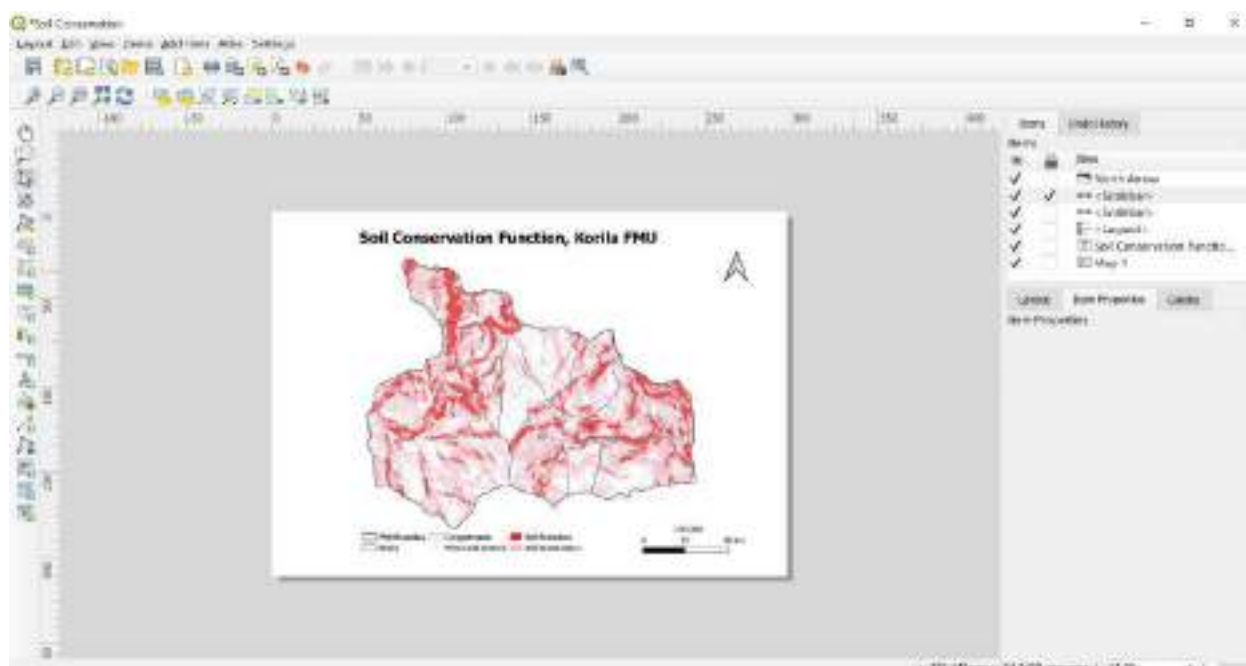


Add North arrow

- Click add North Arrow
- Move the mouse on page > Left click on mouse > drag the mouse to form box on the page to fit North arrow



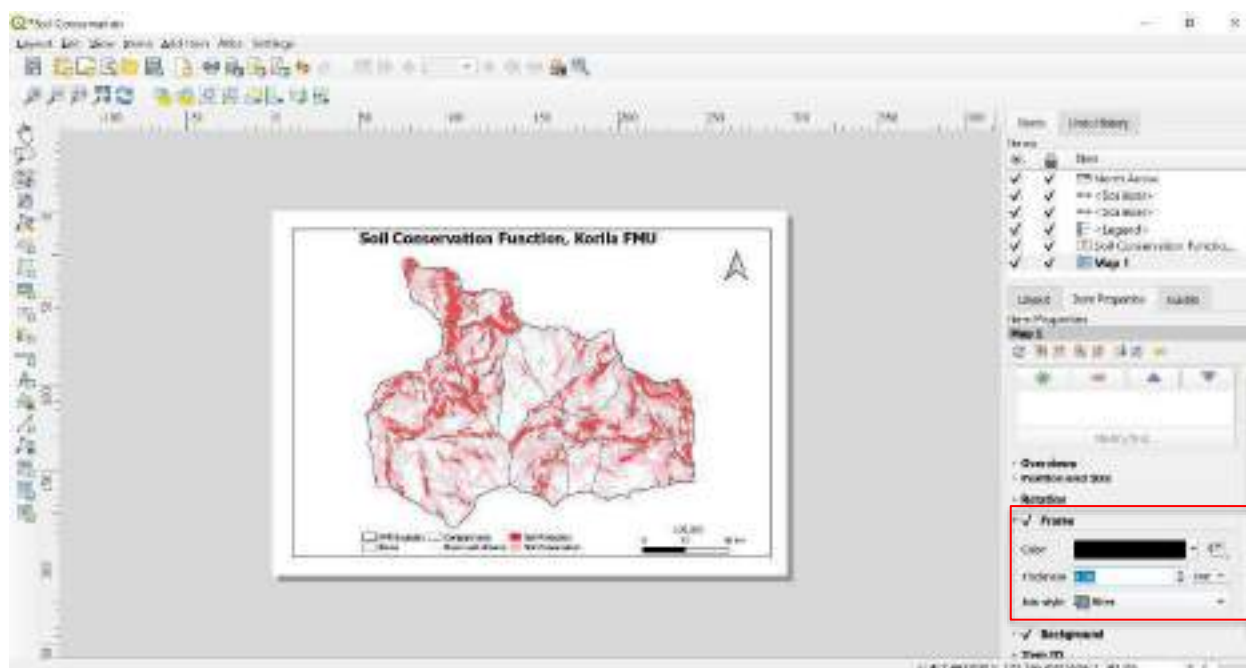




Add frame on the map

- In the item box > Click on Map1 > Click Item Properties > Click Frame > Check Frame

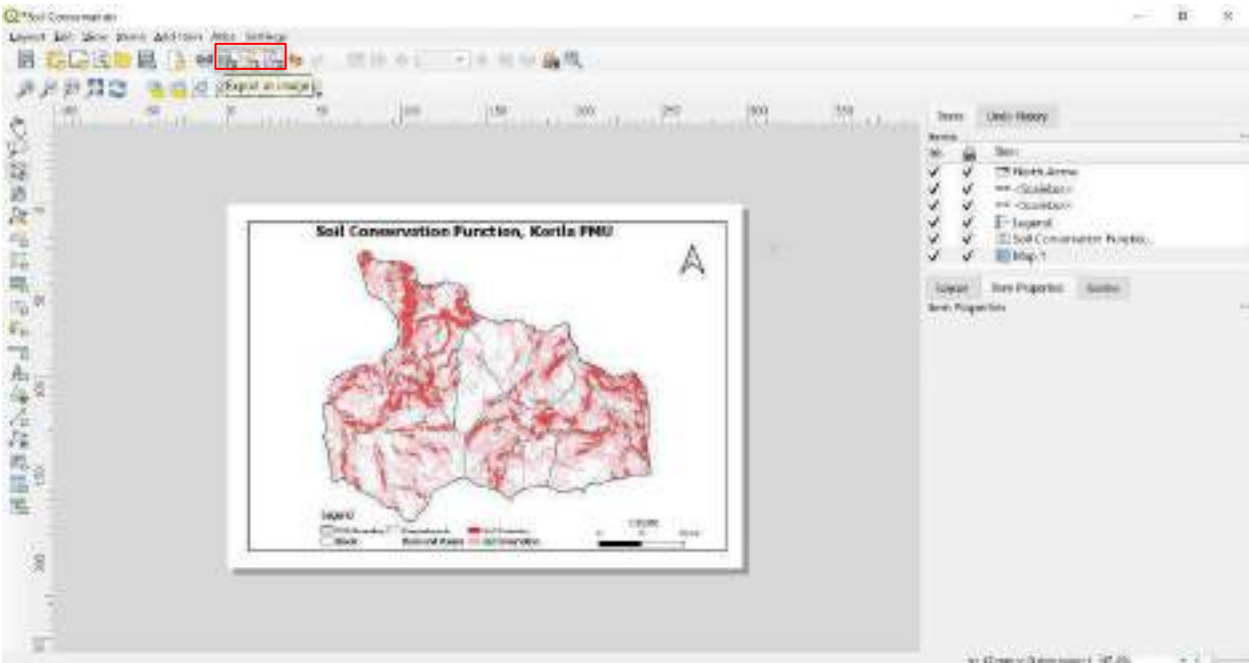
Colour, thickness and style can be adjusted accordingly



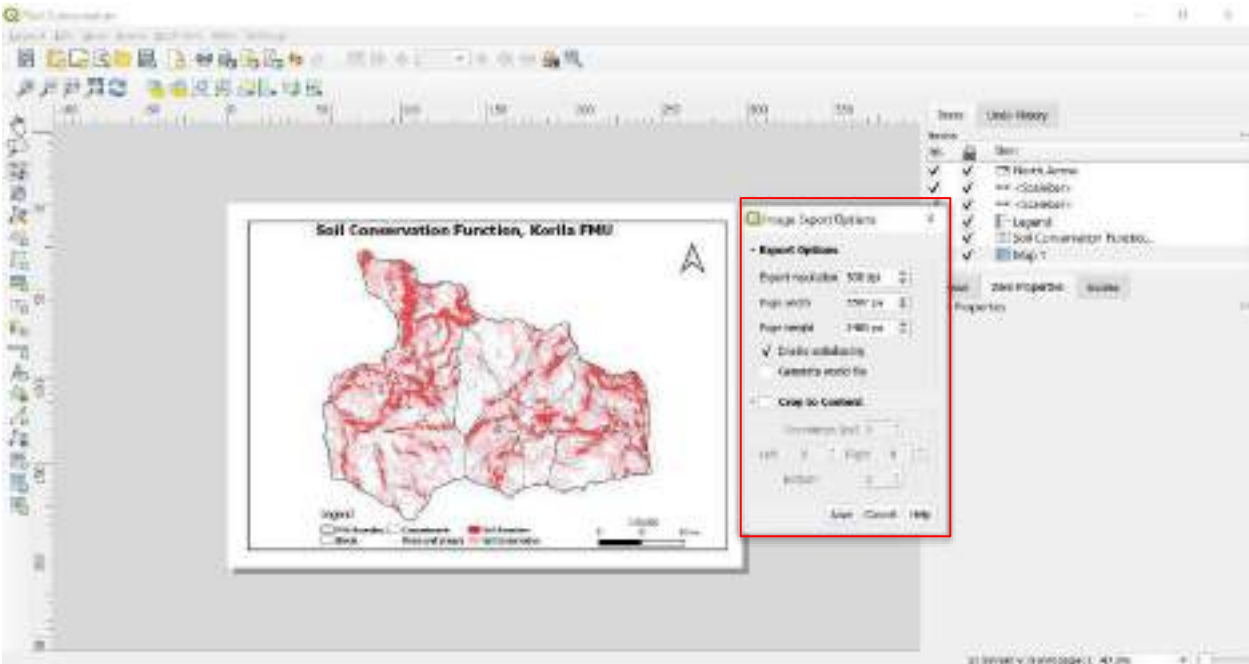
Exporting the map

Map can be exported as in three different format (JPEG, SVG and PDF)

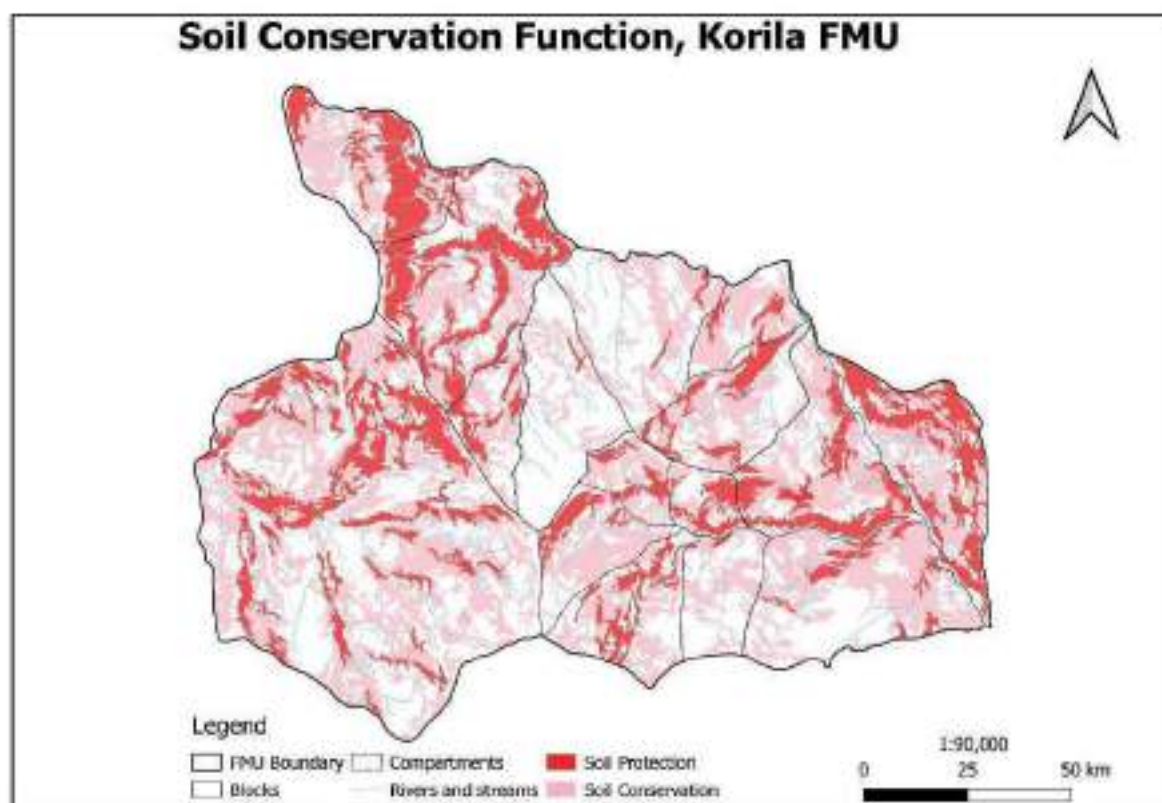
- Click Export as image > save the image in the destination folder with appropriate name



Resolution, width and height of map can be adjusted Export Option.





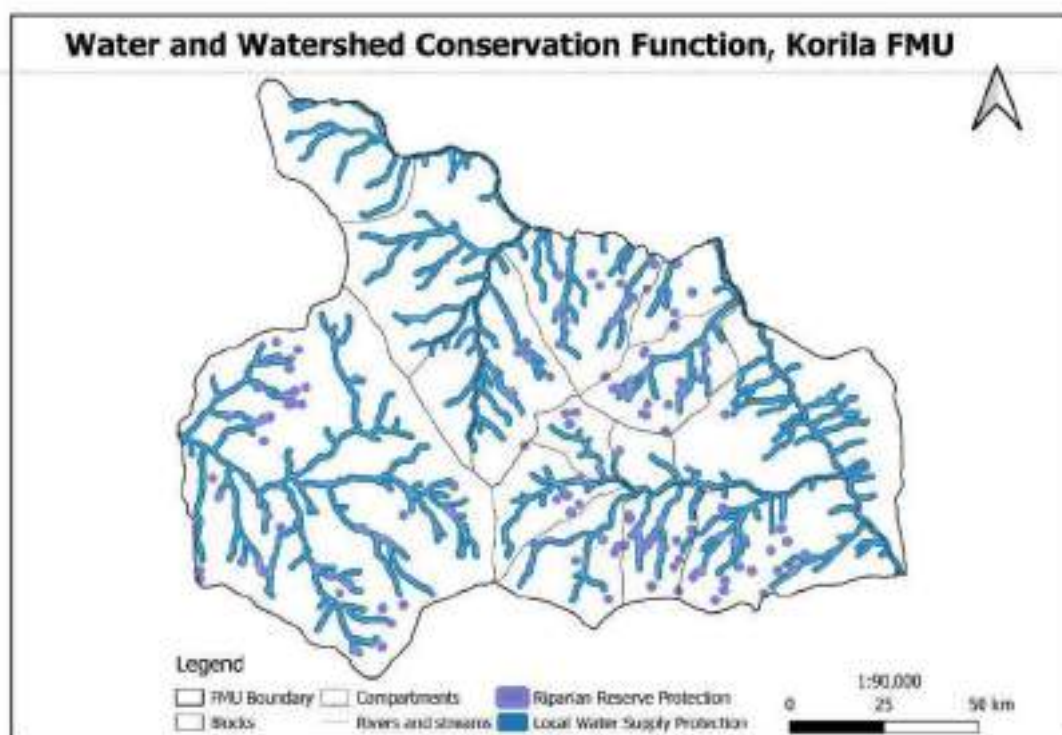


### **1.9.2.2 Water and Watershed Conservation Function Map**

Refer to mapping process for soil conservation function to produce water and watershed conservation function map

Layers needed:

- *FMU Boundary, Blocks and Compartment layer*
- *Rivers layer*
- *Riparian Reserve Protection layer*
- *Local Water Supply Protection layer*

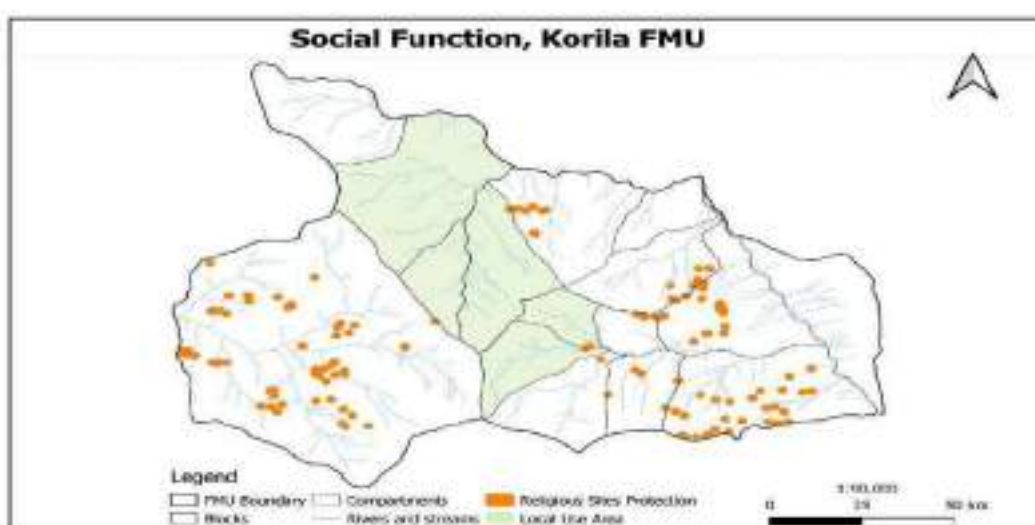


### 1.9.2.3 Social Function Map

Refer to mapping process for soil conservation function to produce social function map

Layers needed:

- *FMU Boundary, Blocks and Compartment layer*
- *Rivers layer*
- *Local use area layer*
- *Religious sites protection layer*

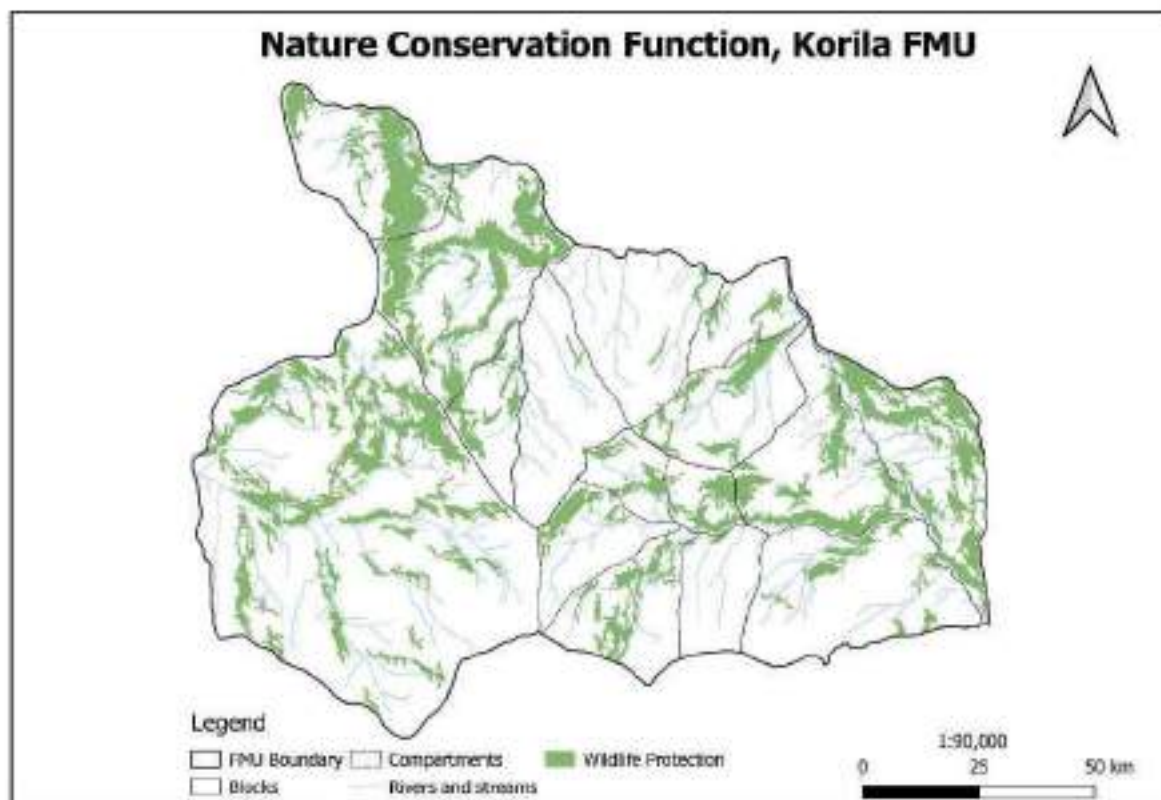


#### **1.9.2.4 Nature Conservation Function Map**

Refer to mapping process for soil conservation function to produce social function map

Layers needed:

- FMU Boundary, Blocks and Compartment layer
- Rivers layer
- Wildlife protection layer

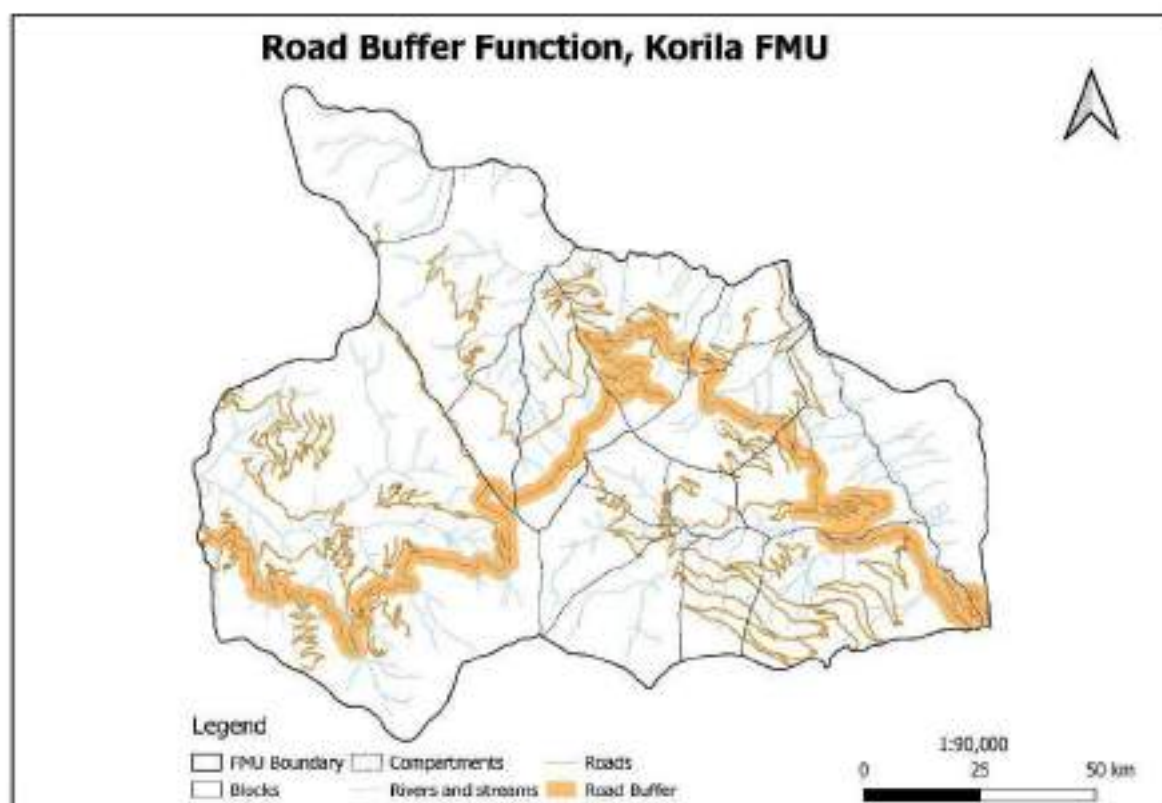


#### **1.9.2.5 Road Buffer Function Map**

Refer to mapping process for soil conservation function to produce road buffer function map

Layers needed:

- *FMU Boundary, Blocks and Compartment layer*
- *Rivers layer*
- *Road layer*
- *Road buffer layer*



### 1.9.2.6 Production Function Map

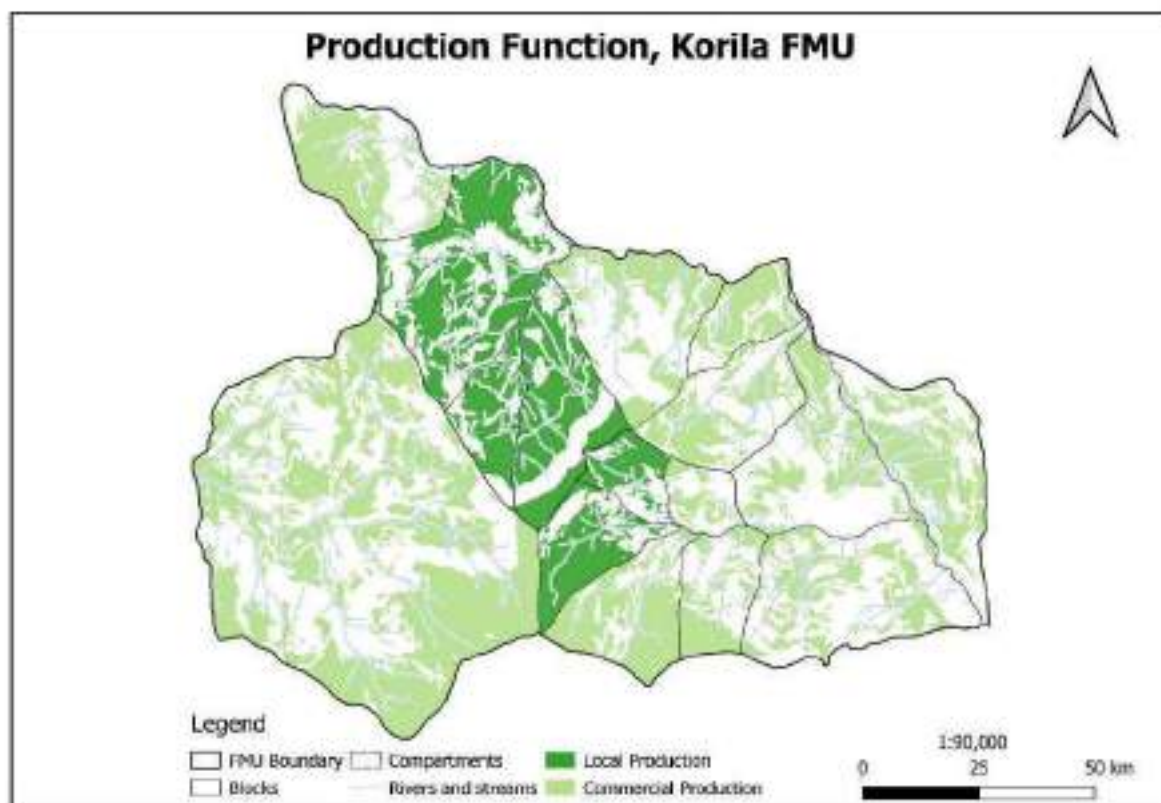
Production Function Map is divided into commercial production and local use only. The Production layer is derived upon excluding soil protection, riparian reserve protection, special watershed management area, local water supply protection, local use area, religious site protection, wildlife protection, biodiversity protection, road buffer and non-forest area layers.

Refer to mapping process for soil conservation function to produce production function map

Layers needed:

- *FMU Boundary, Blocks and Compartment layer*
- *Rivers layer*
- *Local Production layer*
- *Commercial Production layer*





### 1.9.3. Preparation of Management Circle Map

For the ease of implementation, forest management area is grouped into three management circles viz. Protection Management Circle, Non-production Management Circle and Production Management Circle (Figure 1.8 Management Circle for FMU).

- **Protection Management Circle:** This circle comprises of all the protection layers derived during the forest function mapping.
- **Non-production Management Circle:** This circle comprises of non-forest layers after the exclusion of Protection Management Circle layers.
- **Production Management Circle:** This circle comprises of stable forest area layer from where timber can be sustainably produced. The area remaining after exclusion of Protection and Non-production Management Circles is mapped as the Production Management Circle.

Refer to mapping process for soil conservation function to produce management circle map

Layers needed:

- *FMU Boundary, Blocks and Compartment layer*
- *Rivers layer*
- *Protected merged layer (Soil Protection layer, Riparian Reserve Protection layer, Local Water Supply Protection layer, Religious sites protection layer, Wildlife protection layer, Road buffer layer); Rename this layer as "Protection Management Circle"*
- *Non-production layer (area other than forests and protection layer); Rename this layer as "Non-Production Management Circle"*

Production layer; Rename this as “Production Management Circle”

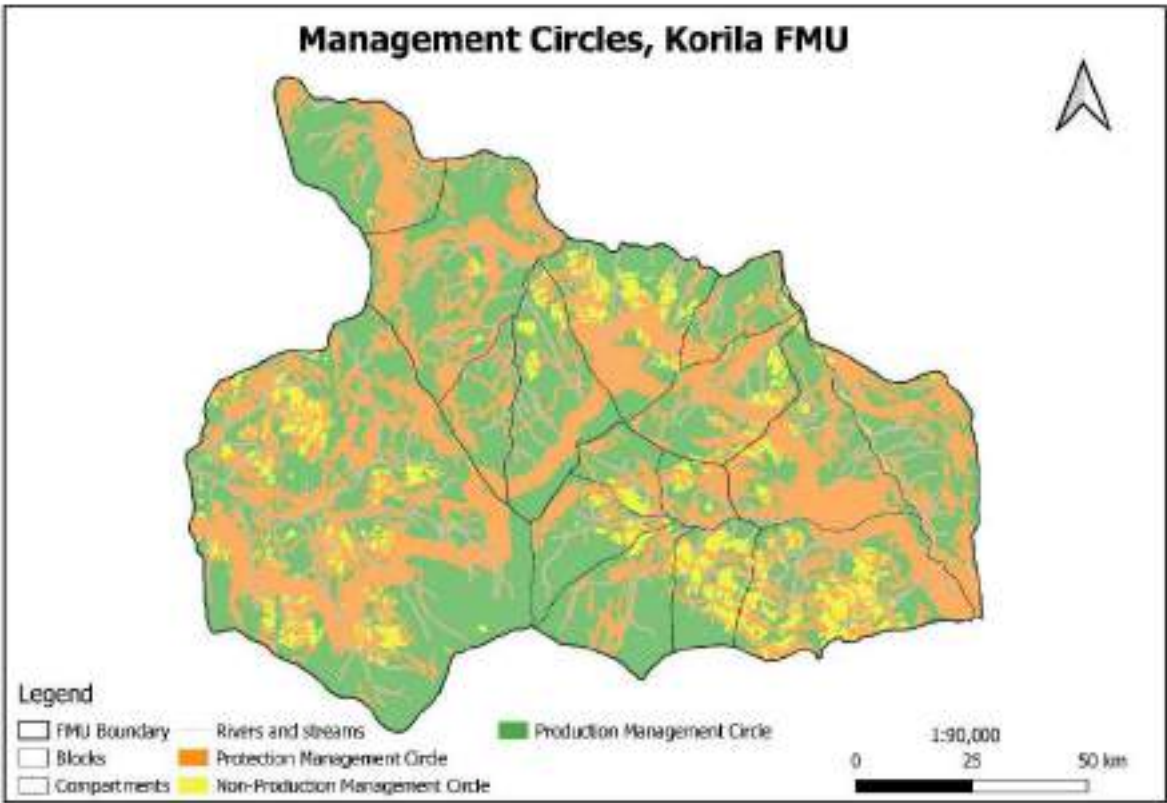


Figure 1.8 Management Circle for FMU



## **1.10. Calculating sustained yield**

### **1.10.1. Objective**

To determine the sustained yield expressed as annual allowable cut (AAC) for the operable area.

### **1.10.2. Outputs**

Estimated allowable AAC for the operable zone (by working circle). Area statement and other tabular data.

### **1.10.3. Lead responsibility**

Divisional Forest Offices

### **1.10.4. Timing of the activity**

AAC calculation shall be undertaken after forest function mapping, inventory and data processing.

### **1.10.5. The importance of yield regulation to sustainable forest management**

A prerequisite of sustainable forest management is that the removal of forest products does not exceed the rate of replacement. Without this basic balance, provided by yield regulation, sustainable forest management is impossible and the forest resource shall gradually be depleted (Higman *et al*, 1999). Yield regulation, 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).

Yield regulation is of great importance to the forest manager who needs to have predictable production levels each year. It must be clearly understood that the AAC calculated is the total maximum sustainable harvestable timber supply for each year of the plan period.

All timber removal from the FMU should be within the estimated AAC. AAC is calculated by working circle and the summation of AAC of all the working circles shall be the AAC of the whole FMU.

#### *Box 1.4. A cautionary note*

It is essential that *ad hoc* and unplanned felling does not take place and that the AAC is not exceeded, nor timber harvested from areas where it has not been specifically allocated. In the event, timber harvesting should be done from unplanned area (e.g., fire burnt, Pest and disease, etc.), the volume extracted shall be adjusted within the total AAC.

AAC calculations are based on the best possible understanding of the forest resource at the time of plan preparation. However, it is essential that the AAC calculated is reviewed during the plan period and any necessary revisions are incorporated into the revised forest management and related operational plans.

#### **1.10.5.1 Regulation of yield**

In even-aged forestry, there are likely to be two types of yield; the final or main yield and the intermediate yield from thinning. In irregular (uneven-aged) forestry, the final and intermediate are indistinguishable and combined in one felling operation.

Regulation of yield requires firstly a calculation of what the amount of the yield should be, secondly an apportionment of the yield to thinning and final felling and thirdly, construction of a cutting plan which determines the identity of stands to be felled or thinned and the timing of their felling or thinning (Osmaston, 1984).

The forest management plan should not rigidly prescribe the years in which particular stands shall be felled but shall state the sustained yield by working circle within the operable area of the FMU and define the principles that the forest manager (CFO/Unit In-charge) should observe in selecting annual coupes. The

operational plan shall clearly identify the areas to be harvested on an annual basis. It is essential that there is control or annual comparison of what has been prescribed and what is actually done, supported by an explanation of the differences. Unless there is such a control, undesirable differences between planning and implementation are liable to occur and multiply (Osmaston, 1984).

### **1.10.5.2 Calculation of sustained yield expressed as annual allowable cut**

Yield regulation for the harvesting of timber is often defined by AAC. The guidelines presented in this section of the *code* are designed to guide the forest management planner through the process of working out the AAC for an FMU; they should not be considered as rigidly prescriptive. The forest management planner should exercise professional expertise and judgement in deciding on the appropriate method to use. This section of the code includes both general recommendations and those specific to the Bhutanese context.

In simple terms, the AAC can be volume-based or area-based: with an area-based approach the area of land to be harvested annually is fixed but the volume may fluctuate; with a volume-based approach, the volume is fixed but the area of land from which it comes may vary from year to year (Higman *et al*, 1999). AAC is the volume (or area) of timber that is 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 that the last block has been cut, the first block should be ready to harvest again.

Parkash (1986) states that methods of yield regulation based on volume (of growing stock or increment) are generally referred to as *formula methods* and warns that these should rarely be relied on as the sole basis of yield regulation as these are liable to inaccuracies when applied to normal forests. In that case of abnormal forests (i.e. forests where there is not an even distribution of age classes by area) they are particularly dangerous as they are based on abstract quantities and pay little or no attention to the distribution of age classes and the condition of the crop. The fact that a certain forest has a certain volume, and a certain increment, does not indicate whether any part of the forest is of exploitable size and, if so, how much. The use of an area check, when using formula methods, is essential.

Yield regulation becomes a matter of combining the utmost use of what is available with the wise conservation of growth potential until more precision of purpose and method can be attained. Where uncertainty exists, it is essential to apply the *precautionary principle*, i.e. always stay on the safe side.

Armitage (1998) states that where a knowledge of the uncut or regrowth, forest resources is incomplete, where there is little or no information on forest increment or where forest management is being introduced for the first time, the allowable cut should be derived using one of the classical empirical procedures.

The many methods of yield calculation can be classified by the variables used:

1. A combination of area and rotation (felling cycle)
2. A combination of area, volume and rotation (felling cycle)
3. A combination of volume and forest increment
4. A consideration of volume only

Table 1.43 presents a range of approaches to AAC calculation that have been used in FMUs in Bhutan and briefly presents the advantages and disadvantages of each. This table is not exhaustive but is designed to illustrate to the forest management planner the range of options that should be considered.

Table 1.43. Approaches to AAC calculation

Basis	Method	Formulae	Advantages	Disadvantages	Comments
Combination of area & rotation	Annual coupe by gross area	Annual coupe = net operable area/rotation	Easy and rapid to apply. Less inventory data required than for volume-based method. Works well for evenly stocked areas.	Not suited to forests with variable stocking (i.e. natural forest in Bhutan). Difficult to predict annual volumes. Least precise method.	Based on suitable and accessible area (Dorji & Incoll, 2001). Can be applied to regular & irregular forest
Volume only (growing stock volume)	Von Mantel's formula	$AAC = 2 \times GSa/R$	Simple. Requires only actual volume of GS and rotation. Does not require increment data. Regulates yield according to actual growing stock. Useful preliminary step in yield regulation.	Liable to inaccuracy. Does not consider difference between actual and normal GS nor composition of forest. Requires complete enumeration of growing stock. Neglects age class distribution and rate of growth.	AAC calculated should be treated as a general indication and not be blindly prescribed. Applicable to regular forest.
Combination of area, volume & rotation	As recommended by Whitfield (2001)	$AAC = \frac{\text{per working circle} = (\text{Net operable area} \times \text{mature volume})}{R}$	Simple, easily understood & robust formula.	Does not reflect losses in volume that occur during logging or due to stem decay. Disregards increment of existing or potential timber trees.	See rationale in this section for use of this approach.

Basis	Method	Formulae	Advantages	Disadvantages	Comments
Combination of volume & increment	Austrian formula/method	$AAC = \frac{I + (GSa - GSr)/a}{I}$	Choice of adjustment period. Keeps normal GS in mind. Distinguishes between capital (GS) and income (I)	Disregards age-class distribution. Determination of MAI in irregular forests is difficult.	Applicable to regular and irregular forests. Reliable increment data not currently available in Bhutan.
	Hanzlik formula	$AAC = \frac{(Vm/R) + I}{I}$			Used in the conversion of virgin forest to an uneven-aged sustained yield unit. Assumes that mature untouched stands have no net increment.

Abbreviation	In full
A	Adjustment period (the period during which the difference between normal and actual GS is adjusted)
AAC	Annual allowable cut
GSa	Present (actual) GS
GSr	Desired (normal) GS
GS	Growing stock
I	Increment of the entire forest
MAI	Mean annual increment
R	Rotation (or felling cycle)
Vm	Total volume in mature stands

Box 1.5 Some consideration to natural forests and plantation

Although the principles are similar, the calculation of AAC is slightly different for natural forest systems and plantations (adapted from Higman *et al*, 1999). These differences are summarised here.

Calculations of AAC for natural forest require as much information as possible about:

- The existing quantity and quality of the existing forest resource; including species composition, volume and their distribution per diameter class. This information is obtained through inventories.
- The rate of growth of the forest, for particular species and harvesting intensity, after harvest is not currently available in Bhutan; Ideally this information should be obtained from growth and yield plots.
- The total production area (see comments below on determining net operable area)
- The levels of harvest or extraction that have already been carried out
- Natural regeneration and ecological effects of harvesting; this information can be obtained through long-term monitoring and research using permanent sample plots

Some points to bear in mind when calculating AAC:

- *Growth rates* are dramatically altered by harvesting; actual growth rates must be measured following harvesting
- *True harvest intensity*; it is important to take into account not only the level of harvest itself but the level of damage caused during harvesting as well. Armitage (1998) suggests a reduction of AAC by an 'exploitation factor' and a 'safety factor' which provide some allowance for losses at harvesting and also for damage to residual stand during harvesting.
- *Harvesting techniques*; the levels of damage from harvesting and subsequent post-harvest growth rates can be significantly affected by harvesting techniques. Careful harvesting can minimise damage to existing regeneration.
- *Operational control*; In order to make sure that harvest levels on the ground are in line with those predicted, an effective means of operational control needs to be in place. It is vital that harvesting operations do not concentrate on high value or easily accessible trees.

All these factors need to be combined to ensure a balanced and feasible harvest level.

For plantations the existing forest resource and growth rates may be better known and documented. This may allow the AAC to be calculated as the annual increment (or maximum mean annual increment) for the forest area.

### **1.10.5.3 Further comments on AAC calculation**

Whitfield (2001) presents a review of a range of calculation methods that have been used in the FMU management planning in Bhutan and develops a rationale for the use of one particular approach.

#### ***Which AAC calculation methodology?***

##### **Volume or area?**

Area based approaches require less inventory data than for volume approaches and work well with an even distribution of volume over the forest which is not the case in the natural forests of Bhutan. An area based AAC would then indicate difficulties for authorized agency in practical planning and operational viability as actual volume brought to the market year on year would vary quite dramatically. It may also discourage a balanced approach to compiling the annual program.

Expressing AAC by volume requires greater knowledge of the growing stock to appreciate whether a theoretical cut is actually likely to be sustainable but it is more useful in varied forests as it allows timber output to be stabilised.

##### **Standing or felled sale volume**

Felled merchantable volume is used in many countries. Whilst merchantable volume is ideal for authorized agency planning, at present it is not an appropriate measure for sustainable management of Bhutan's forests.

#### **What about Increment?**

In theory, with a perfectly structured *normal* forest, it should be possible to sustainably cut the annual increment each year. Some calculation methods rely quite heavily on increment. Unfortunately, data on growth rates is still very limited for Bhutan and it shall be some time before valuable data from permanent plots is available. In addition, we are not dealing with a perfectly structured forest but a very varied natural growing stock, some of which (particularly the fir zone) shall actually be in negative increment at present as the rate of decay exceeds new growth.

In the long term, we would hope increment to increase as over mature stands are replaced by younger stock but it shall be many years before this second growth forest is available for harvest. In the meantime, we have an over mature growing stock and too little and unreliable increment data to use in determining AAC.

#### ***Selecting the most appropriate method of AAC calculation***

A very wide range of formulae and calculation approaches are available and advantages and disadvantages can be argued for each. Whitfield (2001) suggests that whilst it is difficult to define a clear *best* method for Bhutan, there is a strong case for standardisation around a fairly simple and robust single methodology. However, as already stated, the forest management planner should exercise professional judgement in deciding on the appropriate method; these guidelines are presented in order to aid this decision making not to actually make the decision.

Whitfield (2001) recommend one particular approach (Equation 11) and comments that whether or not this approach is adopted is much less important than ensuring the data inputs to calculations are realistic and account for the various factors described. This is a very important point; the variables that are entered into AAC calculations must be arrived at with reference to clearly defined parameters.

The calculation of the theoretical or *normalised* cut is simple, easy to work with and communicate to all staff. More complex methods are not necessarily more accurate or useful. This method is also less dependent on reliable inventory data for the whole FMU, instead focusing on the volume for mature forest, which is of greatest interest for medium term planning. The calculation of this theoretical or *normalised* cut gives a reasonable starting point but no indication of whether the current structure of the forest is able to sustain that cut. It is then essential to analyse the existing growing stock by estimated maturity (age) class. The planner looks at the forest structure and very simply tries different strategies for a sustainable cut. It is then



a process rather than a calculation method and should therefore help the planner understand the forest structure and arrive at a more practical solution than simply using a standard AAC formula.

Working with uneven aged stands to start with makes the starting point for age class estimation quite approximate. For future working however, the concept of age classes should work well with the relatively even aged, systematic group selection and seed tree cutting approaches. Spreadsheets are also an ideal tool for working with these data.

#### **AAC calculation in detail**

$$AAC = \frac{\text{Net operable area}}{\text{Rotation}} \times \text{Average Volume/ha} \quad (18)$$

#### **Net operable area**

Beyond establishing the accessible area for the FMU with some precision and even establishing buffers for main mapable streams and rivers, other un-mapable minor terrain, rock, water or other conservation features shall prevent harvesting of small but significant patches.

When the cable lines are being laid out, some patches are found to be inoperable due to, for example, small rock crags running across the main slope or other minor ridges that limit gravity system cable lines. FMUs and even blocks within FMUs can vary significantly in this respect.

Reducing gross mapped area to net area should be decided with input from experienced Field office and authorized agency staff. It is suggested that for most FMUs, a reduction to net area should be applied at between 15% and 35%. This can be expressed as a correction factor  $f_{inop}$  which is an estimate of the proposed operable area; a reduction of 15% would correspond to  $f_{inop}$  of 85% and a reduction of 35% to  $f_{inop}$  of 65%.

This reduction is of course applied after the boundaries of the gross operable area have been decided and therefore only relates to those elements that could not be mapped.

Group selection and other silvicultural systems almost inevitably lead to some small patches of mature timber being left in later phases due to the presence of new regeneration and the damage that total removal of the over-storey would cause. In such challenging terrain as Bhutan, exact geometric group layout is rarely possible, interlocking of groups is therefore more approximate and further area is lost. As silvicultural systems progress, experience can inform what allowance should be made for un-removable over-storey but for now it is recommended that area for the AAC calculation is further reduced by around 10%. This can be expressed as a correction factor  $f_{silv}$  which refers to the area that can actually be harvested out of silvicultural reasons (i.e. it takes into account patches which shall not be removed due to silvicultural reasons).

The two correction factors,  $f_{inop}$  and  $f_{silv}$ , are applied to the gross area in order to calculate the net area:

$$\text{Net area} = \text{gross area} \times f_{inop} \times f_{silv} \quad (19)$$

#### **Rotation (and regeneration period)**

Rotation is an imprecise concept in silvicultural systems other than clear cutting and replanting. Yield regulation by size class is more common than by age in selection systems. However, for the group selection and seed tree systems in use in Bhutan, the objective is to have more or less even aged regeneration in the areas worked at each cut.

Given that reliable increment data is still very limited for Bhutan, assumed rotation lengths need to be cautious. There are a range of unanswered questions about regeneration potential and establishment of successor crops for most of the commercial species.

If we consider the general age of say a future spruce and hemlock group at maturity to be 120 years, it shall clearly be more than 120 years since the stand was harvested. An optimistic regeneration period for most species in Bhutan may be years from completion of harvesting which would probably be comfortable for pine but perhaps challenging for fir. A minimum 10 years regeneration period should be added to the rotation



figure for calculation purposes. In FMU zones where regeneration is problematic and taking longer than this, greater allowances should be made.

Delays in effective regeneration can seriously damage the prospects of achieving good regeneration at all, so it is important to address this issue on the ground rather than just build in longer and longer regeneration periods into the calculation. It should be ensured that the regeneration is established within the 10-year period. However, for subsequent plan period, regeneration period should be determined based on the assessment of the regeneration in the past plan.

### **Average standing volume**

The average standing volume is estimated from inventory of trees of  $\geq 10$  cm diameter collected as per Resource Inventory & Data Processing described in 1.8. However, about 5 % reduction in the inventoried mature standing volume/ha for spruce and fir species above 60-100 years is advised due to death of some standing trees prior to harvest.

The inventory shall of course have excluded any dead trees but working with over-mature natural stands, some further unrecoverable volume shall be lost before all the over-mature stands are finally harvested over the next say 60, 80, 100 years. Salvage cutting shall not practically be able to address all areas and small pockets.

As the measure of AAC is standing rather than merchantable volume, this is not an allowance for rot but only subsequent death of standing trees. An allowance should be made based on experience and research findings.

*Table 1.44 Summary of suggested area, rotation and volume reduction factors*

Net Operable Area (applied <u>after</u> excluding all mappable inoperable)	15-35% Gross to net harvestable area reduction 10% reduction for un-removable over storey
Rotation	+10 years minimum regeneration period for first plan For subsequent plan, based on regeneration success of past plans
Mature Standing volume	5% fir & spruce zone mortality reduction

Allowing for the above reductions, theoretical or normalised AACs can be calculated for the FMU. The next step is to analyse each by age class to evaluate whether this sustained cut can actually be delivered.

It is important to remember that the sampling error stated on the inventory sheets must be taken into account when calculating AAC and that a reliable minimum estimate should be made. Subtracting the sampling error percentage from the average standing volume per working circle does this.

### **Maturity class analysis**

Data on maturity or age is not directly available although it is usually quite possible to categorize by maturity and assign estimated age classes to stand groupings. The Forest Type Maps usually provide canopy cover and tree height classes and together with inventory data, an average maturity class can be assigned to polygons on the map. It is important to lump small polygons in with their neighbours, as we are only interested in a practical scale of working units. If a poorly stocked variable area is unlikely to improve over time then it should be classed as mature but of course taking into account the lower volume per hectare. In future, improved remote sensed imagery interpretation could provide Forest Type Maps directly by maturity classes rather than just canopy cover or tree height.

To illustrate this point; in the Gidakom plan for the period 1992-2002 ((Dhital *et al*, 1992), the mixed conifer and fir working group included three stand classes; mature high density, immature high density and immature low density. For Gidakom mixed conifer, the mature class area was of course assumed to be at or above the future defined rotation age and the two immature class areas were evenly distributed between assumed age classes 30 and 40. Whether or not these stands are actually around that age or not is less important than

the judgement that assuming a 120-year rotation, they shall be mature and available for harvest in 80 and 90 years time. The process of initially allocating stands to quite roughly estimated age classes should then be reasonably straightforward. Once harvesting begins, harvested area is recruited into the regeneration phase and monitoring of age classes from there on should become more precise.

The theoretical example below shows how data from two maturity stratum of un-logged area in the mixed conifer working group are assessed. Sub-compartments 1 and 2 have been logged once. Data from their sub-compartment records is summarised and amalgamated with the un-logged areas in this table to provide a total estimated age class distribution for the working circle.

*Table 1.45 Maturity class*

<b>Mixed Conifer</b> age class allocation		Area by Age Class							
Maturity Classes	Total Net Operable Area	Regen.	0-9	10	20	30	40	-----	130+
Mature	500								500
Immature	20			10	10				
Operational Forest Sub-Compt 1	100	10	20						70
Operational Forest Sub-Compt 2	150	50							100
	770	60	20	10	10				670

With age data now structured, we can easily trial how a theoretical AAC of say 1500 m<sup>3</sup>, equivalent to say 5 Ha of mature forest would develop over time. The exercise aims simply to check whether there is broadly enough mature area available to last until the younger age classes become available.

In the example, 670 Ha of mature forest needs to last 110 years until the area currently in the 20-age class matures and luckily it does. If however there was only 330 Ha of mature forest then the AAC would have to be reduced: 330 Ha divided by 110 years = 3 Ha a year and 900m<sup>3</sup>.

### **Balancing AACs for forest types/working groups**

The Gidakom approach works on a sustainable cut from each working group. Whilst this is a good starting point, probably the FMU as a whole should be the unit of sustainability, not any given forest type. AAC should still be built up by working group and the age class structure again analysed by group but this need not be the unit for FMU yield regulation.

If there is going to be a gap in available mature timber from one working group in say 70 years (after the first growth mature stands have all been cut but the younger stands are still immature) another predominantly mature working group may be able to *plug* the gap. If however, on analysing the whole FMU production flows there is still going to be a gap in mature stand availability, the AAC of course has to be reduced. The process looks at how age class structure shall develop over the first rotation, first for each working group and then for the whole FMU. This is easily achieved using a spreadsheet, finally linking the individual zone sheets together for the whole FMU summary volume forecast. Different solutions can be tested very easily.

The worked spreadsheet example provided in Table 1.47 Worksheet shows how volume flows from two different working groups may be managed on a whole FMU level.

Table 1.46. Checks on age class profiles

In the example below, the areas of two Working Groups – Hemlock/ Spruce and Blue Pine have been categorised by age class and worked in a spreadsheet to show area and volume flows over 15 10-year periods. Mature Pine runs out in periods 7 and 8 before younger stands become available. The gap here is plugged by Hemlock and Spruce. Later in Period 14, the pine area plugs a similar gap in the Hemlock/ spruce production.

Table 1.47 Worksheet showing volumes from different working circles

### Hemlock and Spruce

130 yr rotation, 1000Ha net productive area

Hemlock and Spruce															2,667 67	
130 yr rotation, 1000Ha net productive area															400	
Period	Regen.	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	120-129	130+	Area to Harvest	Volume production
1			100	100										800	67	26,667
2	67			100	100									733	67	26,667
3	67	67			100	100								667	67	26,667
4	67	67	67		100	100	100							600	67	26,667
5	67	67	67	67			100							533	67	26,667
6	67	67	67	67	67		100							467	67	26,667
7	67	67	67	67	67	67			100					400	129	51,667
8	129	67	67	67	67	67	67			100				271	129	51,667
9	129	129	67	67	67	67	67	67			100	100		142	67	26,667
10	67	129	129	67	67	67	67	67	67			100	100	75	67	26,667
11	67	67	129	129	67	67	67	67	67	67			100	108	67	26,667
12	67	67	67	129	129	67	67	67	67	67	67			142	67	26,667
13	67	67	67	67	129	129	67	67	67	67	67	67		75	67	26,667
14	67	67	67	67	67	129	129	129	67	67	67	67	67	8	8	3,200
15	8	67	67	67	67	67	129	129	129	67	67	67	67	67	67	26,667

Blue Pine

100 yr rotation, 1000Ha net productive area

Blue Pine															2,500
100 yr rotation, 1000Ha net productive area															83
Mature volume / Ha															300
Normalised AAC															83
Periodic area															83
Period	Regen.	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100+	Area to Harvest	Volume production	
1			300	200								500	83	25,000	
2	83			300	200							417	83	25,000	
3	83	83			300	200						333	83	25,000	
4	83	83	83			300	200					250	83	25,000	
5	83	83	83	83			300	200				167	83	25,000	
6	83	83	83	83	83			300	200			83	83	25,000	
7	83	83	83	83	83	83			300	200				25,000	
8		83	83	83	83	83	83			300	200			25,000	
9			83	83	83	83	83	83			300			25,000	
10	83			83	83	83	83	83	83			200	83	25,000	
11	83	83			83	83	83	83	83	83		417	83	25,000	
12	83	83	83		83	83	83	83	83	83	83	333	83	25,000	
13	83	83	83	83		83	83	83	83	83	83	250	83	25,000	
14	83	83	83	83	83		83	83	83	83	83	250	83	25,000	
15	162	83	83	83	83	83		83	83	83	83	250	162	48,467	
												172	83	25,000	

Whole FMU

FMU Normalised AAC 5,167

Period	Volume production
1	51,667
2	51,667
3	51,667
4	51,667
5	51,667
6	51,667
7	51,667
8	51,667
9	51,667
10	51,667
11	51,667
12	51,667
13	51,667
14	51,667
15	51,667
<hr/>	
775,000	

NB - Total return periods = rotation plus 10 years regen plus 10 years harvesting phase.

Whilst it may be preferable to liquidate the over mature spruce/ hemlock/ fir early on and retain the pine,

### **Thinning volume?**

Most AACs in current management plans include an element of thinning volume in the final calculation, usually for blue pine. Whilst silviculture thinning in pine is highly desirable, market limitations are currently preventing much of this planned volume being realised. The result is that the AACs have not been changed and the thinning element is just adjusted from the overall AAC.

Until markets for smaller products are properly developed, annual thinning volume should not be added to AAC calculations.

### **Considerations for broadleaved FMUs**

There are important unresolved problems with broadleaved silviculture in Bhutan; particularly limited understanding of regeneration dynamics of valuable species. Good regeneration has proved extremely difficult. The best silvicultural systems for managing broadleaved forest is uncertain and require more researches to achieve stand succession towards commercially useful species.

When calculating AACs for broadleaved forest, it is therefore extremely important to be even more cautious and leave a considerable safety margin. Assumed rotation lengths used in calculations should be significantly longer than the 100 years used in many plans at present.

### **What is the unit of sustainability?**

All FMU management plans aim to manage FMU on a sustained yield basis. This, besides fulfilling local and national needs, also maintains ecological health. To ensure control and protection of the intensively managed forest, adequate staff should be placed for implementation of required interventions. There could however be production arguments for exceeding a sustainable cut for a period in some FMUs, particularly the pressure to log over mature wood before it is lost or further degraded. It is recommended that FMUs be retained as the principle unit for sustained yield.

#### *Box 1.6 Avoiding problems and pitfalls with AAC*

Inventory procedures, forest data management, practical harvesting and marketing issues all impact on the ability to deliver a sustainable AAC. These are dealt with in the appropriate sections of the code.

In order to ensure that the AAC is set at a genuinely sustainable level, it is essential that:

1. Structure of the existing forest should be taken into account.
2. Assumed rotation lengths are realistic (e.g. account for long regeneration periods).
3. Account is taken of the possible decline in utilisable standing volume (e.g. resulting from fir dieback and spruce bark beetle).
4. The operable area is accurately estimated and does not include areas that are subsequently considered as practically inoperable.

Sufficient allowance is made for portions of operable stands being inaccessible or inoperable due to small terrain features. *Gross* area must be reduced to a workable *net* area.

## **1.11. Silvicultural Systems and Prescriptions**

### **1.11.1. Objective**

To determine appropriate silvicultural systems for FMU.

### **1.11.2. Outputs**

Statement of options and recommendations for silvicultural systems, supported by rationale.

### **1.11.3. Lead responsibility**

Divisional Forest Offices in collaboration with FRMD.

### **1.11.4. Introduction to silvicultural systems**

Silviculture is the art and science of controlling the establishment, growth, composition, health and quality of forests and woodlands to meet the targeted diverse needs and values of landowners and society on a sustainable basis. Silviculture involves manipulating the natural biological processes of the forest in order to achieve specific end results. It includes all operations that are done between one harvest and the next, such as planting, thinning, pruning and weeding. Harvesting operations are a major silvicultural treatment (Higman *et al*, 1999).

The choice of silvicultural system is crucial in determining whether the forest can produce the desired products and services on a sustainable basis. The sustainability of the forest ecosystem under management depends on the silvicultural systems applied; applying the wrong silvicultural system shall damage the forests ability to regenerate or provide the desired results (Higman *et al*, 1999). For example, past experience shows that the strip clear felling was not successful in broadleaf forest of Bhutan.

### **1.11.5. Types of Silvicultural Systems**

This section outlines the principles of silvicultural systems commonly adopted in Bhutan and presents some ideas on management approaches. Because silvicultural systems depend upon so many factors it should not be assumed that they can be applied uniformly across all regions. The system that works well in one forest type may not work in another. Long-term research is needed to understand the effects of individual silvicultural interventions and their combined effects (Higman *et al*, 1999).

#### **1.11.5.1. Selection System**

In selection systems, felling and regeneration are not confined to certain parts of the forest but are distributed all over the operational area. The felling involves removing single tree or small groups of trees. Felling done in this manner are termed selection felling; they result in an uneven-age or irregular type of forest in which all the age or size classes are mixed together over every part of the area (adapted from Mathews, 1999).

Under selection systems, scattered trees or groups of trees are selected over the whole area and removed. Where conditions are favourable, natural regeneration springs up in the gaps so created. Under ideal conditions this process goes on year after year over the whole forest, the volume being removed being fixed by rules of management. This results in the constant maintenance throughout the whole area of an uneven-aged or irregular structure (adapted from Mathews, 1999).

In their most primitive form, selection felling consists of removing all trees that have attained a certain diameter, sometimes with the provision that any trees that have attained a certain diameter should be retained. Such crude and unregulated selection felling are mere exploitation requiring little or no silvicultural skill; they do not ensure regeneration nor do they provide for a regular sustained yield and they often result in serious deterioration of the forest (Mathews, 1999)



Selection felling should provide for sustained yields by making thinnings among the various age classes to ensure that:

1. these are maintained in their correct proportions
2. a suitable mixture of species is maintained
3. young saplings are freed from suppression
4. defective stems are removed wherever they are hampering better ones

#### **1.11.5.1.1. Single-tree selection system**

In this system, individual trees are removed and new regeneration is expected to occur in their place (Dhital, 1993b). This system is more suited to shade-bearing than light demanding species, since the gaps created by the removal of single trees are too small for the regeneration of light demanders or for the smaller trees to escape suppression from the larger ones standing over them (Mathews, 1999).

Single tree selection system is usually prescribed for even aged to achieve uneven aged stand and result in a mixed and stratified structure with a continuous series of age classes, and continual recruitment to the growing stock by natural regeneration. The distribution of stem diameters is such that each diameter class has fewer stems than the adjoining smaller diameter class, and also the ratio of the number of stems in a class to the number of stems in the adjoining class is constant.

Further consideration should be given to felling cycle, the structure of the growing stock and yield regulation; refer to Mathews (1999) and Osmaston (1984).

#### **1.11.5.2. Group selection system**

The group selection system is a form of selection system that is suited to a range of species, ranging from light-demanders, through moderate shade-bearers to shade-enduring species (Mathews, 1999). Group size is varied in accordance with light requirements. The group selection system can be very appropriate for the conversion of regular to irregular forest.

The group selection system is commonly used system in Bhutan in both conifer and broadleaved forest types. No treatment of the forest floor to induce natural regeneration is required in the mixed conifer forests managed under the group selection system (Norbu & Desmond, 2000). Norbu & Desmond, 2000 observed a significantly higher number of seedlings on wet sites compared to dry sites for spruce, hemlock, and all species combined. This indicates that the suitability of the group selection system within the mixed conifer forest may also depend on site conditions (soil, slope, aspect, etc.). The main practical problem with this system is that of securing regeneration of the right species. This system mainly depends upon natural regeneration; however, understanding regarding the conditions that shall provide good regeneration of the desired species is still incomplete (RGoB, 1991).

Criteria for selection of groups, as presented by Dhital (1993b) and Statz & Wyrsh (1993), are included in the code section on Silvicultural Considerations. From a study of silvicultural systems in mixed conifers (Thimphu and Bumthang), group selection is considered an appropriate silvicultural system for managing temperate conifer forests. The system promotes natural regeneration and requires no treatment of the forest floor to induce natural regeneration (Moktan, 2003). However, if there is poor natural regeneration, some level of floor treatment may be recommended to assist the natural regeneration.

#### **1.11.5.3. Seed tree system**

The seed tree system is a form of uniform system in which the seed bearers are widely spaced over the area to be regenerated. It is mainly used for light demanding species with seed that is dispersed by wind (Mathews, 1999).

The seed tree system is recommended for pine forest and commonly practiced in the temperate region. Pines are pioneer species that regenerate easily when light is ample and are not suited to selection systems. The pine forest types where the seed tree system can be applied is characterized by sparse ground vegetation,

which provides good conditions for natural regeneration; not all pine forest types provide this condition (RGoB, 1991).

It is an even-aged system in which the generation shift is facilitated through a natural regeneration phase. During this phase, the mature stand is opened through a number of regeneration felling where the remaining trees serve as seed trees. This phase can be 10-20 years long and include three felling occasions. The last seed trees are removed when the regeneration is established in terms of number of trees per hectare and average tree height (RGoB, 1991), or left indefinitely (Dhital, 1993b).

*Box 1.7 Factors determining the success of seed tree methods*

The success of the seed tree method depends on (Mathews, 1999):

1. selection of superior seed bearers for phenotypic quality of stem and branching habit, absence of serious damage by disease, evidence of ability to produce seed, and wind firmness
2. high production of viable seed per tree
3. adequate dispersal of seed on to well-prepared seed-beds
4. good survival of seedlings during the critical early stages of growth

The main difference from the shelterwood cutting is that the remaining crown cover is not enough to make the cutting area micro-climatically different from a broad, open, clear cut area (Dhital, 1993b). Dhital (1993b) states that this system should not be applied on steep and exposed south and southwest sites in Blue pine. On such sites a selection system should be applied.

#### **1.11.5.4. Clear cutting (and plantation) systems**

Under clear felling systems successive areas are clear felled and regenerated, usually by artificial means but sometimes naturally.

Clear cutting is an appropriate silvicultural system recommended in the event of periodic catastrophic disturbance. For example, fire burnt, insect and disease infestation, etc. This helps in containing and preventing further spread of pest and diseases.

#### **1.11.5.5. Coppice system**

The coppice system involves reproduction by stool shoots or suckers. When felled near ground level many broadleaved species, up to a certain age, reproduce from coppice from the stool of stump. Coppice is usually cut close to the ground.

Coppice is essentially a system for the production of fuelwood and small or medium-sized material, but not for the production of large timber. The rotation is determined by the specification of the produce required. Coppice can be managed on the basis of annual coupes by area.

Whilst not widespread or in extensive use in Bhutan, the coppice system may be appropriate for the management of certain forest types for certain objectives; e.g. evergreen oak forest for fuelwood.

A variation of the coppice system is *coppice with standards*, this consists of two distinct elements; a lower even-aged storey treated as coppice and an upperstorey of standards (single-stemmed trees usually grown for timber) forming an uneven-aged crop and treated as high forest. This system is not widely applied in Bhutan but is worthy of consideration for local use forest areas where timber and firewood production can be combined.

- Coppice and coppice with standards silvicultural system

Table 1.48 . Summary of silvicultural systems

Silvicultural system	Appropriate forest types	Advantages	Disadvantages	Comments & issues
Single-tree selection	Hemlock Fir	Forest cover maintained, exposure of soil minimal Minimised wind & snow damage All seed years can be used for regeneration, seedlings well protected Flexible system Large proportion of growing stock and yield in trees of large size & high value Individual trees of good form can be promoted	Considerable skill required to mark felling Felling and extraction must be done with care Not appropriate to light demanders The work of felling, extraction, establishment and tending is scattered over a wide area	
Group selection	Spruce, Hemlock, Fir (mixed conifer)	Can be applied to wide range of species, ranging from light-demanders, through moderate shade-bearers to shade-enduring species	The work of felling, extraction, establishment and tending is scattered over a wide area. Felling and extraction must be done with care.	In spruce forest, avoid large canopy openings especially on dry sites; thinning & tending should be done. Small group size for hemlock, light & frequent thinning may be required. Small groups in sensitive Fir forest ecosystems.
Seed tree	Chir pine Blue pine	Felling are straightforward to carry out  Crops of even-age type can be produced, typically with long, clean stems	Damage can occur to young growth during harvesting	Thinning and tending are important in pine forests

Silvicultural system		Appropriate forest types	Advantages	Disadvantages	Comments & issues
Patch clear cut		Sub-tropical broadleaved (with caution), Cool moist broadleaved & evergreen oak	Impact of grazing may be less than in strip clear. Patch coupes may result in less grazing impact than strip coupes.	May expose site to erosion. May produce adverse microclimate for regeneration of favoured tree species.	Poorly understood stand dynamics & regeneration processes in sub-tropical & warm broadleaved forest types. This system should only be applied with great caution, consider single-tree & group selection as lower risk alternatives
Strip clear cut		Sub-tropical broadleaved (with caution), Cool moist broadleaved & evergreen oak	Simple and quick & economic harvesting operations. Harvesting completed before new crop regenerates. Affords complete overhead light for light-demanding species.	May expose site to erosion. May produce adverse microclimate for regeneration of favoured tree species Artificial regeneration may be expensive. Visual impact can be high. Strip coupes may lead to greater impact of cattle grazing than for patch coupes.	Poorly understood stand dynamics & regeneration processes in sub-tropical & warm broadleaved forest types.
Coppice		Evergreen oak	Simple to apply. Can produce large volume of small diameter timber on short rotations	Young shoots prone to browsing. Limited use for timber production.	May be appropriate for local use and fuel-wood production.

### 1.11.6. Silvicultural characteristics and considerations in relation to the main forest types and tree species

This sub-section includes information on silvicultural characteristics and considerations with reference to the main forest types and tree species. It has been compiled from research references and other sources in order to provide background information and to serve as a reference for the forest management planner. Where information is available specific to species it is included under species sub-headings, where information is available by forest type it is included under forest type sub-headings. This information presented is not exhaustive and is in the form of an indicative summary; forest management planners should strive to continually develop their understanding of applied forest ecology and silviculture and make sure that they are familiar with current research reports etc. (such as Gratzner & Glatzel, undated).

#### 1.11.6.1. Subtropical forest

Forests along the southern foothills may be broadly classified as subtropical forest, forming dense jungle on steep slopes and river banks. Natural Sal forests (*Shorea robusta*) occurs as scattered patches in Sarpang and Samtse Dzongkhags. These forest types occurs at an altitudinal range of 130 to 1000 m.a.s.l , extending upto 1200 m.a.s.l and characterized with high precipitation ( 2500 to 5000 m.a.s.l).

Silvicultural characteristics of some of the major tree species found in the subtropical forest are detailed in Table 1.49

Table 1.49 Silvicultural characteristics of some key species in subtropical forest

Sl. No	Name	Silvicultural Characteristics
1	<i>Shorea robusta</i> (Sal)	<ul style="list-style-type: none"> <li>• large gregarious tree found scattered in Sarpang and Samtse Dzongkhags</li> <li>• light demander and grows well in well drained sandy loam soil with water retention capacity of 85%.</li> <li>• sensitive to drought and grazing</li> <li>• moderately frost hardy and fire resistant</li> </ul>
2	<i>Duabanga grandiflora</i> (Patang shing)	<ul style="list-style-type: none"> <li>• Light demander from an early age and seedling thrive in areas exposed to light.</li> <li>• Young seedling subject to damage by insect, drought &amp; heavy shade</li> <li>• Require complete drainage and loose moist soil for survival.</li> </ul>
3	<i>Chukrasia tabularis</i>	<ul style="list-style-type: none"> <li>• Seedlings are sensitive to drought. However, excess soil moisture can cause seedlings to damp-off.</li> <li>• Usually evergreen in its natural range and deciduous elsewhere.</li> <li>• Found in well-drained moist soils in the plains.</li> <li>• Sensitive to browsing.</li> <li>• Require comparatively lighter thinning in the early stages</li> </ul>

#### 1.11.6.2. Chir pine forest

Chir Pine forests in Bhutan are confined to low altitude (900 to 1800 m.a.s.l (-2000 m.a.s.l)), xerophytic forests which usually occur in the deeper dry/rain shadow valleys namely., Mo Chhu/Sunkosh river, Kuri Chu and Kholong Chhu/ Drangme Chhu systems. These valleys have a very long dry season during which forest fire is common, and heavy rain occurs only in the monsoon season when abundant herbs, especially grasses, appear. Grazing is widespread but Chir Pine needles are not palatable to cattle. The annual rainfall ranges from 1000 mm to 1300 mm.

### 1.11.6.3. *Pinus roxburghii* (Chirpine)

Chir Pine trees and saplings are usually resistant to fire/burning but the shrub layer is more susceptible and therefore poorly developed. Usually other trees species are not found in this type of forests. The pines are able to expand or maintain their position through infrequent ‘hot’ fires that destroy all competing under-growths. If the fire is frequent and ‘light’, the undergrowth may not be killed but the very young pine seedlings are vulnerable. Under such repeated conditions, Pine stands can be degraded over time

**Silvicultural characters:** Chirpine is a strong light demander. However, it is an undemanding, fast growing shade tolerant pioneer in the seedling/juvenile stage. It is capable of colonising sites that are hostile to broad-leaved pioneers. It forms almost pure, single-storied, even-aged stands (Dorji & Chong, 1998). It is frost hardy and fire-resistant owing to its thick corky bark. Chirpine usually comes up in almost any type of soil but intolerant to poorly drained and richly calcareous soil

**Regeneration:** Chir Pine sheds its seed from April to July and usually germinate within ten days of falling in conducive environment.

**Silviculture system:** The seed tree system is usually prescribed for Chir pine forests; in this system around 20 seed trees per hectare are retained and the rest of the crop removed from the annual coupe. If regeneration is unsuccessful supplementary direct seeding or planting may be required.

In areas with sparse ground vegetation the seed tree system can be suitable and in areas with dense ground vegetation, weeding, soil scarification and artificial planting could be practiced to assist the natural regeneration (RGoB, 1991). If advanced regeneration is present at the time of felling then special care should be taken to avoid damage.

### 1.11.6.4. Warm broadleaved forest

Warm broadleaved forest is essentially a type of subtropical forest, but occurs at a higher altitude (1000 to 2000 m.a.s.l extending upto 2300 m.a.s.l) with a lower rainfall (2300 to 4000 mm) and contains a mixture of evergreen and deciduous broad-leaved tree species. Many tropical genera are absent and more temperate genera appear. The transition from lower into higher zone is gradual. In deeper valleys this formation occurs far into the interior, as in Kholung Chhu valley south of Trashiyangtse. However, it is most abundant throughout southern Bhutan on the hills north of Gelephu and Deothang and in the Mewan chhu valley.

Sl. No	Name	Silvicultural Characteristics
1	<i>Schima wallichii</i>	<ul style="list-style-type: none"> <li>• Moderately light demander and fairly resistant to fire</li> <li>• Sensitive to grazing and browsing in seedling stage</li> <li>• It has a tap root system and grows in basic soil; prefers well-drained soil</li> <li>• Good coppice</li> <li>• Seeds are light and dispersed by wind.</li> </ul>
2	<i>Engelhardia spicata</i>	<ul style="list-style-type: none"> <li>• natural regeneration is excellent wherever the seedlings get sufficient light and are protected from grazing</li> </ul>
3	<i>Magnolia excelsa</i>	<ul style="list-style-type: none"> <li>• Light demander and requires overhead light for good growth but seedlings can establish well under a moderate through high canopy.</li> <li>• Prefers partial shade and well-drained soil but can tolerate acidic soil.</li> <li>• Susceptible to frost and drought.</li> <li>• Also associated with cool broadleaved forests.</li> </ul>
4	<i>Macaranga denticulata</i>	<ul style="list-style-type: none"> <li>• a fast growing pioneer that rapidly colonises open gaps after disturbances such as logging. Although comparatively short-lived it can negatively affect natural establishment and growth of more valuable timber species.</li> </ul>



5	<i>Alnus nepalensis</i>	<ul style="list-style-type: none"> <li>• Tolerates both shade and poorly drained soil</li> <li>• Provided that there is sufficient light, <i>Alnus</i> displays the habit of springing up gregariously on new ground such as landslips and abandoned cultivation.</li> <li>• Susceptible to wind damage</li> </ul>
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### Silvicultural System:

There are important unresolved problems with broadleaved silviculture in Bhutan; particularly limited understanding of regeneration dynamics of valuable species. Good regeneration has proved extremely difficult. The best silvicultural systems for managing broadleaved forest is uncertain and require more researches to achieve stand succession towards commercially useful species.

The working approach at the time of writing is generally that of small-scale patch-cut; however, any silvicultural recommendations should be developed with caution and with thorough consideration to species composition, stand dynamics, regeneration processes and protection requirements. With this in mind it is more appropriate to consider a combination of single-tree and patch cut systems with small groups of 20-30m (Schindele, 2003).

### 1.11.6.5. Evergreen oak forest

The evergreen Oak forests occurs on an altitudinal range of 2000 to 2600 m.a.s.l , and sometimes going down to about 1800 m.a.s.l with an annual rainfall ranges from 2000 mm to 3000 mm Evergreen Oak forests are a very characteristic feature of some parts of central Bhutan, especially around Trongsa and on the hills above Mongar. They apparently receive lower rainfall than Warm broad-leaved forests and composition varies according to altitude and rainfall. At a lower levels *Castanopsis hystrix* and *C. tribuloides* are often dominant, higher up *Quercus lamellosa* becomes commoners; with increasing dryness more xerophytic *Quercus* species, e.g. *Quercus lanata*, and *Q. semecarpifolia*, and sometimes *Pinus wallichiana* appear. The shrub layer is often poorly represented, whilst the shady humid forest floor is dominated by small herbs, e.g. Urticaceae and bryophytes.

Some of the key species found in this forest types are described in Table 1.50.

Table 1.50 Silvicultural characteristics of some key species in evergreen oak forest

Sl. No	Name	Silvicultural Characteristics
1.	Oaks	
	<i>Q. semecarpifolia</i>	<ul style="list-style-type: none"> <li>• Shade-demanding as a germinant and shade tolerant during initial growth.</li> <li>• Growth of the seedlings is reported to be slow; it coppices and pollards well, although coppice and pollard shoots are liable to be bent or broken by snow and coppice growth is very slow (Rosset, 1999).</li> </ul>
	<i>Q. glauca</i>	<ul style="list-style-type: none"> <li>• Found in moist site conditions, can stand a considerable amount of shade during regeneration but needs direct overhead light for maximum growth; coppices freely.</li> </ul>
	<i>Q. lamellosa and lineata;</i>	<ul style="list-style-type: none"> <li>• Although both species are shade bearers they require overhead light to fully develop their growth potential.</li> </ul>
2	<i>Castanopsis hystrix and tribuloides</i>	<ul style="list-style-type: none"> <li>• Occur in warm broadleaved and evergreen oak forests.</li> <li>• Natural regeneration is reported to be fairly good in some areas in India and the seedlings can tolerate a</li> </ul>

		good deal of shade for some years; both species coppice well (Kleine, 1996; derived from Grierson & Long, 1983 and Troup, 1921).
3	<i>Juglans regia</i>	<ul style="list-style-type: none"> <li>• Light demander but can stand some shade in the initial seedling stages.</li> <li>• For the production of straight clean boles it must be grown in denser stands, owing to its tendency to produce large spreading branches.</li> </ul>

#### 1.11.6.6. Cool moist broadleaved forests

Cool moist broad-leaved forest occurs above warm broadleaved forest with cooler climate and are generally mixed forest in which oaks are less common, and other trees, both deciduous and evergreen, e.g *Persea* spp, *Exbucklandia* spp, etc., are more abundant together with dense shrubs, climbers and many epiphytes. In Bhutan, Cool Broad-leaved forest is extensive in some of the eastern Dzongkhags (e.g. around Tshilingor-Wamrong–Khaling stretch) and on the steep hillsides of South east of Sengor.

The cool moist broad-leaved forest occurs on an altitudinal range of 2000 to 2900 m.a.s.l , with an annual rainfall ranges from 2000 mm to 3000 mm. Silvicultural characteristics of some of the key species found in the forest type are explained in Table 1.51.

Table 1.51 Some key species in cool moist broadleaved forest

Sl. No	Name	Silvicultural characteristics
1	<i>Acer cambellii</i>	<ul style="list-style-type: none"> <li>• Shade tolerant</li> <li>• Reproduce freely by seed. Coppice well as well.</li> </ul>
2	<i>Persea</i> spp	<ul style="list-style-type: none"> <li>• Usually require well-drained aerated soil</li> </ul>
5	<i>Betula alnoides</i>	<ul style="list-style-type: none"> <li>• Natural regeneration is only possible in open gaps with patches of new soil.</li> <li>• This species prefers moist site conditions</li> <li>• Frost hardy and fairly fast growing</li> </ul>

In addition, *Symplocos dryophila* and *Quercus* spp are also dominant in this forest type.

#### Silviculture System:

Generally, patch cut system is prescribed for commercial harvesting in broadleaved forest (RNR RC, 2003). The “patch” in patch cutting system would mean smaller groups as compared to groups in Group Selection System. As per the research findings, the patch cutting system with fencing is proven to be the best option in terms of fostering biodiversity, mitigating grazing impact and safeguarding financial viability for sustainable management of mixed broadleaf forests in Eastern Bhutan. If regeneration is unsuccessful supplementary direct seeding or planting may be required in the harvested areas post timber harvesting.

#### 1.11.6.7. Blue pine forest

Blue Pine forest occupies the inner dry valleys of Bhutan where rainfall is very low except during the monsoon season. It is best developed in Haa, Paro and Thimphu valleys in the west and in Bumthang further east. It is often dominant and act as pioneer colonist of burnt or disturbed ground. Tree species commonly associated with Blue Pine are *Quercus griffithii*, *Q. semicarpifolia*, *Q. lanata*, *Populus ciliata*, etc., but many xerophytic shrubs also occur and herbs are common during the monsoon season. There is a gradual transition between this forest type and Evergreen oak forest and with Spruce, Hemlock and Fir forests on the moisture slopes above the main valley. When Blue Pines are found mixed with Spruce, Hemlock and Fir, they get protected from forest fires and often attain a greater stature than in the valleys. It is very susceptible to forest fires.

Bluepine forests occurs on an altitudinal range of 2100-3000 m.a.s.l extending upto 3200 m.a.s.l , with an annual rainfall ranges from 700 mm to 1200 mm. The only tree species commonly associated with Bluepine is *Quercus griffithii*. *Q. griffithii* is deciduous in nature and thrives in all types of soil.

### **Blue pine (*Pinus wallichiana*)**

Blue pine forest is a common pioneer species appearing after disturbance in the cool moist broad-leaved forest and lower spruce and hemlock zones .

### **Reproduction**

Blue pine starts flowering between the age of 10 and 20 years and has frequent good seed years; more frequent than for other conifer species. The germination of blue pine is best on well-drained fresh soil and on sites exposed to sunlight. Reproduction may fail on very dry or hard soils as well as on slope with southern exposition when the soil surface can be heated to high temperatures. Because it is a light-demanding species, it is sensitive to strong competition from weeds, shrubs and other trees (Rosset, 1999, Statz & Wyrsh, 1993).

### **Silviculture characteristics:**

Bluepine are strong light demander. It is fire sensitive and more susceptible to snow damage in comparison to other conifer species.

### **Regeneration**

If there is enough light and a suitable seed bearer in the neighbourhood, there is no problem to regenerate blue pine successfully. It may be useful to protect the area from grazing, if the pressure from cattle is high. The area also has to be protected from fire.

To regenerate a mature blue pine stand, a short regeneration period should be chosen with seed tree felling which removes more than half of the old stand. Immediately after the regeneration has established the remainder of the old stand has to be removed.

To regenerate blue pine in a mixed stand, the suitable site for regenerating has to be found (ridges and southern exposed slopes within the stand) and exposed to light. If need be, some light scarification of the soil may help regeneration.

Depending upon the desired assortment, the rotation period may lie between 50 (cham assortments) and 90 to 130 years (timber assortments) on good sites.

### **Tending and thinning**

Thinning and tending are important for young blue pine stands, especially where regeneration is very dense, in order to augment the stand stability against snowfall and storm damages as well as to improve the quality of the future stand. This has to be carried out regularly starting from the early stages of stand development. It is better to conduct moderate thinning operations at frequent intervals. Blue pine tends to keep dry branches. If high quality timber is to be produced, artificial pruning may be required. Pruning would also reduce fire risk (Rosset, 1999).

Rosset & Rinchen (1999) describe the effects three different thinning intensities (control, moderate (20% of standing volume) and heavy (27 % of standing volume)) of thinning operations on productivity, stability and economics of blue pine stands. The thinning treatments had a clear positive effect on diameter and volume increment, resulting in a higher production of usable timber volume. Thinning treatments had a positive effect on individual tree stability. Moderate thinning intensity is recommended both for optimisation of economic returns and improvement of stand stability.

## Silvicultural System

The seed tree system is usually prescribed for Blue pine forests; in this system around 20 seed trees per hectare are retained and the rest of the crop removed from the annual coupe. Research also recommend single tree selection or group selection system in areas. However, in case of pest, clear-felling of the mistle-toe infested site is usually recommended (RNR-RDC, 2014).

## Risks

On good sites with good increments there is potential danger of broken trees by snow and storms; this danger is accentuated on sites where blue pine grows densely. Blue pine is susceptible to mistletoe (in western Bhutan), may be browsed and scraped by cattle and is very sensitive to fire. Blue pine stands can be severely damaged by bark beetles especially if logging is carried out during the flying season (summer) and not in a proper manner (without collecting lops and tops, debarking of logs and burning of slash) (Rosset, 1999).

### 1.11.6.8. Spruce forest

Though Spruce forest is often found mixed with Fir and Hemlock or with Blue Pine, Larch, Oak, Maple, Birch, etc., a separate Spruce forest type can frequently be recognized. Spruce forest generally occupies drier site than Hemlock forest at a similar altitude. Spruce forests occurs on an altitudinal range of 2700 to 3100 m.a.s.l extending upto 3200 m.a.s.l with an annual rainfall ranging from 500 mm to 1000 mm. It is commonly found in Thimphu, Paro, Haa, Wangdue Phodrang and Bumthang Dzongkhag. *Picea spinulosa* is the common species in western Bhutan, but in Eastern Bhutan, it is found mixed with *Picea brachytyla*. Together with Blue Pine it may form a sort of pioneer forest.

#### *Picea spinulosa* (East Himalayan spruce)

## Reproduction

Not much is known about the seed production patterns of spruce but it seems likely that flowering and good seed production appear only at intervals of three to seven years. Having a shade tolerant character in youth, spruce can regenerate under hemlock, oak and blue pine, but it also regenerates well in exposed conditions on bare mineral soil (Rosset, 1999).

## Silviculture

Spruce is a moderate light demander but stands some shade, especially in its early youth. For growth though it needs full overhead light in order not to be suppressed. According to Darabant *et al* (2001) this species proved to be able to increase growth up to full sunlight, and, at the same time it can survive periods of moderate shade. Natural regeneration is sometimes very easy, but in some cases very difficult. Rosset (1999) suggests that one major reason for the difficulty of successfully regenerating stands with spruce on dry sites might be the excessive size of canopy opening, giving strong competitive advantages to weed species, bamboos and bushes. Long-term studies have shown that competition by herbs can be reduced by keeping moderate shade (Darabant *et al*, 2001). Another reason might be the presence of thick humus layers, hindering seed germination and growth.

Uneven-aged management of this species has to focus on keeping basal areas below 30m<sup>2</sup>, the threshold for high light dependent seedling mortality (Darabant *et al*, 2001).

Logging should be as clean as possible in order to avoid bark beetle attack. In order to minimise the danger of bark-beetle attacks and to avoid subsequent problems with natural regeneration, it is strongly recommended that large canopy openings are avoided whilst operating in dry forest types with spruce.

A study of regeneration dynamics in mixed conifers (in Thimphu, Bumthang and Haa) found that small-size artificial openings (group-cuts of 100m<sup>2</sup>) trigger profuse natural regeneration of the desired mixed conifer species and that grazing impact is negligible and fencing not necessary (Moktan, 2003).

### **Thinning and tending**

Similar to blue pine stands, thinning and tending should be conducted in spruce forests to avoid slim trees and unstable stands (Statz & Wyrsh, 1993, Rosset, 1999).

### **Silvicultural system**

It is generally recommended to practice group selection system and single tree system in spruce forest. The recommended size of the group usually depends on the site and understorey conditions.

### **Risks**

As a seedling, spruce is very susceptible to drought, in pole stands mixed with blue pine, it may be susceptible to snow break. Uprooting or windbreak damage may occur on exposed sites.

The most important danger is the bark beetle (*Ips schmutzenhoferii*); drought stress, disturbance of mycorrhizal fungi by soil trampling and excessive canopy opening seem to be conducive factors for bark-beetle attacks.

#### **1.11.6.9. Hemlock forest**

Hemlock forest is similar to Spruce forest but occupies wetter sites. Shrubby and arborescent Rhododendrons are frequent and the high humidity is ideal for dense growth of epiphytic and terrestrial ferns, lichens and bryophytes. Hemlock mixed with other montane conifers are common. In Bhutan, Hemlock forest is common on the main mountain ridges below the Fir forests, throughout the central and northern part of the country at an altitudinal range of 2800-3100 m.a.s.l. The annual rainfall ranges from 1300 mm to 2000 mm.

#### ***Tsuga Dumosa* (Himalayan hemlock)**

### **Reproduction**

Hemlock flowers nearly every year and a large amount of seed is normally produced; regeneration is normally no problem provided that there is a little light. Hemlock is not a light demander; optimal conditions for natural regeneration seem to be the shelter of older trees, which prevent the uppermost layer of the soil from drying out (Statz & Wyrsh, 1993, Rosset, 1999).

### **Silviculture**

### **Regeneration**

Hemlock has a shade-bearing character (although less so than fir) and can show fast initial growth under shady conditions. It prefers humid sites with or without humus layer. The critical factor for regeneration seems to be soil moisture. In general, regeneration is not a problem and provided the soil conditions are not too dry; there seem to be less silvicultural constraints than spruce as far as the minimal size of canopy opening is concerned (Rosset, 1999, Statz & Wyrsh, 1993).

Hemlock forest seems to have fewer weeds and shrub associates than spruce forests and is therefore less subject to regeneration problems due to competition. However, existing undergrowth of bamboos and rhododendrons might inhibit regeneration (Rosset, 1999). Hemlock regeneration is very sensitive to dry site conditions; the most suitable conditions seem to be in the shelter of older trees, which prevents the soil from drying up. (Statz & Wyrsh, 1993).

Group selection systems with small openings which would be closed by the time hemlock regeneration reaches sapling stage would provide enough light for growth of regeneration and at the same time maximise understorey stocking. Light levels in the understorey should not drop below 4% sunlight as increased mortality occurs (Darabant *et al*, 2001). Larger canopy openings (0.3 ha) have been found to result in lower abundance of regeneration with generally higher growth rates especially in the case of hemlock (Rosset & Rinchen, 1998, in Darabant *et al*, 2001). However openings that provide more than 40% of open light climate would not result in increased diameter growth (Darabant *et al*, 2001).

A study of regeneration dynamics in mixed conifers (in Thimphu, Bumthang and Haa) found that small-size artificial openings (group-cuts of 100m<sup>2</sup>) trigger profuse natural regeneration of the desired mixed conifer species and that grazing impact is negligible and fencing not necessary (Moktan, 2003).

### **Tending, thinning and felling**

On small areas, hemlock can form dense even-aged pole stands, which seem to undergo natural thinning without too many losses. However, light and frequent thinning may be necessary for larger stands. Hemlock tends to form multi-storied forests, which should be maintained.

A single-tree or small group/slit selection system may be applied to this type of forest. Special attention should be paid to the middle layer, in which the trees may be slim and weak. By removing an older tree in favour of such a middle layer tree, the latter should still be protected by a larger tree or be strong enough not to get broke by wind or snow (Rosset, 1999).

### **Silvicultural system**

It is generally recommended to practice group selection system and single tree system in spruce forest. The recommended size of the group usually depends on the site and understorey conditions. Prescribed grazing should be encouraged in areas dominated by dense bamboo understorey to reduce bamboo height (RNR-RDC, 2014)\_

### **Risks**

Older Hemlocks and sometimes younger trees growing in very shady conditions tend to form a broad crown with long branches which may be broken by snow, forming a tree with several tops and exposing the timber to fungal attacks. In even-aged pole stands, which may be quite dense, there is also a risk of damage by snow, but the risk is not as accentuated as blue pine (Rosset, 1999).

Saplings may be browsed by cattle and yak, but only when no better fodder species are available (Rosset, 1999).

#### **1.11.6.10. Fir forest**

Fir forest is the characteristics of highest forested ridges (3300 to 3800 m.a.s.l), where large tracts are covered by virtually no tree species other than scattered Hemlock and Birch patches in some locations. The dense canopy provides a humid environment for a luxuriant understory of Rhododendron and other shrubs, and the mossy ground layer supports many small herbs, e.g. *Primula* species and *Bryocarpum himalaicum*. As in Hemlock forest, in addition to the high rainfall (1300 mm to 2000 mm), considerable mist-precipitation occurs from the frequent cloud cover.

#### ***Abies densa* (East Himalayan fir)**

Bürgi *et al* (1992) state that Fir forests are very sensitive ecosystems, that the sensitivity to disturbances of ecosystems increases towards the timberline and that any utilisation should be based on profound knowledge of the system such that appropriate utilisation methods, which avoid the destruction of the system, are used.

Bürgi (2002) states that because the structure (uneven-aged) and species composition of these forests should not be altered to any great extent, in order to maintain the protective and ecological function of the forest, utilisation involving modern harvesting equipment is not economically viable. A traditional utilisation, e.g. shingle production for the local market, as a single-tree or small group selection forest, is possible without changing the forest in an undesirable way.

At its ecological optimum, fir forms extended monospecific stands which regenerate from single tree gaps formed by breakage of severely rotten trees (Rosset, 1999).



*Box 1.8 Silvicultural treatments for selection management of fir forest*

- Remove few mature trees to promote regeneration on a relatively small area
- Fell mature trees minimising damage to saplings and seedlings
- Selective thin out middle layer to stabilise stand structure
- Perform tending operations removing some broadleaved trees in the middle and lower canopies
- As the fir saplings start to colonise remove a few old trees gradually

## **Reproduction**

Fir does not flower and produce seed every year. The flowering interval is not known, but may lie between three and seven years. Fir is a shade bearer, but also regenerates in abundance on open sites (Rosset, 1999). As a shade-loving species its competitive advantage against pioneers like maple, birch and other broadleaves decreases with increasing opening/group size (Statz & Wyrsh, 1993).

The seeds of Fir germinate best on slightly hydromorphic (i.e. developed in the presence of excess water) humus layers, nurse logs and moss carpets. In open areas outside of the closed forest, fir regenerates preferentially on bare mineral soils because humus layers tend to overheat and dry out in the high radiation environment. Within the forest, there is frequently a dense sapling bank waiting to be released by formation of gaps in the canopy (Rosset, 1999).

## **Silviculture**

In its optimal range, Fir regeneration competes with bamboo on better sites and with large-leaf rhododendron species on more acidic sites. On bamboo sites regeneration is on nurse logs and in gaps in the bamboo understorey. Competition with large leaved rhododendrons can be severe, as these rhododendrons occupy the same seedbed niches. And outgrow fir in marginal light (Rosset, 1999).

Darabant *et al* (2001) describe the silviculture of fir in relation to light environment; light is the single most important factor influencing forest dynamics. Basal area thresholds for management have been derived; the median of light levels experienced by recently dead saplings was at 5% sunlight which corresponds to a basal area of level of 40 to 60 m<sup>2</sup>. Gradual opening of the canopy leads to increased radial growth up to 60% sunlight, corresponding to basal area of 8 m<sup>2</sup>. As forest management has to focus on overall tree growth and not only that of saplings, keeping basal area levels as low as 8m<sup>2</sup> is not feasible; a compromise has to be found between growth of merchantable trees and growth of saplings.

Single-tree and group selection silvicultural systems are recommended for management of fir forests.

## **Risks**

In western Bhutan, die-back of large stands at high altitude was observed during the 1980's. It is suspected that this episodic die-back was triggered by climatic conditions, possibly drought stress.

Fir regeneration is highly vulnerable to damage by grazing cattle; this has the potential in the long term to lead to the collapse of the fir zone.

The risk of branches and crowns being broken by storms, snow load and rime ice is very high due to the broad and flattened shape of the crown. Cull percentage in most forest stands is very high (Rosset, 1999).

### **1.11.6.11. Rhododendron-Juniper forest and Alpine Scrub forest**

This forest types are characterized by pure Juniper stand, *Lyonia* and rhododendron species.

Selection of silvicultural systems

Silvicultural decision making is always influenced by considerations related to the forest ecosystem, the social environment, technical possibilities and economics. Silvicultural strategies should be based on silvicultural knowledge and also integrate the social reality surrounding the forest area and take into account the institutional and economic constraints of the implementing forest agencies (Kleine, 1996).

*Table 1.52 Factors deciding on choice of silvicultural system*

<b>Factors</b>	<b>Categorization of silvicultural systems in the Code</b>
Forest type, species composition and structure	Forest types reflecting different biogeoclimatic conditions <sup>4</sup>
Environmental conditions, such as soil, topography, aspect, altitude and climate	
Labour, machinery, road access and other inputs available for management	Management types reflecting available inputs and required products & services <sup>5</sup>
The end-products and services required	

The possible effects of the choice of silvicultural system should be considered when developing or implementing a silvicultural system and should form part of the description and justification of the silvicultural system in the FMP (see Box 1.9 Points to consider when developing or deciding upon a silvicultural system (derived from Higman et al, 1999) below).

*Box 1.9 Points to consider when developing or deciding upon a silvicultural system (derived from Higman et al, 1999)*

- Effects on growth rates of harvestable species (timber and non-timber);
- Effects on forest services (such as watershed protection or aesthetic value);
- Effects on biodiversity and wildlife (intensive silviculture may simplify the forest structure);
- Effects on ecological sustainability (processes such as nutrient and water cycles);
- Effects on seed production (sufficient seed trees should be left to ensure regeneration);
- Effects on regeneration (light conditions required by various tree species);
- Applicability to forest ecology (silvicultural systems should mimic natural disturbance dynamics);
- Social acceptability (particularly to communities within or close to the forest).

The decision on silvicultural system also depends on forest function. The decision regarding the selection of silvicultural system cannot be reduced to simplistic mimicking of textbook techniques that may be applicable to other climates, tree species or ecosystems. In choosing a silvicultural system, the forest management planner must combine these considerations with local knowledge of the site and species ecology, regeneration requirements of different tree species, stand development processes, traditional and new harvesting techniques, and the anticipated silvicultural needs of the forests (adapted from British Columbia, 1995).

<sup>4</sup> Forest types include: sub-tropical, warm-temperate broadleaf, chir pine, cool-temperate broadleaf, evergreen oak, blue pine, hemlock, spruce & fir forests;

<sup>5</sup> Management types include: FMU, WS, CF, PF, leased land, GRF outside FMUs, managed forests in PAs.

### **1.11.7. Silvicultural Strategies and Prescriptions**

Silvicultural strategies and operational prescriptions are integral parts of forest management planning; as such they depend on the overall management objectives selected for particular forest area. Silvicultural decision-making is required at both strategic (FMU) and operational (compartment/sub-compartment level), refer to Table 1.53 From management objective to silvicultural strategy and operational planning.

Kleine (1996) recommends that during the process of developing ideas for silvicultural management the two planning levels must be clearly separated. Besides well-defined management objectives, a silvicultural strategy needs to be described at the FMU level. In order to successfully translate this silvicultural strategy into real field operations, detailed planning at the compartment level is required.

#### **1.11.7.1. Strategic Level (forest management unit)**

A silvicultural strategy should be developed from the management objectives. The strategy should be designed in such a way so as to directly contribute to the achievement of the objectives. The silvicultural strategy is mainly reflected in the choice of silvicultural systems as well as the definition of rotation age.

#### **1.11.7.2. Operational Level (compartment, forest stand)**

The silvicultural management concept outlined at the strategic level is translated into actual field operations with the help of planning at stand level; this step forms part of the operational planning process. The logical sequence of this approach is be illustrated by reference to an example (adapted from Kleine, 1996), see Table 1.53. Branney (2003) provides a detailed step-wise approach to identifying and implementing silvicultural options in community forests, much of the information includes is of relevance to FMU management planning and implementation.

*Table 1.53 From management objective to silvicultural strategy and operational planning*

<p>Forest management objective (example)</p> <p>To manage and improve the forest for the production of hardwoods (timber, firewood, household implements etc.) as well as fodder (i.e. leaves and grass) on a sustained yield basis whilst maintaining the protective functions (i.e. water and soil) and rich biological diversity (derived from Dhital, 1993a by Kleine, 1996).</p>
<p>Silvicultural strategy (example)</p> <ul style="list-style-type: none"> <li>• Generally, the broadleaved forests have the potential to be managed for multiple uses relying primarily on natural regeneration. This can be efficiently achieved by manipulating the main canopy through harvesting of mature trees in combination with temporary protection from grazing. Planting is considered a supplementary measure at small scale only. Silvicultural treatments (i.e. weeding, cleaning, thinning) of the natural regeneration shall ensure improved stand conditions in terms of commercial species composition and stocking;</li> <li>• In order to operationalise the technical strategy given above, an integrated approach is required. Participation of local forest users should ensure a sympathetic attitude towards regulated forest management;</li> <li>• Under the proposed strategy, planning and monitoring at the stand level shall be required (derived from Dhital, 1993a by Kleine, 1996).</li> </ul>
<p>Silvicultural prescriptions</p> <p>These prescriptions shall form part of the annual operational plan and should be guided by;</p> <ul style="list-style-type: none"> <li>• a specific production goal assigned to each stand (with reference to commercial and local use); (derived from Dhital, 1993a by Kleine, 1996).</li> <li>• the actual stocking conditions of the stand (with reference to the successional development phase of the stand; Kleine (1996) describes old-age, fragmentation and building phases) since the sequence of operations depends upon the progress of the stand and regeneration growth.</li> <li>• the forest function of the stand (this can be derived from the forest function map). (derived from Dhital, 1993a by Kleine, 1996).</li> </ul>

#### **1.11.8. Forest grazing**

Cattle farming has always been an important part of Bhutan's integrated soil utilisation systems. As an important source of ruminant fodder, forest undergrowth has continuously been used for cattle grazing, either beyond the cultivated fields, or along migration routes. Forest grazing is still the main fodder resource of ruminant feed, especially in the summer period (Roder, 1998 in Rosset, 1998).

The removal of overstorey by logging releases moisture and nutrients and increases light for herbaceous and shrub vegetation (Miller, 1986 in Rosset, 1998). Mechanised forest harvesting systems, with construction of forest roads and opening up of forest along cable-crane lines do, therefore, invite an increased concentration of cattle in managed forest areas.

Livestock grazing in forested areas can have strong detrimental effects on forest ecosystems, in particular during the critical phase of stand regeneration by browsing of young trees, physical damage to trees from trampling, removal of the soil's protective layer, and soil compaction.

Tensions are likely to arise between cattle and yak owners and foresters. But also, Miller (1986, in Rosset, 1998) suggests cattle grazing can sometimes be beneficial by exposing soils for tree regeneration by reducing competition between tree seedlings and herbaceous, bamboo and shrub species.

An analysis of a long-term regeneration trial in Hurchi FMU, Bumthang (hemlock rich, mixed conifer forest) illustrates the complexity of the issues of cattle grazing in forest areas. Observations suggested on the one hand that damage by cattle to conifer species is negligible but that damage to broadleaved species were very important (Rosset, 1998).

*Box 1.10 Forest grazing; some unanswered questions*

Most of the presently available information (Rosset, 1998) is qualitative and based on rather subjective observations; it is not possible to respond satisfactorily to the following questions:

1. What are the positive and/or negative effects of cattle grazing on different forest types?
2. What is the sensitivity of different species to (conifer and broadleaved) to cattle grazing?
3. What is the carrying capacity of different forest types?
4. At what stages and for how long should the forest stands under regeneration be protected from cattle grazing?

In view of the important social and traditional aspects of cattle grazing in forested areas, a solution to the damages by cattle is likely to be found only with an increased participation of cattle owners in the planning and management of forestry operations.

Integrating cattle grazing in forest management is important. Therefore, an appropriate planning forum is needed in order to bring together all stakeholders including graziers. Consideration should be given to the improvement of forage resources (e.g. Tsamdrog) and to the negotiated and agreed regulation of grazing through the segregation of grazing areas from timber production areas (at least during the vulnerable regeneration period) (Moktan, 2003).

Norbu (2000) presents a strategy for integrating cattle grazing in broadleaved forests that is based upon active participation of stakeholders in forest planning and management. The components of the proposed strategy include:

- Native fodder tree management
- Regulating grazing in Tsamdrops and forests through:
  - Improvised controlled grazing
  - Involvement of herders, farmers and other stakeholders in forest management

Management of cattle grazing in forest

## **1.12. Environmental Impact Assessment**

*Environmental assessment is defined as all procedures required under Bhutanese law to identify means to ensure that the activities of a project are managed in an environmentally sound and sustainable way (NEC, 2002).*

*An anticipatory environmental management tool for the orderly and systematic evaluation of a proposal and its effects on the environment (Wood, 1993).*

EIA is process of predicting and evaluating the likely positive and negative impacts of a proposed FMU on environment, socio-economic and culture.

Operations in an FMU shall have impacts (both positive and negative) on a wide range of *receptors*. Examples of some of these receptors would include watershed areas (including water quality), precious ecology (including wildlife), employment levels, local economy and people livelihood.

Possible negative impacts might include erosion and siltation resulting from road construction or logging and disturbance of sites of ecological importance; including endangered and protected wildlife species.

Possible positive impacts might include increased opportunities for local employment and improvement of degraded land, protection of wildlife corridors and protection of watershed and smaller catchments.

The primary purpose of EA is to ensure that decision makers are provided with sufficient, unbiased and balanced information about the likely consequences of a proposed project before a decision is taken on whether or not consent should be granted.

EA consists of three major phases:

1. Information is collected regarding the state of the environment prior to the initiation of a proposed project;
2. Baseline data from the first phase is used together with information about the project's proposed activities, in order to make predictions about the nature and the scale of changes that would be likely to occur in the environment if the project were to go ahead;
3. Baseline data and predictions are incorporated into an environmental impact statement (EIS). The EIS is then submitted to the *competent authority* and taken into account in reaching a decision on whether or not the proposed project should be allowed to go ahead. The competent authority is the body responsible for granting environmental clearance for projects. In the case of FMUs, EIS is considered to be an integral part of the FMP.

#### **1.12.1. The Legislative Context**

The Environmental Assessment Act (2000) establishes procedures for the assessment of potential effects of strategic plans, policies, programs and projects on the environment, and for the determination of policies and measures to reduce potential adverse effects and to promote environmental benefits.

A project means any activity that may have significant effects on the environment. The direct implication for forest management is that for all forest operations, an environmental assessment must be undertaken and environmental clearance granted. The process of preparing a forest management plan includes undertaking an environmental assessment in accordance with the requirements of this Act.

Article 16 of the Act requires that: The applicant shall ensure that concerned people and organisations are informed and consulted before submission of the EA documents to the competent authority. Concerned people mean individuals, groups and communities whose interests may be affected by a project. In the case of FMU planning, the forums for consultation are the FMU-level Committees.

#### **1.12.2. Objective**

To undertake EA of FMUs in accordance with the Environmental Assessment Act (2000) and thereby identify actual and potential impacts on the environment as a result of planned forestry operations and accordingly plan to minimize, mitigate or avoid negative environmental impacts and maximise positive environmental impacts.

#### **1.12.3. Output**

An environmental impact statement (EIS), as an integral part of the FMP, fulfilling the environmental standard requirements of the FMU in reference.

The environmental impact statement report is submitted to NEC for their review and approval.



#### 1.12.4. Lead responsibility

Divisional Forest Office

#### 1.12.5. The Environmental Impact Assessment Process for FMUs

EIA is a multidisciplinary process; this means that it involves team based approach with a range of experts and stakeholders following a sequence of steps or stages. Within the context of FMUs, the EIA process shall be complementary to the overall forest management planning process, whereby the Environmental Impact Statement section of the Forest Management Plan shall outline the likely environmental impacts and the corresponding mitigating measures that the plan should encompass (Table 1.54 Summary of environmental impact assessment process)

The institutional mechanism and the flow of information regarding the process for obtaining the Environmental Clearance for the FMUs from NECS (Figure 1.9). The DoFPS directorate shall submit the proposed FMP to NECS and upon receipt, the NECS shall review Environmental Statement of the FMP and accordingly make the following decisions for granting/rejecting Environmental Clearance.

*Decision A: Environmental Clearance granted;*

*Decision B: Further study required: FMP returned to the Head, DoFPS for further information/clarification/assessment;*

*Decision C: Environmental Clearance not granted based on justifications provided by NECS.*

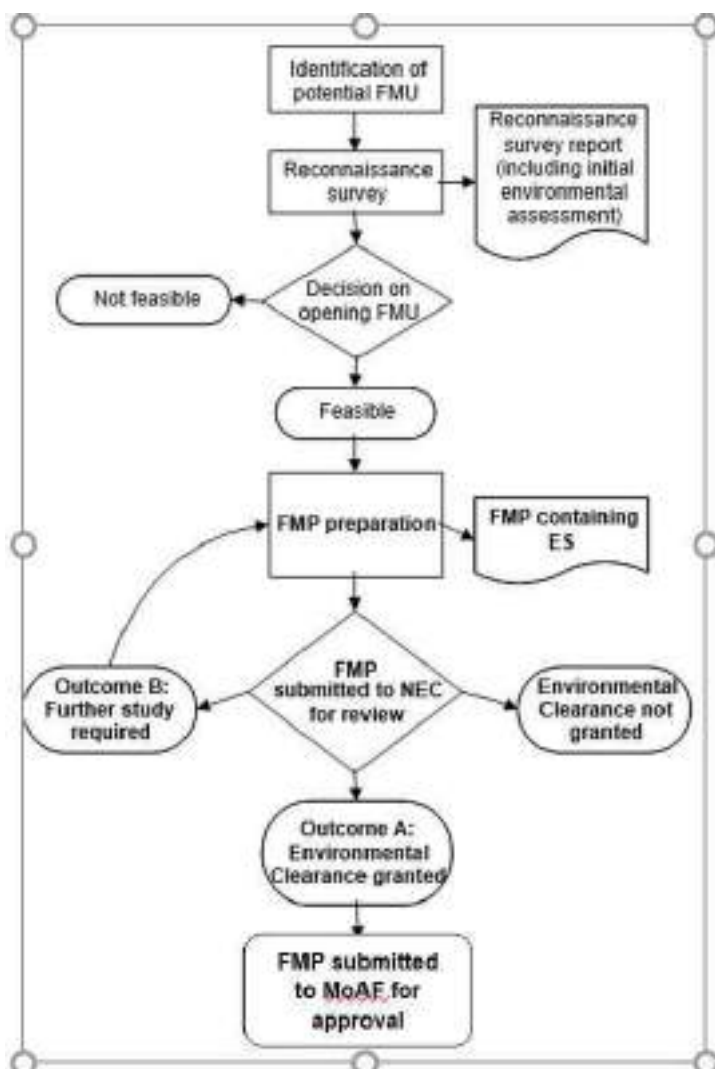


Figure 1.9 Institutional mechanism for environmental assessment & clearance for FMUs

Table 1.54 Summary of environmental impact assessment process

Activity/step	Objective	Outcome	Lead agency
1. Description of project	To provide detailed information on proposed activities	Detailed description of proposed activities (to be included in ES)	DFO/FRMD
2. Description of baseline environment	To provide detailed description of baseline environment	Detailed description of baseline environment (to be included in ES)	DFO/FRMD
3. Prediction of impacts	To identify and estimate changes in the environment	Statement of predicted impacts (to be included in ES)	DFO/FRMD
4. Evaluation of significant impacts	To determine magnitude and significance of impacts	Statement of significant impacts with reference to thresholds of concern	DFO/FRMD
5. Identification of mitigating measures	To identify mitigating measures for all adverse effects (& to define responsibilities for their implementation)	Statement of mitigating measures (to be included in ES)	DFO/FRMD
6. Presentation of findings in ES	To clearly state methodology, data, results of assessments & assumptions	Comprehensive, accurate & well structured statement to inform competent authority (including non-technical summary)	DFO/FRMD
7. ES considered by competent authority	To achieve environmental clearance	Environmental clearance granted	NECS/DoFPS
8. Monitoring & auditing	To improve understanding of environmental impact To compare predicted impacts with those that actually occur	Information on the accuracy of predictions and effectiveness of mitigating measures	DFO/FRMD/NECS

### **1.13. Financial and Economic Appraisal**

The financial and economic appraisal of an FMU must address a number of different themes; financial forecasts for the plan period, long-term cost-benefit analysis including consideration of non-market costs and benefits and the supply and demand for forest products. Economic efficiency, economic equity and economic sustainability should be demonstrated.

Forest management often aims to maximise timber production, even though this is just one of many products and services which different stakeholders may seek from the forest. A central aspect of sustainable forest management is the need to optimize the mix of products and services from the forest.

Optimizing benefits in the long-term involves making trade-offs between benefits, which can be reaped today, and those that should be left for the future (see Box 1). It also requires a compromise between saleable products, such as timber and NWFPs, and vital services, such as watershed protection and wildlife habitat. These services often do not have a market and therefore the forest organisation is not financially rewarded for their maintenance (Higman *et al*, 1999).

This section of the code considers the objectives of the various elements of financial and economic appraisal and presents guidelines on the activities required in order to achieve these objectives.

Forest management must be economically viable. This is distinct from the financial viability of forest exploitation. Full economic viability must take account of the reinvestment required for maintenance of the system and the additional costs (or income forgone) due to protection of the forest ecosystem and equitable distribution of the social costs and benefits of forest management. Implementation of sustainable forest management is rarely as financially attractive in the short-term as unsustainable forest exploitation.

A need exists for the development of a comprehensive and thorough methodology for the economic appraisal of FMUs.

#### **1.13.1. Objectives**

- To assess cash flow and financial viability of operations for the plan period
- To undertake cost-benefit analysis and to consider economic viability over the period of the rotation or in perpetuity (including consideration of non-market costs and benefits).
- To identify factors affecting supply and demand for forest products

#### **1.13.2. Outputs**

- 10-year cash flow forecast.
- Long-term cost-benefit analysis (including statement on non-market costs and benefits and implications for forest management).
- Statement of factors affecting supply and demand for forest products in the FMU and the implications for forest management during the plan period.

#### **1.13.3. Lead Responsibility**

Divisional Forest Office in collaboration with Authorized Agency

#### **1.13.4. Steps for Financial and Economic Appraisal**

Financial forecasts for the plan period

The FMP should include a financial forecast for the plan period; this should present in a table or spreadsheet, the income (revenue) and expenditure (costs) associated with management and operations in the FMU. The forecast should include different income and expenditure categories as appropriate and show income and expenditure for each year of the plan period. Estimates of royalties should also be presented in the FMP.

The financial forecast does not show profitability as such, either for the plan period or for a longer period; it does, however, indicate the likely flow of funds directly related to operations in the FMU for the plan period. It can serve as a useful guide to yearly financial planning.

The financial forecast can also be used to estimate revenues and royalties foregone as a result of rural allotment. This can be considered as one element of the *social value* of FMU operations. However, it does not provide a full picture of social values and an indepth assessment is required..

As the time passes, the actual figures of revenues, costs and royalties can be compared to those predicted in the financial forecast. This can be done by inserting an extra column for each year with the heading *actual*. A useful source of information and guidance on forestry budgets and accounts is provided by Bright (2001).

A financial forecast template proposed by Stark, 2003 can be used in order to identify the revenue accruing to and costs borne by authorized agency and to the income in royalties accruing to the Royal Government of Bhutan.

*Table 1.55 Financial forecast (cash flow) example; assumptions, summary and spreadsheet*

Assumptions		
m3 to cft	35.31467	
Recover Volume NRDCL (%/AAC)	60	
Road construction (Nu/km)	2,500,000	
Length of proposed new road (km)	5.0	
Length of existing road (km)	31.0	
New road construction (km/yr)	1.0	
Road maintenance (Nu/km/yr)	12000	
Distance to Depot (km)	24.0	
Haulage Cost (Nu/cft/km) (Nu/m <sup>3</sup> /km)	0.60	21.19
Cable crane (Nu/cft) (Nu/m <sup>3</sup> )	8.69	306.88
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)	228135	
Average compensation (penalties and fines) (Nu)	24842	
All Costs:DFO are taken as an average from the last plan period (Nu)		
Pay & Allowance	356863	
OPE	0	
TA/DA	137623	
Vehicle	5417	
Provident Fund	26037	
Rural Allotment (m <sup>3</sup> )	1350	
Regeneration maintenance (for cable lines) (Nu/ha)	3000	
Hectares of cable lines that require planting in the FMU (approximate) immediately	35	
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 (from 1998)	18.61	

### Cost-benefit analysis

Cost-benefit analysis (CBA) is a relatively simple and robust tool for investment or project appraisal. CBA is used to assess the acceptability of different project or investment options and then for comparing those

options. It involves identifying and quantifying all costs and benefits over a specified time period. CBA is used to compare the achievement of objectives (benefits) with the costs incurred. It attempts to value market and non-market cost and benefits in monetary terms and compare the costs and benefits of managing for different combinations of objectives over time. The process of CBA can be very effective ways of helping the forest manager identify the costs and benefits associated with a particular course of action.

Costs and benefits can be tabulated into a spreadsheet; this spreadsheet shall then show the long-term 'flow' of cost and benefits. These can then be analysed by applying a range of 'tools', often based on the application of discounting and concepts such as *net present value* (NPV) and *land expectation value* (LEV). The cost and benefits analysis for a plan period can be obtained from the financial forecast template shown below. However for longer term or rotation period length or for pertuity they should be analysed using other financial forecasting tools like NPV (Net Present Value) and LEV(Land expectation Value). However, to be more dynamic the financial forecast for a plan period (10 years) is recommended.

Table 1.56 Financial forecast for the plan period

	AAC (m <sup>2</sup> )	Rec. Volume (m <sup>3</sup> )	Nu/cft	Nu/m <sup>3</sup>	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	10 Years
					Nu	Nu	Nu	Nu	Nu	Nu	Nu	Nu	Nu	Nu	Total (Nu)
<b>Revenue: NRDC</b>															
Timber-Commercial	9800	5400	154.89	5.469.17	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	295,334,958.60
Timber-Rural	2500														
<b>Total Revenue NRDC</b>					29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	29,533,495.86	295,334,958.60
<b>Costs: NRDC</b>															
Bridge Construction															
Road Construction		2,500,000			2150000	2150000	2150000	2150000	2150000	2150000	2150000	2150000	2150000	2150000	21,500,000.00
Road Maintenance			15,000		75750	75750	75750	75750	75750	75750	75750	75750	75750	75750	757,500.00
Marking Cost			0.08	2.32	27691	27691	27691	27691	27691	27691	27691	27691	27691	27691	276,908.80
Inventory Costs					30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	300,000.00
Felling and Cross-cutting	5880	1.95			404979.12	404979.12	404979.12	404979.12	404979.12	404979.12	404979.12	404979.12	404979.12	404979.12	4,049,791.20
Debarking	5880	0.35			72688.56	72688.56	72688.56	72688.56	72688.56	72688.56	72688.56	72688.56	72688.56	72688.56	726,885.60
Cable Craning	5880	20			4153632	4153632	4153632	4153632	4153632	4153632	4153632	4153632	4153632	4153632	41,536,320.00
Transportation to Depot	5880	8.32			1727910.912	1727910.912	1727910.912	1727910.912	1727910.912	1727910.912	1727910.912	1727910.912	1727910.912	1727910.912	17,279,109.12
Stand Tending (Spacing etc.)															-
<b>Coupe Regeneration</b>															
Regeneration Maintenance		3,500/cable line			17,500.00	35,000.00	52,500.00	70,000.00	87,500.00	105,000.00	122,500.00	140,000.00	157,500.00	175,000.00	962,500.00
Creation of Plantation		50,000ha				50,000.00	50,000.00	50,000.00	50,000.00	50,000.00	50,000.00	50,000.00	50,000.00	50,000.00	450,000.00
Plantation Maintenance		8,000ha					8,000.00	8,000.00	24,000.00	32,000.00	40,000.00	48,000.00	56,000.00	64,000.00	288,000.00
<b>Total Costs NRDC</b>					8,640,151.47	8,727,651.47	8,753,151.47	8,778,651.47	8,804,151.47	8,829,651.47	8,855,151.47	8,880,651.47	8,906,151.47	8,931,651.47	88,127,014.72
<b>Total Revenue less Total Costs NRDC</b>					20,893,344.39	20,805,844.39	20,780,344.39	20,754,844.39	20,729,344.39	20,703,844.39	20,678,344.39	20,652,844.39	20,627,344.39	20,601,844.39	207,207,943.88
<b>Royalty</b>															
Royalty-Commercial	9800		10	388.41	3807496	3807496	3807496	3807496	3807496	3807496	3807496	3807496	3807496	3807496	38,074,960.00
Royalty-Rural															
<b>Total Royalty NRDC</b>					3,807,496.00	3,807,496.00	3,807,496.00	3,807,496.00	3,807,496.00	3,807,496.00	3,807,496.00	3,807,496.00	3,807,496.00	3,807,496.00	38,074,960.00
<b>Revenue less Royalties NRDC</b>															
Timber-Commercial					25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	257,259,998.60
Timber-Rural															
<b>Total Revenue less Royalty NRDC</b>					25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	25,725,999.86	257,259,998.60
<b>Total Revenue less Royalty Less Costs NRDC</b>					17,065,848.39	16,998,348.39	16,972,848.39	16,947,348.39	16,921,848.39	16,896,348.39	16,870,848.39	16,845,348.39	16,819,848.39	16,794,348.39	169,132,983.88

Estimates of future costs and benefits shall have to be made based upon past and present figures and trends. Certain assumptions shall need to be made, for example, future timber prices; these assumptions should be clearly stated.

	AAC Rec. (M³)	Nu/cft	Nu/m³	Value in Nu							2029	2028	2027	2026	2025	2024	2023	2022	2021	2020	10 years total
				2020	2021	2022	2023	2024	2025	2026	2027	2028	2029								
Revenue :NRDCL																					
Timber- commercial	900	360	143	5050.76	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	18182736
Timber - rural																					
Total Revenue NRDCL				1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	1818273.6	18182736
Cost :NRDCL																					
Road maintenance				14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	140000
Marking cost		0.08	2.82	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	1015.2	10152
Inventory cost																					
Felling and cross cutting		3.5	124	44640	44640	44640	44640	44640	44640	44640	44640	44640	44640	44640	44640	44640	44640	44640	44640	44640	446400
Debarking		3	106	38160	38160	38160	38160	38160	38160	38160	38160	38160	38160	38160	38160	38160	38160	38160	38160	38160	381600
Transportation to depot		16	565	203400	203400	203400	203400	203400	203400	203400	203400	203400	203400	203400	203400	203400	203400	203400	203400	203400	2034000
Plantation Maintenance			Nu.80000/ha	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	4000000
Platation Creation			Nu.100000/ha	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	5000000
Maintenance of nursery			8/seedling																		
Total cost NRDCL				1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	1201215.2	12012152
Total Revenue less Cost				617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	617058.4	6170584
Royalty																					
Royalty -Commercial		8.6	303.752	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	1093507.2
Royalty - Rural																					
Total Royalty NRDCL				109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	109350.72	1093507.2
Revenue less Royalty NRDCL				507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	5077076.8
Timber -commercial																					
Timber -Rural																					
Total Revenue less Royalty NRDCL				1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	1708922.88	17089228.8
Total Revenue less Royalty less Cost NRDCL				507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	507707.68	5077076.8



CBA can narrowly concentrate on financial costs and revenues, or can be broader, and encompass non-market considerations such as social and environmental values by using a range of valuation techniques. In the context of FMUs in Bhutan it is sufficient for CBA to take into account financial costs and revenues and for social and environmental factors to be dealt with by policy and legislation via the instrument of forest function mapping. Economic appraisal is therefore undertaken for essentially commercial operations that are planned and implemented in accordance with what might be termed as *sustainability criteria*. In practice these sustainability criteria are defined by the management restrictions resulting from the forest function mapping process.

### **Supply and demand for forest products**

The process of forest management planning must take into account the supply and demand of forest products. FMPs should include statements on supply and demand and the implications for forest management. In order to do this, it is necessary to examine past trends in supply and demand and also to make predictions about future supply and demand scenarios. This sub-section presents some guidelines on how these considerations may be incorporated into the planning process.

### **Factors affecting supply of forest products**

The supply of forest products from an FMU is determined by the sustained yield of timber and other products. Past trends can be identified from production records for the previous plan period, in the case of planning for the second or subsequent plan period. Supply forecasts for timber can be derived from the AAC calculation and maturity class analysis. Consideration should be given to any expected change in product specification such as species composition, stem form and log size over the plan period and in the longer term.

### **Factors affecting demand for forest products**

The demand for forest products is affected by a number of factors including; population, income per head, availability of substitute products, the state of the wood processing technology, tastes for timber products and the state of business activity (derived from Price, 1998). The implications of these factors need to be taken into account in the planning process. In the context of FMUs in Bhutan specific factors such as urban expansion, public and private sector construction activity and the availability of alternatives to wood for building and heating are likely to significantly affect the demand for forest products.

## **1.14. Approval Procedures**

### **1.14.1. Endorsement by Local Government**

The FMP should be endorsed by the Local Government (LG) after presentation and endorsement by the FMU-Level management committee. Endorsement of the FMP by the LG shall be made easier if clear evidence is provided of stakeholder consultation and participation in planning. Minutes of FMU-level committee meeting should be included as an annexure to the FMP.

### **1.14.2. Endorsement by Department.**

After endorsement of the FMP by the FMU level committee, the FMP has to be presented at FRMD and subsequently to the Technical Advisory Committee (TAC) of the Department for endorsement. The Head of the Department recommends the FMP duly endorsed by TAC.

#### **Objective**

In order to ensure that the plan is consistent with the technical standards and other legal provisions as enshrined in Acts, Policies and Rules.

## **Output**

FMP endorsed by FRMD and the Head of the Department

## **Lead Responsibility**

Divisional Forest Office in collaboration with the FRMD

## **Description of Activity**

The endorsed FMP by FMU level committee and Local Government must be submitted to FRMD by concerned Divisional Forest Office at least 3 months before the close of a financial year. The concerned planner of the Divisional Forest Office must make an in-house presentation at FRMD at prior fixed date agreed in consultation with FRMD. Relevant officials from authorized agency preferably concerned Regional Managers and General Managers shall be invited for the in-house presentation. FRMD shall review the plan and subsequently either recommend for endorsement by TAC or recommend for changes and amendments to the concerned Divisional Forest Office. Presentation at the TAC shall be carried out by FRMD.

The purpose of this step is to ensure that a number of planning criteria have been reached, plan is consistent with the technical standards and other legal provisions as enshrined in Acts, Policies and Rules. Normally it would take the form of a meeting involving the Head of the Department, FRMD and officials from the authorized agency. During the meeting, the salient features of the FMP would be presented and deliberated. The following is a list of criteria by which the committee shall be able to assess the plan (it may not be exhaustive)

- Is the FMP (in its objectives) consistent with national level policy?
- Is the FMP legal in its present format (does it meet all legal criteria)?
- Is the FMP technically correct?
- Is the FMP structure and contents consistent with planning codes and guidelines?
- Have management objectives, options, responsibility, and indicators been identified?
- Is there an established FMU-level management committee and has the committee been involved in the plan preparation?
- Has the FMU-level management committee had a meeting to endorse the plan?
- Has the FMP been endorsed by Local Government?
- Has the environmental assessment been completed?
- Is the plan financially sound; do authorized agency agree that its implementation is feasible?
- Are there any alterations that are needed?

Any comments arising should be noted in writing with an agreed responsibility for action. If there are many comments, the meeting may have to be re-convened once the amendments have been made. Consideration should be given to ensuring that any changes in the plan are endorsed by the Local Government. FMP fulfilling all these criteria should be submitted to the Ministry of Agriculture and Forests with a recommendation from DoFPS for approval.

### **1.14.3. Approval by Ministry of Agriculture and Forests**

#### **Objective**

To approve the plan for implementation by Head of the Ministry.

#### **Output**

The approved FMU management plan; ready for implementation

#### **Lead Responsibility**

Head of Department shall submit plan to Ministry recommending its approval.

### **1.15. Amendment and plan revision**

The approved Plan may be revised during the implementation period if major changes occur in the area of FMU and in the event of major disasters.

The Head of Department shall authorize a revision of the plan based on proposal for amendment from the respective DFO.

### **1.16. Operational Planning**

An approved operational plan is the legally binding document basis by which implementation is guided and responsibility and accountability are determined for the one-year operational period. Operational plans (OPs) are developed to:

- identify and describe forest management activities which shall be carried out during the coming year and (in the case of rolling two-year plans) during the following year; and
- estimate the cost of carrying out the activities and identify funding sources.

#### **1.16.1. General Principles**

Operational plans should follow the general principles as indicated below so that they are effective and practical forest management tools.

##### *Simple structure and format*

Since they are prepared annually, OPs should be as simple and concise as possible. A standard format that can be easily completed is very appropriate; however, the format must contain all the necessary information for planning purposes.

##### *Objective led*

As with FMPs, OPs should be objective-led. This means that **any activity identified for implementation in the OP should relate to a specific management objective in the FMP. While preparing the OP, it is essential to cross-reference to the FMP.**

##### *Site specific and quantitative*

Since OPs are prepared for operational purposes, they should contain enough information for them to be implemented by the FMU Incharge. Any specified activity in the OP should therefore relate to a particular identified location in the forest (site specific) and be quantified in terms of costs and physical quantity.

##### *Participatory*

A number of activities in the OP can have a specifically local interest or potential impact on local stakeholders. In such cases, the plan for that activity should be prepared in a participatory manner with the involvement of the concerned stakeholders. This is achieved by ensuring that the FMU-level management committee is an effective forum for participatory planning.

##### *Prepared annually (for a two-year rolling period)*

OPs are prepared annually but the plan period is for two years (see Box 1.11). Therefore, activities for the second year of the plan are carried forward into the first year of the next plan. This has important implications for budgeting (since it shall then be possible to estimate budgets well in advance of the start of the financial planning year) and for participatory processes since these can be carried out a year before the start of the activity.

*Box 1.11 Explanation of 'rolling' operational plans*

For each year of the ten-year period of the forest management plan, an operational plan must be in place.

The operational plan shall include detail of activities for the 1<sup>st</sup> year (let's call it year 1) and an outline of activities for the 2<sup>nd</sup> year (year 2). Mid way through year 1, the UIC shall prepare a detailed plan for year 2 (based on the outline from the year 1 plan) and an outline plan for year 3.

The 'rolling plan' is a way of describing the operational plan and is not something separate or different to the operational plan.

This table may help to illustrate the point. Each separate colour block represents one operational plan including detailed planning for the first year and outline planning for the next.

Year 1	2	3	4	5	6	...
De-tailed	Outline	De-tailed	Outline	De-tailed	Outline	Etc.
	De-tailed	Outline	De-tailed	Outline	De-tailed	Out-line

The advantages of preparing OPs annually for a two-year rolling period are that budgeting for the following year can be anticipated, continuity of management is made easier and participatory planning can be done well in advance.

### **1.16.2. Timing of Operational Plan Preparation, Submission and Approval**

The timing for preparation and submission of operational plans has been set with the calendar year from 1<sup>st</sup> January to 31<sup>st</sup> December in order to synchronize with the financial year of authorized agency so that the budgeting and financial commitment to the implementation of planned activities is ensured (Table 1.57)

Table 1.57 Operational planning time frame

Sl. No	Task Name	Start	Finish	Duration (days)	2020								2021																
					Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun		
1	OP 2020 : Preparation of OP	16/08/2019	25/10/2019	69																									
2	OP 2020 : Submission to CFO	25/10/2019	31/10/2019	6																									
3	OP 2020 : Submission to FRMD	1/11/2019	7/11/2019	7																									
4	OP 2020: OP Review by FRMD	8/11/2019	18/12/2019	10																									
5	OP 2020 : Submission to Director	19/12/2019	30/12/2019	11																									
6	OP 2020 : OP returned to CFO/UIC	31/12/2019	31/12/2019	1																									
7	OP 2020 : Implementation	1/1/2020	31/12/2020	365																									
8	OP 2021 : Preparation of OP	16/08/2020	25/10/2020	69																									
9	OP 2021 : Submission to CFO	25/10/2020	31/10/2020	6																									
10	OP 2021 : Submission to FRMD	1/11/2020	7/11/2020	7																									
11	OP 2021: OP Review by FRMD	8/11/2020	18/12/2020	10																									
12	OP 2021 : Submission to Director	19/12/2020	30/12/2020	11																									
13	OP 2021 : OP returned to CFO/UIC	31/12/2020	31/12/2020	1																									
14	OP 2021 : Implementation	1/1/2021	31/12/2021	365																									

### **1.16.3. Funding and Implementation**

The OP must contain a budget estimate for the activities proposed. Approval of the OP must therefore be very closely linked with approval of the budget; otherwise the plan shall be for a proposed set of activities with no clear commitment for funding them.

In practical terms, authorized agency has overall responsibility for funding the activities in the OP as part of their role as a development corporation (Roles and Responsibilities). However, the proposed and agreed level of funding must be discussed and agreed during the FMU-level management committee meeting held to endorse the OP.

Although authorized agency shall fund the activities in the OP, this does not necessarily mean that they have complete responsibility for implementation. It is anticipated that activities with a significant commercial harvesting component shall be implemented by the authorized agency; while activities with a significant social or extension interest and monitoring and regulating activities shall be implemented by DFOs.

### **1.16.4. Types of Activity in the OP**

This list is not exhaustive. Different activities may be included if they are required to achieve certain management objectives, whilst all these activities are not needed in every OP. Within the plan all activities should be specific in site and time, and responsibilities should be clearly identified.

Nursery and regeneration activities

- Seed collection
- Nursery raising
- Plantation creation and establishment
- Plantation maintenance
- Natural regeneration management
- Protection of regeneration
- Maintenance of regeneration

#### **Silviculture**

Silvicultural prescriptions should be developed for each unit of management (i.e. compartment, sub-compartment or stand, as appropriate). These silvicultural prescriptions should be based on the specific requirements of each stand in accordance with stocking condition and development stage. Examples of specific operations to consider are:

2. Tending operations
3. Re-spacing operations (of established regeneration)
4. Thinning
5. Sanitation logging/Operation

#### **Harvesting and utilization**

- Operational inventory (to provide data for following year's harvest)
- Cable line survey and enumeration
- Commercial harvesting
- Rural use harvesting
- Regeneration survey

#### **Protection**

- Fire protection
- Protection from grazing
- Protection from illicit activities
- Pests and diseases



**Environmental and conservation**

- Soil and water conservation measures
- Erosion control

**Social and local use**

- Awareness raising and environmental education
- Extension activities e.g. tree planting on private lands
- Recreational use

**Research and monitoring**

- Research activities
- Monitoring (for any of the above activities)

**Administration**

- Staff and labour
- FMU-level management committee
- Participatory planning with local stakeholders (PRAs)
- Report preparation
- Licensing for local forest product collection (NWFPs)

**Infrastructure**

- Building construction and maintenance
- Road construction and maintenance
- Vehicle purchase and maintenance

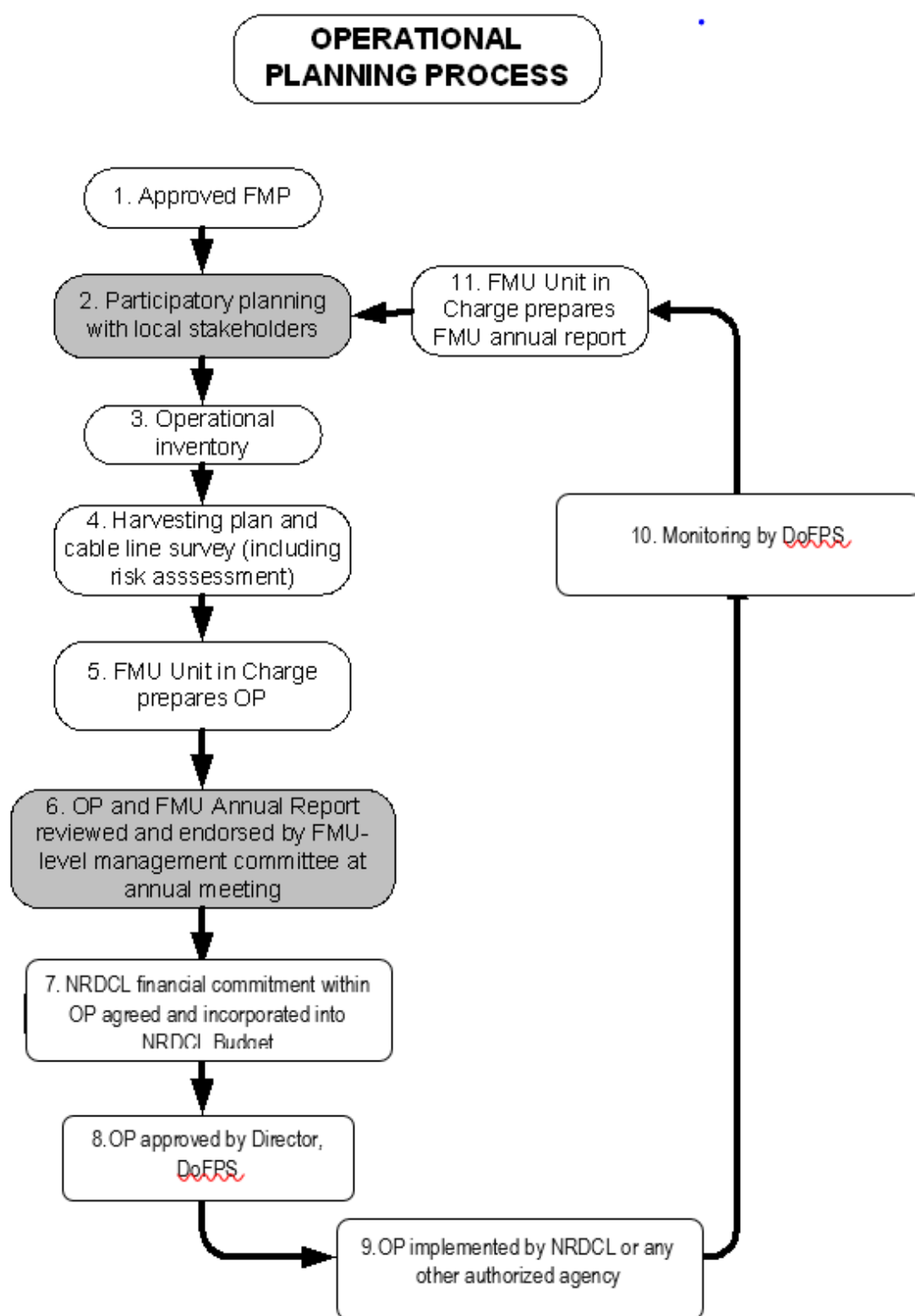


Figure 1.10 Operational planning process flowchart

Table 1.58 Operational planning and implementation process

Activity (Planning Step)	Objective	Output	Responsibility (lead)	Comments
1. Operational inventory	To assess the resource availability for the planned harvesting area  Calculation of the harvestable volume	Site-level inventory data for operational area to be harvested  Precise estimate of volume to be removed during the coming year.	CFO/UIC	For the areas proposed for harvesting during the next two years  May be combined with harvesting plan and cable line survey
2. Harvesting plan and cable line survey	To plan for harvesting and timber extraction activities	Agreed extraction plan	CFO/UIC	Cable line survey may be combined with Operational inventory of the identified harvesting area
3. Preparation of operational plan	To prepare a costed plan for implementation during the next two years (involving stakeholder participation for some activities)  To formalise local institutional responsibility for planned activities (e.g. grazing, fire management, rural timber distribution)	Approved operational plan with budget  Identified responsibilities for each planned activity  Calculated costs for each planned activities	FMU Unit in Charge with local stakeholders as required	Activities must be linked with objectives identified in the FMP and following options and guidelines in the FMP  Each activity with identified responsibility for implementation, estimated cost, and site-specific location  OP prepared according to standard formats
4. OP and FMU Annual Report reviewed and endorsed by FMU-level management committee	To review, monitor and discuss progress in FMU management  To endorse the new OP (prior to approval by DoFPS)	OP endorsed by FMU-level management committee	FMU Unit in Charge presents to the FMU-level management committee	During FMU-level management committee annual meeting
5. authorized agency financial commitment within OP agreed	To ensure that authorized agency is committed to funding the agreed activities in the OP To endorse expenditure estimates for the coming financial year	Budget estimates for the OP endorsed by authorized agency and FMU-level management committee	FMU-level management committee	Meeting needs to take place by October to ensure that budget requirements can be included in the authorized agency annual budget for the next financial year

6. OP approved by Head of Department of Forests and Park Services	To approve the OP for implementation	Approved plan and budget	CFO, FRMD and Director, DoFPS	OP approval linked with sanctioned budget for all planned activities
7. OP implementation by authorized agency and others	To carry out planned activities	All planned FMU activities carried out successfully	According to responsibilities identified in the operational plan	Each activity with a specific responsibility and budget
8. Monitoring of activities	To assess the level of achievement of planned activities	Information for FMU annual monitoring report	FRMD/FMU Unit in Charge	FRMD/DoFPS responsibility is to monitor the implementation of activities carried out by authorized agency. Monitoring also has a cost which needs to appear in the OP
9. FMU Unit in Charge prepares annual FMU monitoring report	To review progress with FMU management and identify and address any implementation problems  To identify any future actions necessary based on the arising issues	Annual FMU Monitoring report	FRMD/FMU Unit in Charge	Prepared annually  Progress is reported against each FMP objective and the associated activities Implementation problems need to be highlighted in the report so that they can be addressed during the next OP

### **1.11.5 Operational Planning Process**

#### **Step 1. Operational inventory**

An operational inventory is an intensive assessment of a relatively small area. The information produced is primarily intended for use in short term “operational” planning, e.g. related to the harvesting of timber volumes within compartments. For the purpose of implementation of any management plan, operational inventory provides required data and information for operational planning.

##### **Objectives**

The main objective of OP is to:

- assess the resource availability for the planned harvesting area; and
- calculate harvestable volume for the year (AAC)

##### **Output**

A precise estimate of volume to be removed during the coming year from a specifically defined harvesting area or block (identified in the FMP).

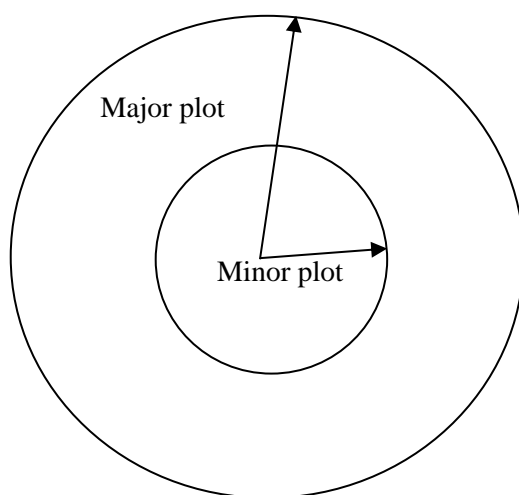
##### **Methodology**

Based on the prescription of the management plan, the FMU area has to be stratified in to production, protection and non-production management working circle. The operational inventory is conducted in the production management circle to estimate the growing stock for particular calendar year. From the past experience, operational inventory should be conducted in 50-200 ha of forest where the harvesting of the timber is prescribed in the management plan.

Although, OP inventory shall be carried out in the production management circle only, under the existing condition and considering the overlapping boundaries of the management circles, it shall be difficult to clearly demarcate the boundaries for survey. Therefore, after generating the systematic sampling grid, all plots falling in the non-production and protection zone shall be not me enumerated. However, the sampling intensity minimum of 50 plots or at least 2% of area should be sampled during each operational inventory.

##### **Plot Design and size**

Each Inventory plot shall consist of two concentric fixed size circular plots viz, major plot and minor plot of 12.62 m and 5.64 m radius respectively. The trees with dbh>30 cm shall be enumerated in the major plot while trees with dbh10-29 cm shall be enumerated in the minor plot.



*Figure 1.11 Plot Design*

<b>Plots</b>	<b>radius (m)</b>	<b>area (m<sup>2</sup>)</b>	<b>area (ha)</b>	<b>dbh</b>
Minor	5.64	40	0.004	10-29 cm
Major	12.62	500	0.05	> 30 cm dbh

All trees with dbh  $\geq 10$  cm shall be enumerated and compiled in Operational Plan Tally sheet (Table 1.59) by species and by diameter class.



Table 1.59 Operation Inventory: Tally Sheet

OPERATIONAL INVENTORY: TALLY SHEET																																																																											
		Plot Identification																																																																									
1. inventory unit	.....	5. date	<table><tr><td></td><td></td><td>/</td><td></td><td>/</td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>			/		/																																																																			
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2. plot number	<table><tr><td></td><td></td><td></td><td></td></tr></table>					6. altitude (m)	<table><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr></table>																																																																				
3. sheet number	<table><tr><td></td></tr></table>		7. land use type	<table><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr></table>																																																																							
4. crew leader	.....	8. canopy height (m)	.....																																																																								
If plot not accessible, or LUT no natural forest/tall bamboo: stop recording here		9. canopy closure (%)	.....																																																																								
Trees 10+ cm dbh		10. accessible?	(Y) (N) (if not, remark)																																																																								
(dbh 30+ cm on major plot, r < 12.62 m; dbh 10-29 cm on minor plot, r < 5.64 m)																																																																											
species	dbh	ht																																																																									
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12. general remarks																																																																											

**Data Analysis**

Operational inventory data shall be analysed using Table 1.60 Compilation sheet Table 1.61, Table 1.62 and Table 1.63.

Table 1.60 Compilation sheet

<b>OPERATIONAL INVENTORY: COMPILATION SHEET (FIXED-SIZE PLOT)</b>									
1. inventory area	:	4. species group							
2. stratum	:	5. volume table							
3. nr of plots	:	6. Table Class							
<i>col1</i>	<i>col2</i>	<i>col3</i> (3 decimals)	<i>col4</i> (3 decimals)	<i>col5</i> (3 decimals)	<i>col6</i> (0 decimals)	<i>col7</i> (2 decimals)	<i>col8</i> (2 decimals)	<i>col9</i> (2 decimals)	
dbh class (cm)	class basal area (m2)	class volume (m3)	plot size (ha)	expansion factor	tally	nrha (stems/ha)	basha (m2/ha)	volha (m3/ha)	
10 --19	0.017								
20-29	0.047								
30-39	0.093								
40-49	0.156								
					sum for all dbh classes				
Explanation		Col6: Count, and fill in							
Col3: look up in volume table, for given species group and dbh class		Col7: : col5 * col6							
Col4: : plot size for given dbh class		Col8: : col7 * col2							
Col5: : ( 1 / col4) / (nr. of plots)		Col9: : col7 * col3							
(when rounding: round to the nearest EVEN digit; e.g. 0.635 to 0.64 but 0.665 to 0.66)									

Table 1.61 Example of stand and stock table sheet 1 -No. of trees for conifer

STAND & STOCK TABLE SHEET 1 - NUMBER OF TREES												
1. inventory area	Tangzam/II											
2. stratum	Mix conifer											
3. nr. of sampling units	37											
4. estimated parameter	: Average Number of Trees per Ha											
	(report all values to 2 decimals)											
	Dbh class (cm)											
Species group	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	120+
Hemlock												
Fir												
Spruce												
Juniper												
total conifer												
Acer												
Betula												
Others												
total broadleaf												
total all species												
%												

Table 1.62 Example of stand and stock table sheet 1 -Basal area for conifer

STAND & STOCK TABLE SHEET 2 - BASAL AREA												
1. inventory area	Tangzam/II											
2. stratum	Mix conifer											
3. nr. of sampling units	37											
4. estimated parameter	: Average Basal area per ha (m <sup>2</sup> / ha)											
	(report all values to 2 decimals)											
	Dbh class (cm)											
Species group	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	120+
Hemlock												
Fir												
Spruce												
Juniper												
total conifer												
Acer												
Betula												
Others												
total broadleaf												
total all species												
%												

Table 1.63 Example of stand and stock table sheet 3 -Volume for conifer

STAND & STOCK TABLE SHEET 3 - VOLUME														
1. inventory area	Tangzam/II													
2. stratum	Mix conifer													
3. nr. of sampling units	37													
4. estimated parameter	: Average Volume per ha (m <sup>3</sup> / ha)													
(report all values to 2 decimals)														
Dbh class (cm)														
Species group	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	120+	total	%
Hemlock														
Fir														
Spruce														
Juniper														
total conifer														
Acer														
Betula														
Others														
total broadleaf														
total all species														
%														

## **Step 2. Harvesting plan and cable line survey**

### **Objective**

- To plan for harvesting and extraction activities.
- To estimate the approximate volume of timber that can be extracted from a cable line.
- To generate a cable line map showing the identified harvesting area with planned cable lines.

### **Outputs**

- Agreed extraction plan for the identified harvesting area
- Volume of timber in standing form that can be extracted from each cable line.
- Cable line map showing cable lines and harvesting area

### **Lead responsibility**

Authorized agency and DFO

### **Description of activities**

The survey takes place within the selected identified harvesting area for the year (identified in the FMP), and it may be combined with operational inventory. Within the area allocated for harvesting, the layout of the cable lines and extraction routes needs to be planned and agreed in advance.

- To ensure that as much of the identified harvesting area as possible is reached (and therefore as much of the available volume can be extracted). This can be done through extending the cable line length to the maximum length possible for extraction of available timber stock from a cable line.
- To ensure that environmental standards and guidelines are being followed.
- To maximize the economic efficiency of the harvesting operations.
- To ensure that safety standards are being applied.

A harvesting plan and cable line survey would involve the production of a cable line map showing the proposed cable lines and extraction routes as well as a description of the operations.

## **Step 3. Preparation of operational plan**

### **Objectives**

- To prepare a costed plan for implementation during the next two years (involving stakeholder participation for some activities)
- To formalize local institutional responsibility for planned activities (e.g. grazing, fire management, rural timber distribution)

### **Outputs**

- Approved operational plan with budget
- Identified responsibilities for each planned activity
- Calculated costs for each planned activity

### **Lead responsibility**

FMU Unit Incharge with local stakeholders as required

### **Description of actions**

The format of the operational plan should help to:

- (a) Ensure that operational activities are specifically related to management objectives specified in the FMP
- (b) Create a greater sense of accountability for both funding and implementing various activities



- (c) Improve and simplify annual reporting on OP activities (in the FMU annual report)

### **1.11.6 Operational plan format**

The recommended format includes six parts as indicated below:

- (a) Title and approval sheet
- (b) Review of Previous year's plan
- (c) Summary of current year activities Review of previous year's plan
- (d) Year 1 activities
- (e) Outline for year 2
- (f) Annexures

Figure 1.12 provides the general framework on the content of the operational plan for January 2018-December 2019 and the components are described briefly.

A. TITLE AND APPROVAL SHEET .....	
B. REVIEW OF THE PREVIOUS YEAR'S PLAN (January 2017 – September 30 <sup>th</sup> 2017).....	
B.1 FMU Annual Report Part 1- Review of activities.....	
B.2. FMU Annual Report Part 2 - Financial Report (2017) .....	
B.3 Past Inventory Status.....	
B.4. Review of past operations .....	
B.4.1 Review of standing volume and clear felled area from Cable lines for the previous year	
B.4.2 Review of standing volume and clear felled area from other activities for the previous	
year.....	
B.4.3 Review of Commercial AAC (area and volume).....	
B.5 Commercial Wood Products Supplied.....	
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Figure 1.12 OP format

## A. TITLE AND APPROVAL SHEET

### Period of Operational Plan:

While OP is for two year rolling plan, only first year of operation of OP is mentioned in the title and approval sheet. For example, rolling operational plan for the period January 2018-December 2019, the tile and approval sheet shall be mentioned “January 2018-December 2018.”

## B. REVIEW OF THE PREVIOUS YEAR’S PLAN (January 2017 – December 2017)

This section shall review the status of the activities planned and implemented during previous year.

**Note:** Plan year shall mean the year for which the plan is being made (eg: January- December 2018). Previous year shall mean the year for which the targets are being measured (January -December 2017).

### B.1 FMU Annual Report Part 1- Review of activities

Brief summary of the physical activities undertaken in the previous plan period. Details of the activities shall be accounted in the tables following it. All activities planned in the previous plan are mandatory to be reported. Target achieved shall be measured against the annual target set for the previous year

**Column 1 (Planned Activities):** List all planned activities that has been proposed in the previous OP (Table C)

**Column 2 (Objective):** Copy the objectives for each activity from table C of the previous year’s OP.

**Column 3 (Planned qty. or number):** This is the target set against each activity for the previous year which can be in numbers or quantity (Copy from the table c of last OP).

**Column 4 (No. or quantity achieved):** This is the achievement of the target set in the previous year. Write down the achievement.

**Column 5 (Comments):** An under or overachievement of the target should be justified in this column.

### B.2. FMU Annual Report Part 2 - Financial Report (2017)

This provides a brief summary of the financial achievement for the previous year. Actual expenditure against the estimated cost for all the activities must be mentioned for the previous year.

### B.3 Past Inventory Status

Block/Compartment	Year of inventory	Number of inventory conducted	Inventory Area (in ha)	Sampling Plots		Total area covered (in ha)	Net Commercial operable area of FMU (in ha)	Balance operable area (in ha)
				Total	Enumerated			
Helela/ I	2015	1	200	50	47	200	1000	800
Helela/ I	2016	1	200	50	50	400	1000	600
Helela/ I	2017	1	200	50	48	600	1000	400

- **Block/Compartment:** Mention Block/compartment name in which the inventory was conducted.
- **Year of inventory:** Mention the year in which the inventory was conducted.
- **Number of inventories conducted:** Mention the number of inventories conducted in that particular year.
- **Inventory area (in ha):** Mention the extend of area covered by the inventory.
- **Sampling plots:** This column is divided into two parts viz. total and enumerated. Under total mentioned the number of operational inventory plots planned initially. Under enumerated mention the number of operational inventory plots which were accessible and enumerated.
- **Total area covered (in ha):** Mention the total area covered during the inventory. In the subsequent year, these shall be the cumulative value of the actual area inventoried every year. Please refer the table above for clarity.

- **Net Commercial operable area of FMU (in ha):** This is the total commercial operable area of the FMU. This value must be derived from the Forest Management Plan of the FMU.
- **Balance operable area (in ha):** The balance operable area shall be the total operable area left after the inventory. This shall be (*Net Commercial operable area of FMU (in ha) - Total area covered (in ha) by the inventory*).

Please note that the information should be till previous year from the start of the plan. *If the plan period started from 2015, then the information should be from 2015 to 2017.*

#### B.4. Review of past operations

This section gives information on the details of timber and other forest produce extracted from the cable line and adhoc areas in the previous year. Please note that it is the information on the actual volume of timber extracted and not the initially planned.

##### B.4.1 Review of standing volume and clear cut area from Cable lines for the previous year.

This section shall give details of timber harvested in the previous year (2017) from cable line.

Block/ Compartment	Cable Line				Total clear felled area (ha)	Standing volume for each species							Total standing volume extracted (m <sup>3</sup> )
	No.	Length (m)	No of Groups/Area (ha)	Corridor Area (ha)		Blue pine (m <sup>3</sup> )	Hemlock (m <sup>3</sup> )	Spruce (m <sup>3</sup> )	Fir (m <sup>3</sup> )	Mixed Conifer (m <sup>3</sup> )	Chirpine (m <sup>3</sup> )	Broadleaf (m <sup>3</sup> )	
Helela/I	2017/1	1000	10/ 1.2	0.4	1.6	600	200		50	150			1000

- **Block/Compartment:** Mention Block/compartment in which the cable line is located
- **Cable line No:** Mention the cable line no (eg. 2017/1)
- **Length (m):** Mention the length of the cable line which was actually harvested. Generally, this should be the same length as was initially planned.
- **No of Groups/ Area(ha):** Mention the number of group openings created and the total area of the clear-felled area within the group. (eg.10/1.2 where 10 is the number of group openings and 1.2 is the total area of the clear-felled area in the groups in ha).
- **Corridor area (ha):** Mention the cable corridor area to be clear felled. Measure the cable corridor width and length. Compute the area using the formula for rectangular plots. For example, if the length and breadth of the cable corridor is 1000m and 8m respectively, then area is computed as 1000m x 8m/ 10000 = 0.8 ha).
- **Total Clear felled area (ha):** This is the sum of group opening area and cable corridor area. (eg. 1.2 + 0.8 = 2.0 ha)
- **Standing volume for each species (m<sup>3</sup>):** Details of standing volume harvested from the cable line in the previous year (eg: 2017). The name of the species shall however vary according to the species inventoried or found in the respective FMU.
- **Total Standing volume (m<sup>3</sup>):** Accounts for the total standing volume extracted from each cable line (Summation of the standing volume extracted from each species).

##### B.4.2 Review of standing volume and clear felled area from other activities for the previous year.

This section shall give details of timber harvested from areas apart from the cable line and includes other activities like farm road constructions, transmission lines in the previous year, etc. (2017).

B.4.2 Review of standing volume and clear felled area from other activities for the previous year.

Block/ Compartment	Activities	Clear Felled Area (Ha)	Standing volume for each species							Total standing volume extracted (m <sup>3</sup> )
			Blue pine (m <sup>3</sup> )	Hemlock (m <sup>3</sup> )	Spruce (m <sup>3</sup> )	Fir (m <sup>3</sup> )	Mixed Conifer (m <sup>3</sup> )	Chirpine (m <sup>3</sup> )	Broadleaf (m <sup>3</sup> )	
	Road									
	Transmission line									
	Sanitation									
	Others									

- **Block/ Compartment:** Mention Block/compartment name in which the activities were carried out.
- **Activities:** Mention the type of adhoc activities carried out (Eg. Farm road construction, transmission line etc.,)
- **Clear felled area(ha):** Mention the clear-felled area for the activities. For example, in case of farm road if the length is 1km (1000m) and the width is 4 m, the total clear-felled area shall be 0.4 ha (1000 x 4/10000 = 0.4 ha).
- **Standing volume for each species:** Details of standing volume harvested from other activities in the previous year (eg: 2017). The name of the species shall however vary according to the species inventoried or found in the respective FMU.
- **Total standing volume (m<sup>3</sup>):** Accounts for the total standing volume extracted adhoc activities (Summation of the standing volume extracted for each species).

#### B.4.3 Review of Commercial AAC (area and volume)

This section is the review of the commercial AAC both in terms of area and volume from the start of the management plan period till the previous year. If the management plan period is from 2015, then these shall account from the year 2015 till 2017 for operational planning in 2018.

Year	Block/ compartment	Total cable lines (Nos.)	AAC Area (ha)				AAC Volume (m³)					
			AAC area/Clear cut equivalent	Cable Coupe operated area	Other operated area	Total Operated area	Balance area	AAC Vol.	Standing vol. extracted from Cable line	Standing Vol. extracted from other	Total standing vol. extracted	Balance Vol.
2015	Helela/1	10	11.6	0.8	1.2	2	9.6	3600	2000	400	2400	1200
2016	Helela/2	8	11.6	0.7	0.5	1.2	10.4	3600	2500	300	2800	800
2017	1. Helela/3 (CL) 2. Helela/4 (Other)	7	11.6	1.6	0.5	2.1	9.5	3600	1000	550	1550	2050

**Year:** This is the year of FMU operation.

**Block/ Compartment:** This is the name of the Block and Compartment where the operation has taken place.

**Total Cable line no:** This is the number of cable line operated in the operation year. After this the table is divided into two sections as **AAC area** and **AAC volume**.

**AAC area (ha):** This is the Clear-cut equivalent area of the FMU in terms of Commercial AAC. It is calculated by using the formula as follows.

*Clear cut equivalent area (ha) = Commercial AAC (m<sup>3</sup>/year) /standing volume (m<sup>3</sup>/ha)*

*Eg. In case of Changang FMU the total Commercial AAC is 1800 m<sup>3</sup>/yr and the RME volume per hectare is 150 m<sup>3</sup>/ha.*

*Therefore, the clearcut equivalent area is= 1800/150= 11.6 ha*



The Commercial AAC and volume per hectare must be derived from Forest Management Plan of the FMU.

- **Cable Coupe operated area (ha):** This is the total clear felled area in the cable lines and groups operated in a particular year. This information can be derived from section B.4.1 of the OPs.
- **Other operated area (Roads, transmission lines, etc.) (ha):** This is the total clear-felled area due to other planned and adhoc activities such as road, transmission lines, sanitation area. This information can be derived from section B.4.2 of the OPs.
- **Total Operated area (ha):** This accounts for the total area felled for harvesting in the plan period for the particular year and is the sum of cable coupe operated area and the adhoc operated areas.
  - ✓ Total operable area (ha) = Cable Coupe operated area (ha) + Adhoc activities Others operated area (Roads, transmission lines, etc.).
- **Balance AAC Area (ha):** This is the Balance AAC area of the FMU for each year. This can be calculated by subtracting *Total Operated area* from the *AAC area (ha)*.  

$$\text{Balance AAC Area (ha)} = \text{AAC area (ha)} - \text{Total Operated area (ha)}$$
 This can be positive or negative depending on the excess /less area operated.

❖ AAC Volume ( $m^3$ ):

- **AAC Vol ( $m^3$ ):** This is the overall AAC of the FMU in  $m^3$  which must be derived from the FMP.
- **Standing volume extracted from Cable line ( $m^3$ ):** This is the standing volume harvested from the cable lines and corridor in  $m^3$  in the previous year. This information can be derived from B.4.1.
- **Standing Volume extracted from adhoc activities ( $m^3$ ):** This is the Standing volume in  $m^3$  harvested from adhoc activities like road, transmission lines, sanitation area etc., This information can be derived from B.4.2
- **Total standing volume extracted ( $m^3$ ):** This accounts for the total standing volume extracted during the previous year.  $\text{Total standing vol. extracted (}m^3\text{)} = \text{Standing vol. Cable line (}m^3\text{)} + \text{Standing Vol. others (}m^3\text{)}$
- **Balance AAC Vol. ( $m^3$ ):** This is the balance volume calculated against the Commercial AAC of the FMU which is left post extraction of timber from cableline and adhoc activities annually.

$$\text{Balance AAC Vol. (}m^3\text{)} = \text{AAC volume of the FMU (}m^3\text{)} - \text{Total standing vol. extracted (}m^3\text{)}$$

This can be positive or negative depending on the overharvesting or under harvesting against the AAC.

## B.5 Commercial Wood Products Supplied

Year	Quantity harvested from PLANNED OP activities ( $m^3$ )					Quantity supplied from UNPLANNED activities ( $m^3$ )					Total standing volume harvested (a)+(b)	Remarks
	Standing volume harvested (a)	Log vol.	Fire-wood	Wood-chips	Others	Standing volume harvested (b)	Log vol.	Fire-wood	Wood-chips	Others		
2015	2400	1500	500	100	100	400	200	100		50	2800	
2016	2800	1400	600	200	300	300	100	50	50		3100	
2017	1550	1000	200	100	50	550	300	50	50		2100	

The section describes the details of wood produce supplied on commercial royalty from the start of the plan till the previous year. If the plan period starts from 2015, then these shall account for the commercial wood produced from 2015 till 2017 (previous year). The table is divided into two sections as follows:

- ❖ Quantity harvested from PLANNED OP activities ( $m^3$ )

This section highlights timber extracted from cable lines during the previous year (2017 in the current case). Any deviation from the plan should be justified in the “Remarks” column.

- **Standing volume harvested(a):** This is the standing volume of timber harvested from cable lines in respective year.
- **Log volume:** This is the log volume (m<sup>3</sup>) extracted from cable line in respective year.
- **Firewood:** This is the volume of firewood (m<sup>3</sup>) extracted from the cable line in respective year.
- **Woodchips:** This is the volume of woodchips (m<sup>3</sup>) extracted from the cable line in respective year.
- **Others:** This is the volume of any other wood products (m<sup>3</sup>) extracted from the cable line in respective year.

❖ Quantity supplied from UNPLANNED activities (m<sup>3</sup>)

This section highlights timber extracted from adhoc activities during the previous year (2017 in the current case). Any deviation from the plan should be justified in the “Remarks” column.

- **Standing volume harvested (a):** This is the standing volume (m<sup>3</sup>) of timber harvested from adhoc activities in respective year.
- **Log volume:** This is the log volume extracted(m<sup>3</sup>) from adhoc activities in respective year.
- **Firewood:** This is the volume of firewood (m<sup>3</sup>) extracted from adhoc activities in respective year.
- **Woodchips:** This is the volume of woodchips (m<sup>3</sup>) extracted from adhoc activities in respective year.
- **Others:** This is the volume of any other wood products (m<sup>3</sup>) extracted from adhoc activities in respective year.

## B.6. Plantation (Afforestation and Reforestation)

This section accounts for the afforestation and reforestation activities taken in the FMU. It starts from the start of the plan year till the previous year (in this case 2017).

### B.6.1. Review of Plantation

Year of assessment	Block/Compartment	Cable Line No	Geo-coordinates	Year of Plantation	Plantation area planned(ha)	Plantation area implemented (ha)	Plantation Survival Percentage	Remarks
2015	Helela/1	2011/1 & 2	N.....E.....	2014	4	3.5	40	
2016	Helela/1	2012/3 & 4	N.....E.....	2015	3	3	40	
2017	Helela/1	2013/ 5& 6	N.....E.....	2016	3.5	3.5	35	

- **Year of assessment:** Year in which the plantation was assessed.
- **Block/Compartment:** Name of the Block/ Compartment where the plantation was carried out.
- **Cable Line No:** Cable line no in which the plantation was carried out.
- **Geo-Coordinates:** Geo-coordinates of the centre of the location of plantation area. The plantation area should be mapped and Shapefile /kml should be submitted.
- **Year of Plantation:** Year when the plantation was carried out.
- **Plantation Area Planned (ha):** Area of plantation planned in a particular year.
- **Plantation Area implemented (ha):** Area in which the actual plantation was carried out.
- **Plantation survival percentage:** Plantation survival % assessed.
- **Remarks:** Any comments and remarks to be entered here regarding over or underachievement of the targets.

The assessment of the plantation must be carried out as per the guidelines developed by SFED.

## B.6.2 Review of Natural Regeneration Survey

Year of Regeneration survey	Block/Compartment	Cable Line No	Planned area (ha)	Area surveyed (ha)	Seedlings/Ha		Remarks (adequate, doubtful, need to plant)
					Section (Corridor)	Group	
2015	Helela/1	2012/1	2	2	1500	1300	need to plant
2016	Helela/1	2012/2	2	2	1800	2000	doubtful
2017	Helela/1	2012/3	3	3	2500	2400	adequate

Details of Natural Regeneration survey report should be attached as annexure.

- **Year of Regeneration Survey:** Year in which the regeneration survey was carried out.
- **Block/Compartment No:** Name of the Block/Compartment in which the survey was carried out.
- **Cable line No:** Cable line no in which the survey was carried out.
- **Planned area (ha):** Planned area of regeneration survey in hectares
- **Area surveyed (ha):** Actual area surveyed against the planned area.
- **Seedlings/ha in Section (corridor):** Number of seedlings/ha in cable corridor area.
- **Seedlings/ha in Group openings:** Number of seedlings/ha in Group openings
- **Remarks:** In this “remarks” column, mention the status as adequate, doubtful or need planting

Refer the Regeneration survey guidelines for details.

## B.7 Road Construction

Block/Compartment	Year of construction	Road planned (km)	Road implemented (km)	Area cleared (Ha)	Standing Volume extracted (m <sup>3</sup> )	Remarks
Helela/1	2015	2	1.5	0.8	1000	
Helela/1	2016	0	0	0	0	
Helela/1	2017	3	3	1.2	1500	

Details of area cleared for road construction for the start of the plan till the previous year. If the plan period is from 2015, then, these shall account for the area cleared and volume extracted from the year 2015 till previous year (2017 in this case).

- **Block/Compartment:** Name of the Block/Compartment in which the road was constructed.
- **Year of Construction:** Year in which the road was constructed.
- **Road Planned (km):** Length of the planned road.
- **Road Implemented (km):** Actual length of road constructed
- **Area cleared (ha):** Area clear felled for right of way. For eg, if the length is 2 km with a width of 4 m, then the area clear felled is 0.8 ha (2000 x 4/10000).
- **Standing volume extracted (m<sup>3</sup>):** Standing volume harvested from the road construction.
- **Remarks:** Any remarks to be mentioned here.

Please note that the Map for new road construction and other activities should be annexed

## B.8. Non-Wood Forest Produce Supply

This section highlights the extraction of NWFPs from the FMU from the start of the plan to the previous year.

Year	Product Types							
	Bamboo (No.)	Sand (TL)	Top Soil (TL)	Stone/ Boulders (TL)	Gravel (TL)	Leaf Mould/ Litters (TL)	Mushroom (Kg)	..... (Unit)
2015	1000	20		50				
2016	2000	100						
2017	10000	0						

Under this section mention the quantity of different types of NWFP supplied in a year.

\*Please add additional columns for NWFP not listed above.

## B.9. Rural Timber Supply

This section highlights the extraction of rural timber from the FMU.

### B.9.1 Review of Rural AAC (volume)

Block/ compartment	Year of operation	Rural AAC (m <sup>3</sup> )		Total Standing volume supplied (m <sup>3</sup> )	Balance Rural AAC of the FMU (m <sup>3</sup> )
		Management Plan	Operational Plan		
Helela/1	2015	1000	1000	700	300
Helela/1	2016	1000	900	1300	-300
Helela/1	2017	1000	800	500	500

Review of the rural AAC (volume) for the start of the plan till the previous year. If the plan period is from 2015, then, these shall account for the rural AAC from the year 2015 till 2017. It is cumulative.

- **Block/Compartment:** Name of the Block/Compartment from which the rural timber was supplied.
- **Year of operation:** Year of operation.
- **Rural AAC (m<sup>3</sup>)**
  - (i) **Management Plan:** The rural AAC as per the management plan.
  - (ii) **Operational Plan:** The annual planned target for supply of rural timber.
- **Total standing volume supplied (m<sup>3</sup>):** This is the total rural timber supplied in standing volume.
- **Balance Rural AAC of the FMU (m<sup>3</sup>):** This is the balance volume calculated against the Rural AAC of the FMU which is left post extraction of rural timber annually.

*Balance Rural AAC Vol. (m<sup>3</sup>) = Rural AAC (m<sup>3</sup>) (Management Plan) of the FMU - Total standing vol. supplied (m<sup>3</sup>)*

## B.9.2 Rural Wood Products supplied

Year	Quantity supplied in standing form (m3)												Total standing volume supplied (m³)	Remarks
	Drashing		Cham		Tsim		Dangchung/poles		Fencing post		Fire-wood			
	No	vol	No	vol	No	vol	No	vol	No	vol	No	vol		
2015	20	26												
2016	30	39												
2017	10	13												

Details of wood produce supplied on rural purpose for the start of the plan till the previous year. If the plan period is from 2015, then, these shall account for the rural wood produced the year 2015 till 2017.

- **Year:** Year of rural timber supplied (eg.2015)
- **Quantity supplied in standing form:** Total quantity of timber supplied in standing form for different produce type; Drashing, Cham, Tsim, Dangchung, Fencing post and Fire wood.
  - **No.:** Number of the produce supplied (eg. 20 Drashing)
  - **Vol:** Corresponding standing volume for the produce supplied (Refer Volume Table)
  - **log vol:** Quantity of log volume from standing volume supplied (No log volume for Tsim, Dangchung, Firewood)
  - **Total standing volume supplied (m<sup>3</sup>):** Summation of total standing volume (m<sup>3</sup>) of all the forest produce supplied. Any over or underachievement shall be described in “Remarks”.

## C. SUMMARY OF ACTIVITIES

This section shall describe briefly the activities that has been planned for the plan year (2018 in this case). Details of the activities shall be accounted in the tables following it. Physical and financial target for the plan period are set and this shall remain as a benchmark against which the target shall be assessed the following year. (Refer REVIEW OF THE PREVIOUS YEAR’S PLAN (January 2017 – December 2017)).

Activity	Objective	Planned Qty. or Nos.	Responsibility for implementation	Responsibility for funding	Total cost of activity (Nu.)
1. Commercial Harvesting	To manage production area and meet commercial timber demand on sustainable basis as per the management plan.				
2. Rural Timber Supply	To manage production area and meet rural timber demand on sustainable basis as per the management plan.				
3. Regeneration Survey	To assess the regeneration status of the operated areas to know the requirement of plantation				
4. Plantation survival assessment	To assess the survival status of the plantation in the operated area				
5. Plantation creation	To supplement the natural regeneration				
6. Plantation maintenance	To ensure the successful establishment of plantation.				

**Column 1 (Activity):** Add activities that is being proposed for implementation in the plan period (Year 1). The activities defined here should be explained in the next column and should be in line with the management plan objectives. Note: The activities mentioned in the above table are mandatory for all the FMUs and additional activities may be defined as per the FMP. The activities might slightly vary according to the area and location of the FMU.

**Column 2 (Objective):** The objectives for each activity has been defined. This should be in line with the FMP.

**Column 3 (Planned qty. or number):** This is the Target set against each activity planned in the plan period (2018). This can be the total volume in m<sup>3</sup> (Commercial and rural harvesting) or area, numbers or others depending on the activity defined in column 1. These shall be the basis on which the OP shall be reviewed next year (Section B).

**Column 4 (Responsibility for implementation):** Designation/Position of the person responsible for implementing the activity should be mentioned (Eg: Unit Incharge or Production Incharge).

**Column 5 (Responsibility for funding):** Mention the organization responsible for funding of the respective activity.

**Column 6 (Estimated cost of activity):** Total estimated cost of the activity from costing done under Budget and sales.

#### **D. YEAR 1 ACTIVITIES.**

This section pertains to the details of each activities planned for the plan period as indicated in SUMMARY OF ACTIVITIES above. The following information should be provided for each activity.

1. **Activity:** Name of the activity. This should be in line with the name of activity listed in section C.
2. **Location:** Name of block of compartment or block in which the activity is being carried out.
3. **Justification for the activity:** Refer to the objective in Section C or the objective in the FMP.
4. **Proposed silviculture system and/or description of what is being proposed:** Description of the silviculture system prescribed in the FMP.
5. **Timing:** The time of the activity. It can be in a month, few months or throughout the year.
6. **Method of implementation:** Name of the implementing agency and details in implementing the activities.
7. **Details of any participatory process followed:** Explanation of any participatory approach conducted /done.
8. **Responsibility:** The agency/person responsible for making sure the activity is implemented on time.
9. **Additional information and comments:** Any additional information.

#### **E. OUT LINE FOR YEAR TWO**

This section highlights the brief outline of activities for year II. If the OP is from January 2018-December 2019, then this section shall consist of outline of activity for the 2<sup>nd</sup> year (January 2019-December 2019).

##### **A. ANNEXURES**

The following annexures should be included in the OP.

ANNEXURE I: Operational Inventory Tables

ANNEXURE II: Budget and Sales

ANNEXURE III: Cable line Map

ANNEXURE IV: Minutes of the FMU level Committee Meeting

ANNEXURE V : Regeneration Survey Report

ANNEXURE VI : Plantation Monitoring and Evaluation Report

ANNEXURE VII : Approval for Adhoc activities.



## 1.12 Implementation framework

### 1.12.1 Road construction

All road design, construction and maintenance in FMUs should be in accordance with the principles of environmentally friendly road construction and with NEC Regulations and sectoral guidelines. This section of the code presents guidelines on road construction and maintenance; these are largely derived from NEC (1999) and Dorji & Incoll (2001). A number of existing documents which are highly relevant to the design, construction and maintenance of forest roads including authorized authority/WWMP (2002), Visser (2001), Winkler (1999), Schaffner & Jimba (1999), RGoB/SNV (2002), Schaffner *et al* (2002) and Technical guidelines on farm road construction. These should be referred for further information.

The main consideration in all forest road building and maintenance is to ensure that roads properly shed water. A cambered profile and good roadside drainage with frequent culverts are therefore very important. A rutted flat surface shall hold water.

Main routes through FMUs benefit from reconstruction using excavator and vibration roller to provide a good cambered profile. Good construction shall not only reduce maintenance liability but also significantly improve the usability of the road.

#### **Road construction and maintenance; impact management recommendations**

The following is an adapted extract from National Environment Commission (1999), Forestry: Bhutanese environmental assessment sectoral guidelines. Forestry roads are complex engineering structures, the design, construction and maintenance of which can have significant impacts on the economics of forestry operations and on the local environment. They are almost always the most problematic features of forest harvesting operations, often causing more soil erosion and land instability than any other component of forestry operations.

Roads, because they also provide access to previously roadless areas, can also greatly increase levels of forest resource use, in particular firewood collection and domestic grazing.

Nevertheless, roads are essential part of the managed forest estate, both for timber extraction and to provide access for forest management and monitoring. The negative economic and environmental impacts of road access can be minimized by adherence to the following general principles and practices:

1. Trained engineers should be responsible for road design and location surveys, and should supervise road construction;
2. Keep roads and fill-slopes away from streams and outside riparian protection zones wherever possible;
3. Road lengths and density should be minimized (*optimised*), consistent with access requirements, so as to reduce erosion potential, deforestation and other environmental impacts, and to enhance access economics;
4. Design widths should be the minimum required for safety and access efficiency, so as to minimize the total area of disturbance (the maximum cleared width that can be justified for FMU access systems shall be 5-6 m);
5. Avoid areas of wet soils and high erosion risk areas so as to minimize construction and maintenance costs and the risk of environmental degradation;
6. Avoid excessive side-cast fill slopes on steep hillsides through the use of a hydraulic excavator and end-hauling of excavated material to a safe, stable storage area (*use cut and fill methods and identify safe dumping sites*).
7. Provide proper equipment for full compaction of the road foundation and allow the road to dry thoroughly before use;

8. Use roadside ditches and properly spaced cross-drains to channel water away from the road structure and onto adjacent stable, vegetated areas;
9. Estimates of size and spacing of culverts used for cross-drains should be based, wherever possible, on local rainfall and runoff information;
10. Where stream crossings are necessary, the crossing structure should be designed on the basis of a detailed site survey and disturbance to the watercourse minimized during construction;
11. Stabilize and revegetate cut and fill slopes with low growing (*fast growing*) shrubs, grasses and legumes as soon as possible after construction is completed, *adopt appropriate bioengineering measures*
12. Ensure proper maintenance of road surfaces, roadside ditches, cross-drains and stream crossings, and enforce road-use restrictions during critical weather conditions
13. Roads not required for permanent access should be "put to bed" by ripping the road surface and sowing of grass and legume mixes (*by adopting appropriate bioengineering works*)
14. Road location and design shall be subjected to environmental assessment as part of the forestry management plan preparation and review while construction, maintenance and abandonment shall be regulated by the application of codes-of-practice in operational contracts.
15. Carry out bioengineering works as appropriate.

For consistency and completeness, it is recommended that a comprehensive set of road engineering codes-of-practice be prepared by the authorized agency, covering the full scope of access development activities as follows:

1. Road location criteria, including operational, physical, environmental, and economic considerations, and procedures for route surveys;
2. Road design and construction standards, including maximum grades, formation and running surface widths, site preparation, bench cut and end-haul requirements, restrictions on waste spoiling, sub-grade and surface material specifications, stream crossing and surface drainage standards, equipment specifications, and timing;
3. Road maintenance standards, including grading, resurfacing, ditch and culvert maintenance, and revegetate and stabilization of cut/fill slopes and borrow areas;
4. Safe storage of fuels and lubricants, and environmentally appropriate means of disposal of used oils and grease (*safe handling/storage of blasting materials (explosives); see Blasting Manual and Rules on Explosives*)
5. Road shut-down indicators (weather or instability risk) and procedures
6. Road abandonment, stabilization and revegetation prescriptions; (rehabilitation/restoration of abandoned roads with bioengineering measures).
7. Road inspection (monitoring) frequencies and reporting requirements

### **1.12.2 Health and Safety**

#### **What is health and safety all about?**

Safety is about preventing people from being harmed at work. This is achieved by the workforce taking the right precautions and the employer providing a satisfactory working environment. Health and safety apply to all working environments, including offices as well as operational sites in the forest. However, the focus of this section of the code is on operations in the field.

Regulation on Occupational Health, Safety and Welfare developed by Department of Labour, Ministry of Labour and Human Resources shall be applicable for maintaining health and safety during forest operations in the FMUs.

This section of the code provides only a brief overview of terminology, roles and responsibilities and conducting of generic and site-specific risk assessment in relation to harvesting and planting operations. Refer to Bradshaw (2003) for comprehensive and detailed guidelines on health and safety in relation to forestry operations.

### **Roles and responsibilities**

Employers and employees must look at the intended workplace (i.e. the harvesting site) to identify all possible hazards. They must then try to minimize the risks of those hazards to the workforce and do **everything that is reasonable and practically possible**.

It is necessary to identify the responsibilities of DoFPS and authorized agency in the planning and implementation of work at a harvesting site. A chain of command must be in place for every worksite; this usually involves two tiers of management (Table 1.64).

*Table 1.64 Forest harvesting risk assessment roles and responsibilities*

<b>Management tier</b>	<b>Description</b>	<b>Key tasks</b>
DoFPS	The controller of the land on which the forestry work is taking place	<ul style="list-style-type: none"> <li>• Co-ordination of the activities of the overall forest environment for health and safety.</li> <li>• Gathering of information regarding hazards on and around the forest site and passing it on to the FWM.</li> <li>• Ensuring that the activities of a worksite do not affect the health and safety of other people.</li> </ul>
Authorised agency	The person who commissions work on a forestry site	<ul style="list-style-type: none"> <li>• Using the information given by the landowner prepare an outline risk assessment for work on the site.</li> <li>• Select competent contractors who have made adequate provision for health and safety.</li> <li>• Specifying the health and safety measures for contractors working on the site.</li> <li>• Liaise with the landowner.</li> <li>• Monitor health and safety on the site.</li> </ul>

It is necessary to produce a **generic risk assessment** for all harvesting operations, in all FMUs, prior to commencement. **DFO and authorized agency should conduct the generic risk assessment at an early stage of operational planning.** The authorized agency should implement outcome of the risk assessment potential exercise.

### **1.12.3 Allotment of Subsidized Timber and NWFP**

The Forest and Nature Conservation Rules and Regulations of Bhutan, 2017, define the legal basis for the supply of subsidised timber for rural house construction and for the supply of other forest produce in rural areas. Appropriate provisions of the Rules should be referred.

This section of the code includes guidelines in relation to rural allotment that aim to ensure that marking is undertaken that is consistent with the principles of sustainable forest management. It is essential that ad hoc and unplanned felling does not take place and that the AAC is not exceeded, nor timber harvested from areas where it has not been specifically allocated.

## **Silvicultural Considerations**

It is essential that all marking of standing tree for rural allotment is done in the rural block identified in the management plan, on single tree selection basis. The successful implementation of silvicultural systems depends, to a large extent, upon appropriate marking guidelines in place and being followed; refer to the code section on silvicultural marking guidelines.

Under no circumstances should the marking officer mark good quality, healthy trees in the stand if this is not consistent with good silvicultural practice. Marking should be done uniformly over the stand to provide enabling condition for improvement of the remaining stand.

After logging by authorized agency, marking for subsequent local use harvesting can further disrupt silvicultural systems. Not only does this harvesting threaten developing regeneration but it may also remove trees from the interlines and so compromise future passes (Whitfield, 2001). Therefore, harvesting of rural timber from interlines must be avoided.

## **Harvesting and utilization**

Manual extraction of timber should be closely supervised in order to ensure that extraction along water course does not take place and that repeated extraction along gullies does not lead to soil erosion. Stream buffers should be identified and no felling or extraction take place in or through them. Regeneration should be protected from manual extraction.

Sanitation of the harvested area should be ensured through efficient utilization of rural timber.

## **Non-wood forest products**

The allotment of non-wood forest products (NWFPs) should be done in accordance with the principles of sustainability; in particular harvest levels should be regulated so that future yields are not reduced. Surveys of NWFP should be undertaken and records kept of allotments. Volume V of the *Code* must be referred to for necessary guidance of sustainable harvesting of NWFPs. Silviculture Implementation Guideline

Section on silvicultural systems under this Chapter provides guidelines on the development of recommendations for silvicultural systems in FMUs; it is designed to help users exercise their professional judgement in developing site-specific management strategies and prescriptions in order to achieve forest management objectives.

This section provides practical guidance on silvicultural implementation; they should, however, be considered as indicative and be further developed and refined to suit specific objectives and local conditions.

Marking guidelines, providing practical guidance on the marking of trees to be harvested, are presented specific to silvicultural system and/or forest type. Notes on other aspects of implementation are also provided.

The marking guidelines are based on accepted silvicultural theory and field experience; they are derived from those presented by Slavicky (1992), Rai (1993), Statz & Wyrsh (1993), Dhital & Pushparajah (1994), Dorji & Chong (1998), Rosset & Rinchen (1999). All of these references are specific to the forests of Bhutan. Some guidelines have also been derived from Mathews (1999).

Ongoing research activities and the continuing accumulation of field experience shall result in the development and refinement of these guidelines over time.

The trees selected shall be marked with the authorized marking hammer close to ground level by Unit staff, and diameter measurements, along with estimated total tree height and tree species, shall be entered in the Marking Register. The volume of each tree shall be estimated using an appropriate Volume Table. The estimated number of logs to be cut shall be calculated and recorded in the Marking Register.

## **Lead Responsibility**

DFO takes the lead role in implementation of silvicultural guidelines.

### **1.12.4.1 Implementation of the Single-Tree Selection System**

#### **1.12.4.1.1 Marking guidelines for the single-tree selection system**

Thinning among the immature stems should be made along with felling of trees of exploitable size as a combined operation (see Box 1.12). Cleanings should also be done amongst the younger age classes as well as interventions to assist regeneration; these may include removal of raw humus, soil cultivation, and even direct seeding or planting in gaps caused by felling and other disturbances.

#### *Box 1.12 Thinning*

As well as removing trees of harvestable/exploitable size, it is necessary to provide for sustained yields by making thinning among the various age-classes to ensure that:

- these are maintained in their correct proportions
- a suitable mixture of species is maintained
- young saplings are freed from suppression
- defective stems are removed wherever they are hampering better ones

#### **1.12.4.1.2 Single-tree selection system; ensuring sustained yields**

Felling under the single-tree selection system should generally involve the removal of:

1. dead and dying trees
2. trees that are diseased misshapen, defective or lacking in vigor or of undesirable species, particularly if they are interfering with better stems or promising groups of young growth
3. trees of exploitable size, particularly if defective or lacking in vigor. Mature and over-mature trees over 50 cm DBH OB should be marked.

**NO MARKING OF TREES SHOULD BE DONE IN PROTECTION MANAGEMENT CIRCLE AND INTER-LINES (RURAL ALLOTMENT)**

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

1. Trees marked for harvesting shall be evenly distributed throughout the stand.
2. Diseased, malformed, dead and decaying trees shall be marked on a priority basis, especially where these are hampering better ones (unless objectives of biodiversity conservation dictate otherwise). These trees can be marked even if below the set diameter limit of 50 cm. However, care should be taken that no large openings are created in the stand by marking these trees.
3. Trees of exploitable size should be marked, particularly if defective or lacking in vigour; mature and over-mature trees over 50cm DBH OB to be marked.
4. No more than one fourth of the stand volume should be marked for harvesting.
5. In mixed stands, an even and suitable distribution of species should be left standing.
6. Where cable cranes are to be used, the extraction lines shall be as narrow as possible, and no wider than 3-4 meters.

## **1.12.4.2 Implementation of the Group Selection System**

### **1.12.4.2.1 Marking Guidelines for the Group Selection System**

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

1. The group selection system shall be used on suitable sites in the mixed conifers, spruce, spruce/pine and, to a lesser extent, in fir stands.
2. Small groups spaced at specified intervals shall be harvested removing all trees over 10cm DBH.
3. The groups shall be located along the extraction lines
4. The distance between the extraction lines shall be not less than 60 m (refer to Box 3 and Cable line and group layout).
5. The distance between the groups, along the extraction line, shall be not less than 50 m or more than 70 m.
6. The shape of the harvested groups can be irregular, according to the site and terrain conditions.
7. Existing openings in the stand having already established regeneration should be used as a nucleus for marking the groups.
8. Signs of existing windfall in the stand should form the basis of the opening. In such a case, opening boundaries should correspond to changes in soil moisture that is often the cause of the windfall.
9. Wind firm trees must surround the selection groups. This could be achieved by leaving intermediate height trees along the edge of the opening.
10. Trees falling along the extraction corridors shall be marked for harvesting
11. The extraction corridors must be 2-4 m.
12. The maximum size of the groups shall be on average less than 0.1 hectare in the fir stands and, less than 0.15 hectares in the mixed conifers, spruce, spruce/pine stands, depending on the site characteristics and stand condition.
13. Diseased, dead and malformed trees shall be marked on the priority basis and should be used as a nucleus for creating an opening.
14. Boundaries of openings should, where possible corresponds to changes in slope. An opening should not end in the middle of a steep slope since tree shall slide into the remaining stand during logging.
15. Care must be taken in choosing the boundary of the opening. Trees which can be expected to fall into the opening should be marked while trees leaning out of the proposed opening must be left standing so as to minimize damage to the remaining stand.
16. Trees damaged during harvesting shall be cut and removed in the subsequent cleaning operations.



*Box 1.13 Avoiding problems with implementation of the group selection system*

In order to ensure successful implementation of the group selection system it is essential that too much volume is not removed in the first pass to be consistent with the cutting cycles recommended in the management plan.

In the past, unrealistic AACs, exaggerated expectations of sustainable yield per hectare and lack of understanding of the systems have probably pressured operational staff in some cases to reduce or work on minimal spacing between cable lines and remove volume from *interlines* (the matrix between first pass lines); the long-term consequences is that future yields shall be lower than originally planned. In areas that were thought to be able to sustain say three consecutive passes, only one or two shall be possible and periods between passes may well be longer (Whitfield, 2001).

In some FMUs there has been a tendency to locate cable lines at wider spacing than prescribed in order to avoid relatively poorly stocked areas and to favour harvesting of better stocked areas. Again, the consequence of this is that future yields shall be lower than originally planned.

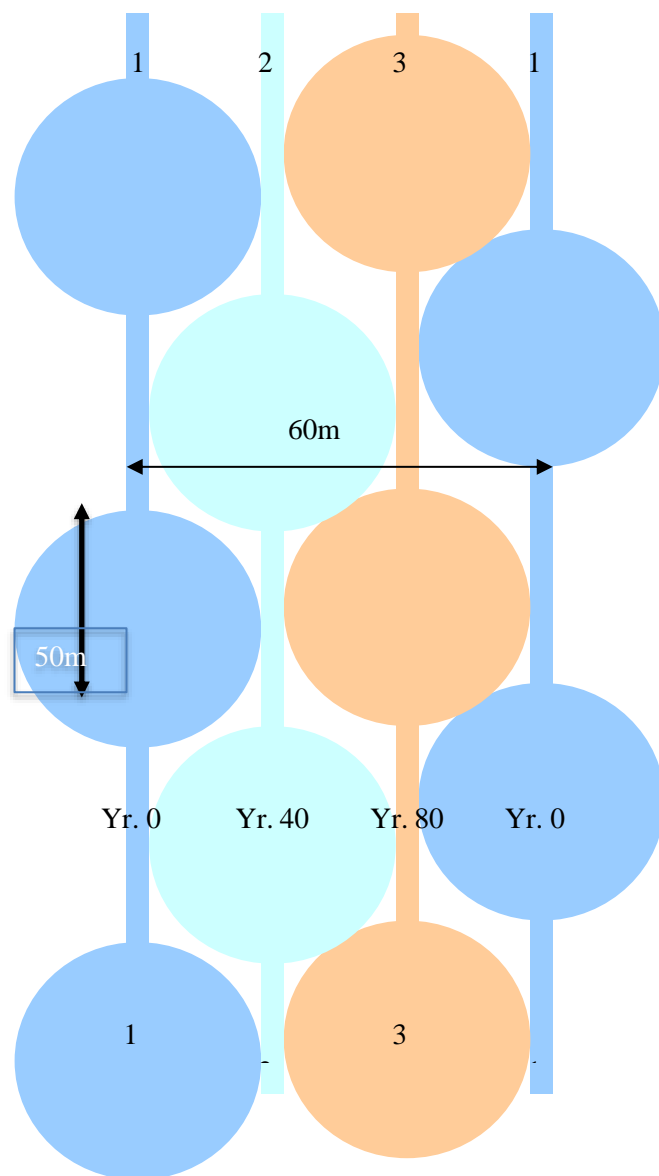
Both of these scenarios must be avoided; cable line positioning must be carefully and rigorously controlled and monitored.

#### **1.12.4.2.2 Cable line and Group Layout**

The approach of working to a minimum cable line spacing of 60m for the group selection system shall only work if matched with appropriate felling group sizes (Figure 1.16). If a total of three passes are intended and assuming roughly circular groups, an absolute minimum of 60m cable spacing should just work for 0.15 Ha groups. If, however 0.2 Ha groups (25m radius) are used then cable lines shall need to be a minimum of 75m apart to prevent subsequent cable lines running through old previously cut groups and damaging regeneration. Line spacing and group size then need to be carefully considered on a site-by-site basis and provide for a specific number of subsequent passes. One prescription shall not be appropriate everywhere.

In reality, systematic location of groups is almost impossible. The theoretical layout (Figure 1.13) shall never be a practical option in Bhutan's terrain. Even with well-planned initial lines and groups, further harvestable area shall therefore be lost due to less than optimal *fitting* of first and subsequent groups. This residual volume cannot be "swept up" in the final pass due to the damage it would do to regenerating areas. This loss of area is of course in addition to net operable area being reduced due to minor terrain features and blank areas.

These factors have not been taken account of in current AAC calculations and shall have a very significant impact on future sustainable cuts (Whitfield, 2001).



*Figure 1.13 Likely best-case layout for group selection with 60m initial cable space*

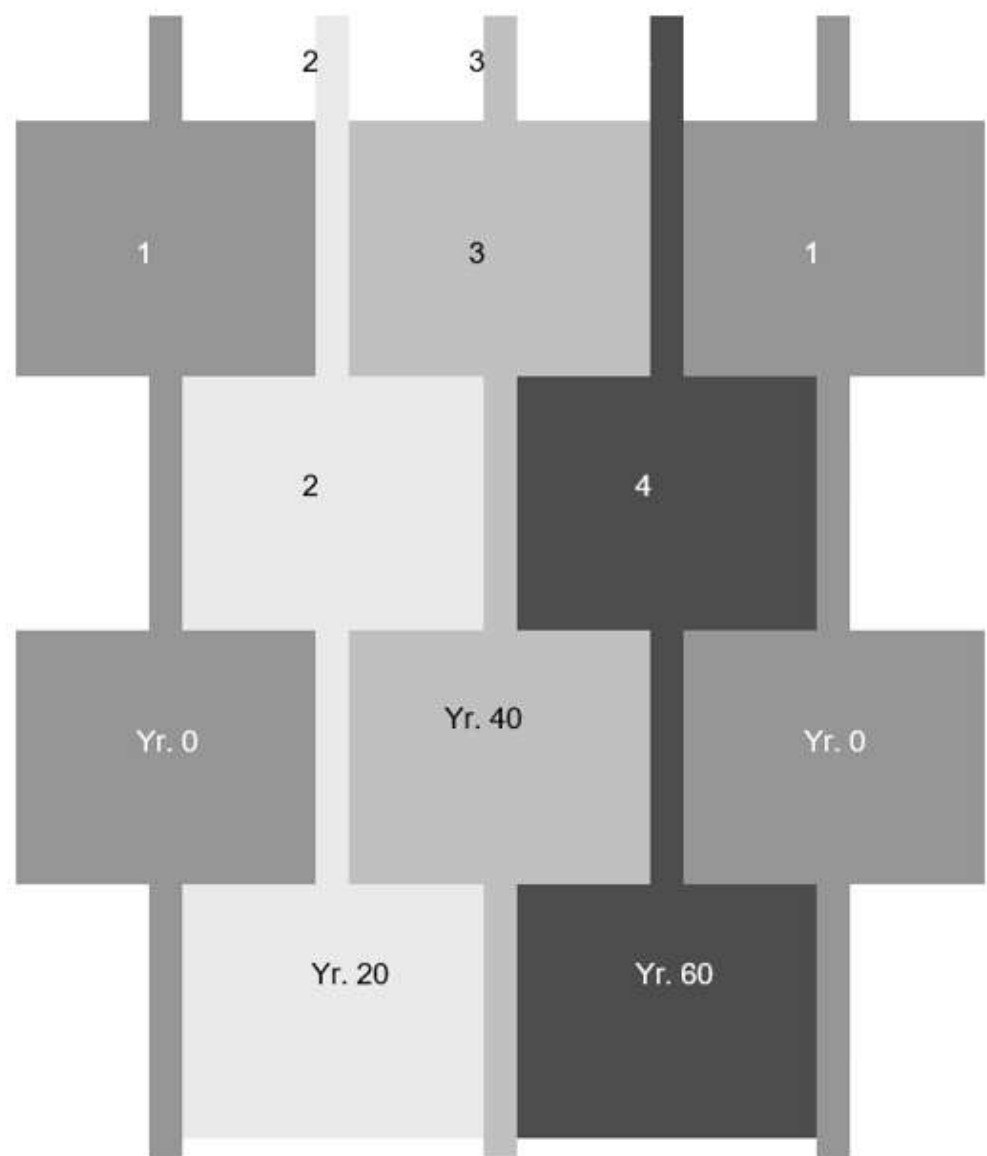


Figure 1.14 Theoretical model for square interlocking groups

#### **1.12.4.2.3 Conversion Period**

It is not necessarily appropriate for an over-mature stand to be fully restructured into a *normal* forest with equalized age structure from zero years to rotation age in the first rotation. The stand is not the unit of sustainability but (most probably) the FMU.

For a stand with a 120-year rotation, the entire mature stand could be removed and regeneration begun over a 60 year *conversion period*. In this case with three passes at 20-year intervals.

This approach may be particularly useful in stands where over mature volume is expected to degrade significantly. It does assume that at this rate of logging, there shall still be enough mature volume in the FMU to last until the immature or regenerating stands become available.

Compressed conversion periods shall have a greater environmental impact than extended ones. If, for example, all the operable mature timber in a stand is harvested over two passes 25 years apart, the ecological impact shall be quite significant and probably quite unacceptable for the majority of sites in Bhutan. This is a concern for areas where, due to inadequate initial line spacing, only one subsequent pass is now practically possible.

When planning prescriptions and operations, the conversion period adopted, the number of passes and therefore the cable line and group spacing, all need to reflect the site sensitivity. Less sensitive sites with degrading very over mature stands may require a shorter conversion period resulting in closer initial line spacing and higher removal per pass than more sensitive sites. Operations should move away from applying a standard line spacing and group size prescription across all sites. Planners need to write detailed guidance into the FMPs and operational staff at Territorial level need to be much more active in deciding and implementing specific prescriptions based on this guidance.

This is not difficult or complex work and field staff should be capable of adopting the approach with basic training and support (Whitfield, 2001).

#### **1.12.4.2.4 Other Silvicultural Impacts; Sanitation Felling**

Sanitation felling is an essential operation but one that can also limit the viability of future passes under group selection. When working a stand for a sanitation or salvage operation, it is essential to consider future normal passes and to lay out cable lines accordingly. It then makes sense for the cable lines to be a normal length and to carry out operations along that line in unaffected as well as beetle affected parts of the stand. Group salvage cuts often have to be larger than for normal working but consideration needs to be given to adhering as near as possible to the ideal group layout and again, cutting groups in the unaffected parts of the stand as well (Whitfield, 2001).

#### **1.12.4.2.5 Regeneration of harvested areas**

There is little doubt that most conifer forest types in most situations have good regeneration potential; however, a variety of factors limit success including:

- Grazing; a very significant problem. Sometimes over stated as the sole cause of regeneration failure but successive browsing can delay or totally prevent establishment, leading to other problems such as weed and brush growth.
- Protracted harvesting periods; the first few years following harvesting are critical for good establishment of regeneration. Long periods of residue removal causes disturbance to regeneration. All recoverable volume should be harvested by cable at the outset, an approach that makes good silvicultural sense.
- Weed and brush growth; a significant problem where effective establishment of regeneration has been delayed due to protracted harvesting, grazing, desiccation of seedlings etc. This is always a difficult and costly situation to remedy; prevention is easier than cure.

One of the most serious problems in achieving successful regeneration is delaying action when a weed and brush growth problem becomes apparent. As young brush, including bamboo, starts to develop around small regeneration (or even prior to harvesting), weeding and cleaning must be carried out promptly. If carried out at the right time, this can be far more cost effective and successful than waiting for the regeneration to be swamped by brush and then have to clear and replant. Not only is this going to be an expensive problem to correct but time has been lost. Harvesting in the interlines cannot proceed until regeneration of the first pass is complete and without prompt attention to threatened regeneration, subsequent passes shall be seriously delayed, the AAC may well have to be reduced and the economic sustainability of the FMU becomes doubtful.

There is a developing understanding by forest and authorized agency staff of the right size of openings to promote natural regeneration of various species and this knowledge is being supplemented by recent research. Hemlock can apparently cope with larger openings than Spruce and being light demanding, Blue pine regenerates well in even larger openings. In transition areas between one species zone and another, opening size may help target the desired species. It is vital that this silvicultural knowledge is utilized and implemented. Openings that are too large or too small for the target species can again lead to excessive weed and brush growth before regeneration can become established (Whitfield, 2001).

Some disturbance of the humus layer has been proven to be often quite important in stimulating regeneration. Providing that log dragging is unlikely to create significant channels for water and therefore cause erosion, some disturbance during harvesting is certainly beneficial to regeneration prospects.

Silvicultural expertise needs to be fed back into the management planning process and properly implemented.

### **1.12.4.3 Implementation of the seed tree system**

#### **1.12.4.3.1 Marking guidelines for Chir pine under the Seed Tree System**

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

1. Seed tree system shall be applied to Chir pine stands or mixed stands in which conifer is the predominant species both in numbers and special distribution.
2. The larger trees (DBH OB >30cm), with sound, well-developed crowns, should be selected as seed-bearers (seed trees) and should be spaced at about 15-20 trees per hectare (i.e. approx. 22 -26 metres apart). If no such trees are available smaller trees (more trees per hectare) should be retained.
3. Smaller trees and poles, if thinly scattered, should be felled to create blanks for regeneration. But well-stocked groups of promising stands should be left to form part of the future crop.
4. Well-established advanced growth of both saplings and poles should be completely freed from overhead cover.
5. This system shall not be applied to areas with heavy undergrowth of competing shrubs or herbaceous layer unless ground seedbed preparation is undertaken, prior to or soon after the felling operation.
6. This system should not be applied to stands on steep and over-exposed slopes or on south facing slopes. In the case of gentle south facing slopes, the cable lines may be oriented southwest with corresponding reduction in corridor width to reduce over-exposure to sunlight. On hot aspects it may be advisable to leave considerably more trees per hectare of the felling may be made in strips or in comparatively small groups.
7. In mixed stands with a predominance of Chir pine, silvicultural treatment shall favour the regeneration of pines.
8. Slope condition, wind firmness of surrounding and retained seed-bearers as well as the visual stand value shall be considered whilst using the system.
9. Diseased, malformed, dying, non-wind firm and fire/resin-tap damage stems shall be cut on a priority basis.

10. Retained seed bearers should have a complete canopy, capable of bearing viable cones, disease-free, wind firm and reasonable form.
11. Retained stems should not be the oldest or tallest in the stand. Over-mature trees should be felled on a priority basis.
12. The configuration of the area selected for felling under this system may be irregular in shape.
13. Maximum size of a contiguous area harvested should not exceed one hectare in extent.
14. Advanced growth should be retained and protected where possible during felling.
15. No logs that have not been debarked and lops and tops should be retained; to avoid bark beetle infestation or build-up of fungal infection.
16. No resin tapping shall be permitted on retained seed bearers, which shall be marked prior to felling.

#### **1.12.4.3.2 Marking guidelines for blue pine under the seed tree system**

1. The seed tree system is used in pure pine stands or mixed stands consisting of mixture of pine and spruce with pine predominating.
2. The seed tree system shall be used in the above stands only on suitable sites.
3. The system shall not be used on steep and exposed, south or south west sites
4. In mixed stands an equal distribution of pine and spruce shall be left standing.
5. Slope characteristics, wind firmness and aesthetic values shall be considered.
6. About 20 to 25 trees per hectare (i.e. approx. 22 metres apart) shall be left standing.
7. Diseased, dead, dying and malformed trees shall be cut on priority basis.
8. Trees left standing shall be of good health and form to ascertain good seed source.
9. Trees left standing shall not be the oldest or tallest in the stand. Over mature trees shall be cut on priority basis.
10. The shape of the area chosen for the seed tree system can be irregular.
11. Maximum size of a contiguous area harvested using this system should not exceed one hectare.
12. Gap between two seed tree selection system are should be twice the area of the contiguous area???

#### **1.12.4.4 Implementation of Clear-felling Systems**

##### **1.12.4.4.1 Marking Guidelines for Patch Clear-felling**

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

1. Create several patch or group openings along a line totaling 2-3 Ha per sub-coupe (including sky-line corridor), and with each opening separated by patch of intact forest (of at least 10-20m)
2. The direction of the tree lean, and topography has to be taken into account to prevent large trees being felled on nearby advanced growth,
3. Dead or dying trees or those showing symptoms of decay or damage (snags, scars, conk, etc.) shall be retained in between patches, and in the interline spaces, to safeguard floral and faunal niches or habitats,
4. The totally protected *Taxus baccata* (Yew) shall not be marked for felling under any circumstance and all species listed for protection under the existing Forest and Nature Conservation Act must also be protected if encountered.

*Box 1.14 A note on protected species in harvest areas*

Protected species as listed under Schedule 1 of the existing Forest and Nature Conservation Act should not be felled or cleared during harvesting operations. Patch clear fell and group felling should be done in such a way as to avoid damage to or death of such protected species.



### **1.12.4.5 Implementation of Thinning Operations**

#### **1.12.4.5.1 Marking Guidelines for Thinning**

The objective of thinning is to increase growth and quality of stands and at the same time provide small dimension. Healthy, vigorous trees shall be released by cutting suppressed, diseased and malformed trees.

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

1. The stands for thinning shall be identified from the forest type maps and verified in the field.
2. The stands identified for thinning, if falling within the harvestable limits of cable cranes, shall be subjected to thinning.
3. Observation and monitoring of dwarf mistletoe infestation on blue pine; trees infected with mistletoe should be given first priority for felling. Complete burning of mistletoe infested branches is needed.
4. Mark for thinning 20% of standing volume
5. Marking of trees for thinning shall depend on the number of stems per hectare, age or size class, and the spatial distribution.
6. Only low thinning shall be done in most of the stands, where only dead, dying, suppressed, diseased and defective trees shall be marked first.
7. In stands less than 10 m average height the target spacing should be approx. 4.5m x 4.5 m or about 500 trees per hectare.
8. In stands with pole crop (average height 10-20 m) the spacing of trees after the thinning should be no more than 5-6 m, or approx. 300- 400 trees per hectare.
9. In stands which at present have less than desired tree density and spacing; only trees which grow in clusters, are very close together and therefore compete for light and nutrients can be removed. Diseased trees, especially those infected with mistletoe should be removed.
10. Care must be taken not to create large openings in the thinned stands.
11. Diseased, malformed and suppressed trees shall be thinned on a priority basis.

### **1.12.4.6 Sanitation Felling and Subsequent Passes**

Sanitation felling is a control measure used in response to forest pest and diseases. Major forest pest identified are bark beetle and mistletoe infestation. Sanitation felling is an essential operation but one that can also limit the viability of future passes. When carrying out sanitation or salvage operation, it is essential to consider future normal passes and to lay out cable lines accordingly. It is recommended to carry out operations along that line in unaffected as well as affected parts of the stand. Group salvage cuts often have to be larger than for normal working but ideal group layout has to be considered (Whitfield, 2001). Prescription for management of forest pest and diseases are described in detail in Volume V of the *Code*.

### **1.12.4.7 Pest and Disease**

This section presents outline information on the important forest and forest nursery pests and diseases of Bhutan; outline information is provided on symptoms and damage, preventative measures and control measures. For more detailed descriptions including information on life cycles and management, refer to Volume V of this *Code*.

## **1.13 Record Keeping**

### **1.13.1 Objective**

To produce accurate records for improving management and monitoring and evaluation within the FMUs.

### **1.13.2 Output**

Five Monthly and Four Annual recording forms (Rural Allotment, Commercial Allotment, NWFP and Royalty) for recording information on a sub-compartment basis.

### **1.13.3 Lead responsibility**

Divisional Forest Office staff within the FMU (Unit In-charge and CFO).

### **1.13.4 Description**

FMU record keeping has been identified as a critical area that needs improvement. To date records have been kept in ledgers in the territorial offices, these records – although thought to be comprehensive – appear to be lacking some vital information. Furthermore, the comparisons of records from one office to another, for the same area, have some major discrepancies and are incomplete.

Many current records are keeping track of the AAC and other allotments, however the area that has been operated is not recorded in an easy to follow manner. If someone who is an outsider to the FMU is looking for a particular line or plantation they must be accompanied by one of the FMU staff, this is because there seems to be no record of the locations of the activities that have occurred within the FMU.

This problem of identification is also compounded by the fact that many staff in FMUs are new and proper transition periods for familiarization have not been considered. This leaves many staff unsure as to when cable lines were harvested and when or where surveys have been completed. If you don't know where activities have taken place in an FMU then it is very difficult, if not impossible, to manage the area sustainably.

Other problems have also been identified with record keeping; no compartment registers are being kept and trying to find accurate AAC allotments and records is difficult. This has led to several ideas to rectify this situation. It is not felt that it is too late.

FRMD would like to make record keeping simple yet comprehensive. To do this it is felt that records should be kept by block, compartment and sub-compartment and on year on year basis. This would ensure that each activity that occurs is recorded in an easy to find format. Totals of the AAC allotment would then be submitted monthly to the CFO - as is already required. In this way, exactly when and where operations occurred can be maintained in an easy to review format without using a series of different notebooks or registers. In addition, if the activities within one sub-compartment were required it would not be necessary to search through several lines of records to find activities from just one area.

This guide is intended to direct the way in which records shall be maintained from now on. Records from the check post shall be maintained as usual but records for the activities within the FMU shall now be maintained on a sub-compartment basis uniformly throughout the FMUs across the country.

### **Required Backup Information**

It is recommended that all previous records of activities within the FMUs be transferred to these formats so that all of the operations that have taken place in the FMU are concise and contained within a consistent format. It is recognized that some information from the past is vague or lost completely; it is suggested that the Unit In-charge investigate and inquire, to the best of their ability, to update and record the necessary information.

It is essential that all records of activities and operations within the FMU be maintained so that analysis and investigation of past management can be carried out and AAC allotments can be followed. Although record keeping may not seem as important as some management activities, it is the backbone of future management decisions and the importance must be stressed.

## Updating and Safekeeping Maps

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

### 1.13.5 How to Complete and Maintain the Forms

The record keeping forms has been divided into two categories viz Monthly and Annual recording keeping forms for Commercial and Rural Timbers including NWFPs. The list of forms is as indicated in Table 1.65.

*Table 1.65 Forms for record keeping*

	<b>Monthly Recording keeping forms</b>	<b>FORM NO</b>
1	Monthly Commercial Timber supplied (Cableline)	I
2	Monthly Commercial Timber supplied (adhoc )	II
3	Monthly Rural Timber supplied ( New Construction, Renovation, Extension)	III
4	Monthly Rural Timber Supplied (Firewood, Fencing Poles, Flag poles, others)	IV
5	Monthly Commercial and Rural NWFP Supplied	V
	<b>Annual Record keeping forms</b>	
1	Annual Commercial Timber supplied (Cable line)	VI
2	Annual Commercial Timber supplied (adhoc data)	VII
3	Annual Rural Timber Supplied	VIII
4	Annual Commercial and Rural NWFP supplied	IX
1	<b>Royalty Statement form</b>	X

#### Filling out the forms:

- There are two categories of forms comprising of nine forms in total as indicated in Table 1.65 for recording monthly and annual FMU activities. Monthly forms are meant for keeping records on a monthly basis while the annual form summarizes the information for an entire year.
- Further information required on the **Rural Allotment** form is mainly the name and address of the permit holder along with the permit number, Block and Compartment from which the timber has been marked and handed over, species, product type provided etc.,
- Further information required on the **Commercial Allotment** form is the designated cable line number (year and number, i.e. 2020/01), the length of the cable line and the GPS Co-ordinates of top and end mass (in case of annual form for cable line). The number of groups per line must be recorded along with the total area of the cable line. The number of trees marked in the cable line and groups must be recorded with the total standing volume.

Further details for filling out the forms are given below.

### 1.13.5.1 Monthly Record Keeping Forms

FORM I: Monthly Commercial Timber supplied (Cable line)

Monthly Commercial Timber Production Details from Cable Lines										
Name of the FMU:										
Month/Year:										
Date	COSDTMO No	Block/Compartment	Cableline No	Logs (A)		Poles (B)		Firewood (C)	Woodchips (D)	Total (A+B+C+D)
				Volume (m3)	Species	Volume (m3)	Species	Volume (m3)	Volume (m3)	
			2020/1							

FORM I is for keeping records of the commercial timber supplied/extracted from each cable line in the form of logs, poles, firewood and woodchips on a monthly basis. This is not the standing volume marked and handed over to authorized agency but the volume that has been extracted by authorized agency post allotment of the standing volume.

FORM II: Monthly Commercial Timber Supplied (Adhoc)

Monthly Commercial Timber Production Details from Ad-hoc Areas										
Name of the FMU:										
Month/Year:										
Date	COSDTMO No.	Block/Compartment No	Adhoc type ( Eg. Transmission line)	Logs (A)		Poles (B)		Firewood ( C )	Woodchips (D)	Total (A+B+C+D)
				Volume (m3)	Species	Volume (m3)	Species	Volume (m3)	Volume (m3)	

FORM II is for keeping records of the commercial timber supplied/ extracted from each adhoc areas in the form of Logs, Poles, Firewood and woodchips. The adhoc areas shall include extraction of timber from areas not planned as per the approved Management and Operational Plans. Some examples are timber extraction from Transmission line, farm roads, land lease etc.,).

FORM III: Monthly Rural Timber Supplied (New Construction, Renovation, Extension)

Monthly Rural Timber Allotment Details (New Construction/ Renovation/ Extension)													
Name of the FMU:													
Month/Year:													
Sl. No.	Block/Compartment no	Name of the Applicant	CID No.	Address	Thram No.	House No.	Permit No.	Date of Issue	Purpose (New Construction/ Renovation)	Sanction Letter No. and Date	Volume Marked		Volume extracted
											No of trees marked	Standing Volume (m3)	Log Volume (m3)

FORM III is for keeping records of the rural timber supplied from the FMUs for new construction/ renovation and extension purposes. Note that both the standing volume as well as the corresponding log volumes needs to be recorded.

FORM IV: Monthly Rural Timber Supplied (Firewood, Fencing Poles, Flag poles, others)

Monthly Rural Timber Allotment Details (Firewood, Flag Poles, Fencing Poles, Others)																			
Name of the FMU:																			
Month/Year:																			
Sl. No.	Block/Com partment no	Name of the Applicant	CID No.	Address	Thram No.	House No.	Date of Issue	Permit No.	Purpose	Sanction No. and Date	Type and Quantity of Forest Produce Supplied								Total Qty (m3)
											Firewood (m3)		Fencing Post		Flag Poles		Others		
											Standing Vol. (m3)	Actual Prod.	Standing Vol. (m3)	Nos.	Standing Vol. (m3)	Nos	Standing Vol. (m3)	Nos	
											A		B		C		D		A+B+C+D

FORM IV is for also for keeping records of the rural timber supplied from FMUs for firewood, flag poles and others. Both the standing volume as actual production volume needs to be reflected here.

FORM V: Monthly Commercial and Rural NWFP supplied

Monthly NWFP Supply Record																
Name of the FMU:				Gidakom												
Month/Year:				July (2020)												
Sl. No.	Block/ Compartment no	Name of the Applicant	CID No.	Thram No.	House No.	Address	Permit No.	Date of Issue	Purpose	Sanction No. and Date	Description and Quantity of NWFP Supplied					
											Stone (m3)	Sand (m3)	Soil (m3)	Bamboo (nos.)	Gravel (m3)	Others
1	Jedekha / I	Sangay	10308001870	43	19	Khachadrupchu	78	01.07.2020	sale	786	1000					

FORM V is for recording the supply of NWFPs from the FMU.

### 1.13.5.2 Annual Record Keeping Forms

FORM VI: Annual Commercial Timber Supplied (Cableline)

Annual Cable Line Operation Data												
Name of the FMU:												
Reporting Year:												
Block/ Compartment No.	Cable Line					Total clear felled area (ha)	Standing volume marked and felled (m3)	Volume Extracted (m3)				Total Extrated volume (m3)
	Year/No	Length (m)	GPS Coordinate (Top and Bottom Endmass)	No of Groups/ Area (ha)	Corridor Area (ha)			Log Volume (m3)	Poles(m3)	Firewood (m3)	Woodchips (m3)	
	A	B	C	D	A+B+C+D							
North/ I	eg. 2020/1	1000m	...N.....E	6/2.5	0.4	6.5	1000	600	200	100	80	980

FORM VI is for keeping record of the commercial timber supplied from the cablelines for an entire year. The information for **Volume Extracted** can be transferred from FORM I. However, information on **Cable Line** (length of cableline, GPS-Coordinates, No. of groups/ area(ha), and corridor area (ha)) needs to be derived from the approved annual Operational Plan of the FMU. The information for **Standing Volume** marked can be obtained from the tree marking book (TMB) maintained by the unit Incharge/ site Incharge.

FORM VII: Annual Commercial Timber Supplied (Adhoc)

Annual Commercial Timber Supply from adhoc								
Name of the FMU:								
Reporting Year:								
Block/ Compartment No.	Adhoc area		Standing volume marked and felled (m3)	Volume Extracted (m3)				Total volume extracted (m3)
	Type (eg. Land lease)	Clearfelled area (ha)		Log Volume (m3)	Poles(m3)	Firewood (m3)	Woodchips (m3)	
				A	B	C	D	
								A+B+C+D

FORM VII is for keeping record of the commercial timber supplied from adhoc areas for an entire year. The information for **Volume Extracted** can be transferred from FORM II. The information for **Standing Volume marked and felled** can be obtained from the tree marking book (TMB) maintained by the unit Incharge/ site Incharge.

FORM VIII: Annual Rural Timber Supplied

Annual Rural Timber Supply												
Name of the FMU:												
Reporting Year:												
Quantity Supplied in Standing Form											Total Standing Volume Supplied (m³)	Remarks
Rural House Building Timber			Poles		Fencing Post		Firewood		Others			
No.	Standing Vol. (m3)	Log Vol. (m3)	No.	Standing Vol. (m3)	No.	Standing Vol. (m3)	No.	Standing Vol. (m3)	No.	Standing Vol. (m3)		
A			B		C		D		E	A+B+C+D+E		

FORM VIII is for keeping record of the rural timber supplied from the FMU for an entire year. The information in this form can be transferred from FORM III and IV.

FORM IX: Annual Commercial and Rural NWFP supplied (Forms to be annexed)

Annual NWFP Supply								
Name of the FMU:								
Reporting Year:								
Block/ Compartment no	Product Types							
	Bamboo (Nos.)	Sand (m3)	Top Soil (Tm3)	Stone/ Boulders (m3)	Gravel (m3)	Leaf Mould/ Litters (m3)	Mushroom (Kgs.)	Others (Unit)

FORM IX is for keeping record of the NWFP supplied from the FMU for an entire year. The information in this form can be transferred from FORM V.



FORM X: Royalty Statement

Royalty Statement													
Name of the FMU:			Type of Forest Produce Extracted								Total Amount (Nu.)	Dispatch No. and Date	Remarks
Year	Month	Cable Line No./ Name of Ad-hoc Area	Logs		Firewood/ Lops & Tops		Poles		Sawn Timber				
			Volume (cft)	Amount (Nu.)	Volume (m3)	Amount (Nu.)	No./ Volume (cft)	Amount (Nu.)	Volume (cft)	Amount (Nu.)			

FORM X is keeping records of the royalty which authorized agency is payable every month for timber extraction from FMUs. The royalty statement must be prepared every month and submitted to authorized agency for payment. Please note that royalty is a government revenue which must be remitted on a monthly basis. Keeping it pending till the end of the year may invite audit observations and memos. The information for this form can be derived from FORM I and II.

## 1.14 Monitoring and Evaluation

The Department shall ensure that authorized agency implement activities as per the forest management plan. Towards this, a two-stage verification process is necessary. The first stage checks that on-ground activities are being carried out as planned in the short term, and the second stage checks that the objectives of the plan are being achieved over the longer term. Monitoring (checking on inputs on a year-to-year basis) is the term used for the first stage and evaluation (checking achievements against objectives over five-year periods) is the second stage. The monitoring shall be guided by the monitoring and evaluation framework as indicated in the following section.

### 1.14.5 Monitoring

The Divisional Forest Office shall ensure that the FMU implement the yearly activities as per plan through periodic monitoring. Any deviation from the operational plan or the FMP shall be stopped or prior permission sought from the Department. FRMD, with the help of the DFOs shall conduct annual monitoring and provide recommendations for effective implementation of the plan. Form 1-From 11 should be duly filled by the FMU IC, which shall be summarized in Monitoring Form A by the CFO. One copy should be kept in the CFO office and one copy is to be forwarded to FRMD with Monitoring Form A. The monitoring form A should form the basis of annual monitoring by FRMD.

### Timing

The forms are to be filled in for a one-year period, **1 July to 30 June**, when the information about actual production is available, during the month following year end (July). The only exception to this is the monitoring of regeneration success; the regeneration in harvested areas is first monitored **three years after harvest and again subsequently, at a time depending on the forest type**.

### 1.14.6 Evaluation

Evaluation is the examination of whether project objectives are being achieved. This requires enough time to provide a realistic assessment of progress in fulfilling objectives. Evaluation of the FMU shall be done as per the FMP. The Divisional Forest Office shall intimate FRMD for the need for mid-term and final evaluation when required.

## **Evaluation committee**

The evaluation committee shall be constituted by the head of the Department and shall comprise of a minimum of five member from the following members;

- FRMD (lead agency)
- Advisor to the Department (Team Leader)
- CFO Territorial Division (not from same Division)
- Authorized agency (Regional Manager (not from same Division),
- UWICER
- Local Government

## **Timing**

The Mid-term evaluation is to take place during the last quarter of the fifth year of the FMP period and shall monitor and ensure that the management of the FMU is geared towards achieving the final objectives of the FMP. The Final evaluation is to take place during the last quarter of the ninth year of the FMP period and this should directly inform the preparation of the FMP for the subsequent 10-year period.

### **1.14.7 Monitoring and Evaluation Process**

The monitoring process for FMU in the country was developed by Third Forestry Development Project (TFDP), working closely with the then Forest Resources Development Division (FRMD) of the Ministry of Agriculture (MoA), in 1999. It was developed based on selecting and modifying the *Montreal Process*<sup>6</sup> Indicators for use on FMUs in Bhutan. The indicators decided on were divided into **three groups**:

- 1) Indicators for which information must be collected **every year** (9 indicators).
- 2) Indicators involving information that changes relatively slowly. These indicators are to be assessed **every five years** and compared against, for example, the initial FMU plan (8 indicators).
- 3) Indicators that are evaluated only **once or rarely** (9 indicators). These indicators are about policy, institutions, regulations, guidelines and similar matters.

Different forms were developed for each of these time scales; **Monitoring Form A** for the **annual monitoring** process, **Evaluation Form A** for the **five-year evaluation**, and **Evaluation Form B** for the **once only evaluation**. Forms were also developed for field collection of environmental information for the monitoring and evaluation process.

Some indicators are used for both annual monitoring and five-year evaluations (for example, production from the forest), while some data are collected annually and only evaluated at five-year intervals (for example, fauna diversity). The forms list the indicators, the standards<sup>7</sup> that are accepted as satisfactory, and the calculations that are necessary to assess the standard and update the Progress score.

The above forms are used to compare performance against the selected indicators. It was also necessary to provide a set of forms for collection of data in the field. The field data collection forms consist of **Physical and**

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<sup>6</sup> The *Montreal Process* developed through an international consensus (12 countries, including Australia, Canada, Chile, China and the USA) a set of indicators for the evaluation of sustainable forestry in temperate and boreal forests. Seven Criteria and 67 Indicators were designed for application at a national level.

<sup>7</sup> A standard for an indicator is the value that the indicator will have if that aspect of sustainability is satisfactory. Standards can be either quantitative or qualitative.

**Financial Forms 1-3, Environmental Forms 4-11** and the **Physical, Financial and Environmental Summary Form**. The information from these forms is then used on **Monitoring Form A** and **Evaluation Forms A and B**.

The process consists of the following:

- Field collection of **Physical, Financial and Environmental** information on the set of **Indicators**.
- **Self monitoring** at a field level in the FMU based on the data collection process.
- A **Monitoring Process**, carried out annually, for which the CFO is responsible, including any corrective action necessary.
- An **Evaluation Process**, carried out at five year intervals by a team composed from the Department, NRDCL and external stakeholders. The team is to recommend any corrective action necessary and the CFO is responsible for carrying it out.

Table 1.66 gives an overview of the process and Table 1.67 summarises the purpose of different forms, who fills them in and how often.

*Table 1.66 Summary of the Monitoring and Evaluation Process*

	Stage in the process			
	1. INFORMATION COLLECTION	2. INFORMATION SUMMARY	3. MONITORING	4. EVALUATION
<b>What is happening in each stage?</b>	<b>INFORMATION COLLECTION AND SELF MONITORING AT FIELD FMU LEVEL</b>	<b>SUMMARY OF INFORMATION FOR USE AT DIVISIONAL AND HIGHER LEVELS</b>	<b>MONITORING AT DIVISIONAL LEVEL</b>	<b>EVALUATION AT DIVISIONAL AND NATIONAL LEVEL</b>
Type of form used in the process	Physical and Financial Forms 1-3 Environmental Forms 4-10	Physical, Financial and Environmental (P,F & E) Summary Form	Monitoring Form A	Evaluation Forms A and B
Forms filled in by:	Physical and Financial Forms 1-3 filled in by FMU UIC in July, assisted by RM NRDCL Environmental Forms 4-10 filled in by FMU UIC in March, assisted by RM NRDCL	Filled in by FMU UIC in July every year.	Filled in by CFO in July every year, using Summary Form	Filled in by CFO in July every five years Environmental Form 11 (RRA) used for data collection every five years
Location for storage of Forms	Forms stored in FMU Office	Forms sent to CFO	P,F & E Summary Form and Monitoring Form A forwarded to FRMD	Evaluation Forms A and B forwarded to FRMD
Who should act on what the forms indicate?	FMU UIC should correct deficiencies indicated by the forms	CFO should ensure that action is taken by the FMU UIC	CFO should take action necessary to correct deficiencies indicated by the forms	FRMD, CFO should take action necessary to correct deficiencies indicated by the forms

*Table 1.67 A Summary of Data Collection, Monitoring & Evaluation Forms & Their Use*

<b>Form Nos.</b>	<b>Form Name</b>	<b>Purpose of the Form</b>	<b>Who Fills In the Form?</b>	<b>How Often?</b>
Form 1 Form 2 Form 3	<b>Physical &amp; Financial Data – Commercial Activities Coupes harvested Divisional Activities</b>	Field data collection & recording of FMU activities	FMU UIC	Every July, for the previous year (1 July to 30 June).
Form 4	<b>Code of Forest Practice Forms: Road Drainage by Culverts</b>	Field data collection	FMU UIC	Every March
Form 5	<b>Code of Forest Practice Forms: Road Drainage by Side Drains, Batter &amp; Fill Slopes</b>	Field data collection	FMU UIC	Every March
Form 6	<b>Code of Forest Practice Forms: Stream Crossings</b>	Field data collection	FMU UIC	Every March
Form 7	<b>Code of Forest Practice Forms: Cable Lines</b>	Field data collection	FMU UIC	Every March
Form 8	<b>Code of Forest Practice Forms: Interlines</b>	Field data collection	FMU UIC	Every March
	<b>Physical, Financial and Environmental Summary</b>	Summarise Forms 1 to 8	FMU UIC	Every July for the previous year

Form 9	<b>Monitoring of Animal Indicator Species</b>	Field data collection	FMU UIC	Every April & October
Form 10	<b>Monitoring of Plant Indicator Species and Regeneration</b>	Field data collection	FMU UIC	Every April & October
Form 11	<b>Community Participation RRA Checklist</b>	Field data collection for 5 year Evaluation	FMU UIC	Every 5 Years

<b>Monitoring Form A</b>	<b>Annual Monitoring</b>	Monitoring (data from Summary form)	CFO for FMU concerned	Every Year
<b>Evaluation Form A</b>	<b>Five-Year Evaluation</b>	Evaluation (data from Form A and Forms 9-11)	Evaluation Team	Every 5 Years
<b>Evaluation Form B</b>	<b>1<sup>st</sup> Five-Year Evaluation</b>	Evaluation (data from a range of sources directly into the Form)	Evaluation Team	When 1 <sup>st</sup> 5-year evaluation is done & only rarely thereafter.

## Instructions for Using the Physical and Financial Monitoring Forms or FMUs

There are four forms:

- a. **Form 1 (Commercial Activities detailed).**
- b. **Form 2 (Timber Extraction, Plantation and Regeneration survey)**
- c. **Form 3 (Divisional Activities).**
- d. **Physical, Financial and Environmental Monitoring Summary Form**

Form 1, Form 2 and Form 3 shall be used to collect detailed information and kept in the Unit Office as the basic information about activities in the FMU. These forms are to be filled in by the FMU UIC, using information obtained either from the authorized agency or Divisional Forest Offices.

The fourth form summarises information collected by FMU staff on Forms 1-3 and the Environmental monitoring data collection forms 4-10. The Summary Form is to be used by the CFO to fill in Monitoring Form A. One copy should be kept in the CFO office and one copy is to be forwarded to FRMD with Monitoring Form A. The Summary Form is to be filled in by the FMU UIC.

The forms are to be filled in for a one-year period, **1 July to 30 June**, when the information about actual production is available, during the month following year end (July). The only exception to this is the monitoring of regeneration success; the regeneration in harvested areas is first monitored **three years after harvest and again subsequently, at a time depending on the forest type**. These results, when available, are to be entered in the Coupe Details (Form 2) for the year of harvest.

Throughout the forms, **‘Planned’** means given in the Operational Plan. **‘Implemented’** means what actually happened.

If a box has **grey shading** this means it should not be filled.



## Form 1 - COMMERCIAL ACTIVITIES (detailed)

FMU NAME \_\_\_\_\_ REPORT PERIOD \_\_\_\_\_

FILLED IN BY (name, designation) \_\_\_\_\_

	Planned	Implemented	Actual cost	REMARKS
<b>1. ANNUAL ALLOWABLE CUT (AAC)</b>				
1.1 Total standing volume harvested	m3	m3		
1.2 Area harvested	ha	ha		

### 2. PRODUCTION BY SILVICULTURAL SYSTEM

<b>thinning</b>				
2.1 Standing Volume from marking list	m3	m3	Nu	
2.2 Total working area	ha	ha		
2.3 Method of thinning				describe
<b>single tree selection</b>				
2.4 Standing Volume from marking list	m3	m3	Nu	
2.5 Total working area	ha	ha		
<b>group selection</b>				
2.6 Standing Volume from marking list	m3	m3	Nu	For Salvage operation, mention the Block and compartment in which the operation was carried out.
2.7 Total area harvested	ha	ha		
2.8 Total corridor area	ha	ha		
<b>seed tree</b>				
2.9 Standing Volume from marking list	m3	m3	Nu	
2.10 Total area harvested	ha	ha		
2.11 Number of trees retained per ha	#	#		
<b>clearcut</b>				
2.12 Total area harvested	ha	ha		
2.13 Standing Volume from marking list	m3	m3	Nu	

### 3. NATURAL REGENERATION (stocking assessment on Form 2)

3.1 Site preparation	ha	ha		Cableline no: Year/no.
3.2 Fencing	ha	ha		Cableline no: Year/no.
3.3 Total regeneration cost			Nu	
3.4 Weeding	ha	ha	Nu	Cableline no: Year/no.
3.5 Enrichment plant'g	#	#	Nu	Cableline no: Year/no.

### 4. Plantation (stocking assessment on Form 2)

4.1 Site preparation	ha	ha		Cableline no: Year/no.
4.2 Area planted	ha	ha		Cableline no: Year/no.
4.3 Fencing	ha	ha		Cableline no: Year/no.
4.4 Total Cost			Nu	

### 5. ROADS

5.1 Planning and survey	km	km		
5.2 Formation cutting	km	km		
5.3 Soling	km	km		
5.4 Stabilising walls	#	#		
5.5 Drainage installed	km	km		
5.6 Bioengineering	m	m		
5.7 Road completed	km	km		
5.8 Total construction cost			Nu	
5.9 Bridges constructed	#	#	Nu	
5.10 Maintenance	km	km	Nu	

### 6. RECURRENT COSTS (FMU only)

6.1 NRDCL staff salaries	Nu		Nu	specify number of staff
6.2 NRDCL staff allowances	Nu		Nu	
<b>7. TOTAL OPERATING COST</b>		Nu		

## **Form 1: COMMERCIAL ACTIVITIES (Detailed)**

### **1. Annual Allowable Cut (AAC).**

The 'Planned' values are obtained from the current Operational Plan. If Total volume and area AACs are given in the plan, fill in both boxes. Otherwise, only provide what is given in the Operational Plan. 'Implemented' comes from Form 2, column 10, totaled for the year. If more than one silvicultural system is being implemented, these figures will be the totals for the individual systems.

### **2. Production by Silvicultural System.**

Five silvicultural treatments are listed. Only the treatments being applied for the current year in the FMU need to be filled in. If there is more than one treatment, the planned volume will be the AAC determined for the different silvicultural treatments.

**Total working area** (item 2.2, 2.5), for silvicultural treatments with partial removal (thinning, single tree selection) means the area over which the operation is being carried out. Coupes are to be located and their dimensions measured by Divisional staff in association with NRDCL staff. **All areas, in all the forms, must be corrected for slope.**

For **thinning**, 'method of thinning' (item 2.3) requires a description of which trees are being taken and what proportion of removal. For example, 'from below, 30% of basal area', 'from above, 50cm diameter limit', 'for flag poles, not larger than 15cm dbh'. If percentage removal is given, it is necessary to say whether it refers to number of trees or basal area.

**Total area harvested** (item 2.7) for **group selection**, the individual groups must be measured to estimate their area. The dimensions need to be measured with a tape, **using slope correction**. Measure diameter if the group is roughly circular, measure length x width if it is rectangular. Total area harvested (item 2.10, 2.12) for seed tree and clear cut means the area over which the operation is being carried out. Coupes are to be located and their dimensions measured. The best time to do this is when the trees are being marked.

**'Standing volume from marking list'** (items 2.1, 2.4, 2.6, 2.9, 2.13) are to be calculated from the marking list, using the General Volume Table or Local Volume table by FMU UIC. It is not necessary to prepare summary marking lists provided the original marking list, with the volume calculations, is preserved. In all treatments the marked trees are those to be harvested and checks are necessary to ensure that all the marked trees **are actually harvested**.

In the **'Actual cost'** column, only one box for each silvicultural treatment has to be filled, for each of the 'Implemented' volumes. The cost of producing the total volume should be entered (marking, felling and extraction). This should be obtained from the NRDCL Production Incharge. If the cost is available as Nu/m<sup>3</sup>, multiply this cost by the 'Implemented' column and put this in the box.

**Salvage Production.** Enter information about salvage production under the silvicultural system used to carry it out and put **'Salvage operation'** in the Remarks column along with the name of the Block and compartment in which the salvage operation was carried out. Note that if salvage operations are necessary, other operations should be postponed to keep harvesting within the AAC, if possible.

### **3. Natural Regeneration and 4. Plantation.**

Fill in the area and the cost incurred for natural regeneration preparation works and for plantations carried out under these sections. Mention the Cableline no (Yr/no) in which the works are done (Eg.2018/1, 2018/2) in the remarks column. Assessments of stocking must be made three years after harvesting of the stand and again after that at a time that will vary with the forest type. Stocking assessment results for natural regeneration and plantation shall be filled in the Form 2 for cable line or coupe concerned.

**5. Roads.**

Details need to be filled in for the various steps in road construction. This information is to be obtained from NRDCL.

‘Drainage installed’ (item 5.5) means the distance of road for which **all** drainage works (side drains, culverts, cross drains, causeways and culvert entry and exit protection) have been completed.

‘Maintenance’ (item 5.10) (including bioengineering) is the length of road in the FMU that has received maintenance during the year.

In the ‘Actual cost’ column, enter the total cost for road construction, bridges (if any) and maintenance for the year, in the boxes.

**6. Recurrent costs.**

Enter the budget amount in the ‘Planned’ box and the actual payments in the ‘Actual cost’ box.

**7. Total operating costs.**

Total all the boxes in the ‘Actual cost’ column.

Form 2 - COMMERCIAL ACTIVITIES (Timber Extraction, Plantation and Regeneration Survey)

FMU NAME \_\_\_\_\_ REPORT PERIOD \_\_\_\_\_ FILLED IN BY (NAME) \_\_\_\_\_

Extretaction from Cablelines/ Adhoc activities

1. Block name	Location		Cable lines		6. No of Groups/Patches	7. Total area harvested (Ha)	Volume						Remarks
	2. Compi/ Sub-comp	3. Working Circle	4.Cableline no(Yr./No)	5. Cableline Length(m)			8. Inventory volume (m3/ha)	9. Standing from marking list (m3)	10. Log volume extracted (m3)	11. Log recovery (%)	12. Firewood produced (m3)	13. Log + fwood recovery (%)	
Ngatshang	1a	Conifer	2018/2	800	5	0.5	563	285	180	63	50	81	
			2018/3	1600	11	1.1	563	625	395	63	185	93	
			2018/4	900	6	0.6	563	338	257	76	95	104	

Regeneration stock assessment

1. Block Name	2. Compt /sub-compt	3. Working Circle	4. Cableline no(Yr./No)	5. Area (Ha)	6. Species	7. Stocking %	8. Remarks
Ngatshang	1a	Conifer	2015/2	6	Bluepine, Fir	80%	adequate

Plantation stock assessment

1. Block Name	2. Compt /sub-compt	3. Working Circle	4. Cableline no(Yr./No)	5. Area (Ha)	6. Species	7. Survival %	8. Remarks
Ngatshang	1a	Conifer	2016/1	5	Bluepine, Fir	40%	adequate

**Form 2: COMMERCIAL ACTIVITIES (Timber Extraction, Plantation & Regeneration survey)**

**A. Extraction from Cableline/ adhoc activities**

The first four lines are example data. Numbers given below refer to columns on the Form. The examples given relate to cable crane lines, but the form can be used for any silvicultural treatment, if one line is used for each separate coupe. If other treatments are entered in the form, enter na (for not applicable) in columns 4 and 5.

**1. Block name (Col 1) and 2. Compt/sub compt (Col 2) :** The Block and Compartment/Sub compartment where the coupe is located.

**3. Working Circle (Col 3):** Working Circle in which the coupe is located.

**4. Cable Line no (Col 4):** Cable line number (Eg, 2018/1).

**5. Cable lines length (Col 5) :** Total length of the cable line, adjusted for slope.

**6. No of Groups or Patches (Col 6) :** Give the number of individual groups or patches in the cable line.

**7. Total area harvested (Col 7) :** This means the total area of all the groups, patches or clear felled areas in the cable line (including the cable corridor), **adjusted for slope**. It is the area for which harvesting operations have all been completed, ie marking, felling and extraction. Do not include, for example, areas that have only been marked and felled.

**8. Inventory volume (Col 8) :** is the volume estimated during the operational inventory.

**9. Standing volume from marking list (Col 9):** when the group selection or patch systems are being applied, this is the marked volume from both cable corridor and groups or patches. The volume is to be calculated using local volume tables or general volume tables for all the trees marked, felled and extracted (including cable corridors) in that cable line.

**10. Log volume extracted (Col 10):** col 10, is the total volume of **logs** harvested from the cable line. The data is to be obtained from NRDCL.

**11. Log recovery ( Col 11) :** is the value of ‘Log volume extracted’ as a percentage of ‘Marking list volume cut’.

**12. Firewood produced (Col 12):** is the volume of firewood extracted from the cableline.

**13. Log + firewood recovery (Col 13):** is the sum of column 10 and column 12, expressed as a percentage of column 9.

**B. Regeneration stock assessment.**

**1: Block name (Col 1) and 2: Compartment/ Sub-compartment (Col 2).** The Block and Compartment/Sub-compt where the regeneration assessment is carried out.

**3: Working Circle (Col 3) and 4: Cableline no (Col 4).** The working circle and cableline number where the regeneration assessment is carried out.

**5: Area (Ha):** Total area of regeneration survey carried out.

**6: Species:** Species encountered during regeneration survey

**7. Stocking (%) (Col 5) :** The regeneration assessment results in stocking %. This can be derived from FORM 10.

**C. Plantation Assessment**

**1: Block name (Col 1) and 2: Compt/Sub compartment (Col 2).** The Block and Compartment/Sub compartment where the plantation assessment is carried out

**3: Working Circle (Col 3) and 4: Cableline no (Col 4).** The working circle and cableline number where the plantation assessment is carried out.

**5: Area (Ha):** Total area of plantation carried out.

**6: Species:** Species planated

**7: Survival % (Col 5) :** The Plantation assessment results in terms of survival % of seedlings. This can be derived plantation assessment reports.



Form 3 - DIVISIONAL ACTIVITIES (detailed)

FMU NAME _____		REPORT PERIOD _____		COMMENTS
OPERATIONAL PLAN				
	Planned	Implemented	Actual cost	
<b>1. FOREST FIRES</b>				
1.1 Fire lines for prevention	m	m		
1.2 Fuel reduction burning	ha	ha		
1.3 Training (# of courses / trainees)	No	No		
1.4 Number of fires		No		suppression costs
<b>2. DISEASES / EPIDEMICS / OTHER DAMAGES (e.g. landslides, floods etc)</b>				
2.1 Preventive measures				specify: e.g. debarking, debris burning
2.2 Incidence				specify type of outbreak or damage and area affected
2.3 Control measures				e.g. traplocks, salvage logging
<b>3. SOCIAL ISSUES</b>				
3.1 FMU Level Committee meetings held	No	No		
3.2 Meetings re CFMU held?	No	No		
3.3 Meetings on ( )	No	No		
3.4 Meetings on ( )	No	No		
3.5 Meetings on ( )	No	No		
COMMENTS				
<b>4. RESEARCH</b>				
				specify type and action:
4.1 Silviculture/ecology				
4.2 Social				
4.3 Work study				
4.4 Other				
<b>5. EQUIPMENT / INFRASTRUCTURE (DoFS only)</b>				
				specify type and purpose:
5.1 Vehicles				
5.2 Machinery				
5.3 Field equipment				
5.4 Office equipment				
5.5 Constructions				
<b>6. HUMAN RESOURCES</b>				
				specify position and grade:
6.1 Increase/decrease staff	No	No		
6.2 Purchase of external services	No	No		
6.3 Training (# of courses / trainees)	No	No		
<b>7. COSTS (FMU staff only)</b>				
7.1 Territorial staff salaries	Nu		Nu	specify position and grade
7.2 Territorial staff allowances	Nu		Nu	
7.3 Planning and inventory	Nu		Nu	
7.4 Other incidental expenses	Nu		Nu	
<b>8. TOTAL EXPENSES</b>			Nu	

**Form 3: DIVISIONAL ACTIVITIES, (detailed)**

**1. Forest fires:**

‘Fire lines for prevention’, item 1.1, are fire lines prepared to protect valuable stands or plantations.

‘Fuel reduction burning’, item 1.2, when it is carried out.

‘Training’, item 1.3, relates to fire prevention and control courses.

‘Number of fires’, item 1.4, is the count of wildfires that occurred and ‘area burnt’, item 1.5, is the area of all fires in the FMU for the year.

The cost of these activities should be entered in the ‘Actual cost’ column.

**2. Diseases / Epidemics / Other Damages:**

Provide information on diseases, epidemics and other damages in terms of area and number.

**3. Social Issues.**

Provide information on any types of meeting and public consultations carried out in the FMU.

**4. Research :** Provide information on the type of researches carried out if any.

**5. Equipment/Infrastructure.**

For vehicles, machinery and equipment, specify purchase or disposal and number of items and the cost involved. For ‘constructions’, specify what is being constructed and how many.

**6. Human resources.**

‘Training’ Specify how many staff were trained and the type of training. ‘Purchase of external services’ includes such things as consultants, accountants, electricians, etc.

**7. Recurrent costs.**

Enter the total amounts for staff salaries, allowances and other incidental costs, both budgeted and actual, in the boxes. For item 7.3, indicate what sort of activity in the remarks column.

**8. Total expenses** is the total of all the costs recorded on Form 3.

PHYSICAL, FINANCIAL AND ENVIRONMENTAL MONITORING SUMMARY FORM

**PHYSICAL, FINANCIAL AND ENVIRONMENTAL MONITORING SUMMARY FORM (Page 1)**

**FMU NAME** \_\_\_\_\_

**REPORT PERIOD** \_\_\_\_\_

**FILLED IN BY** (name, designation) \_\_\_\_\_

**COMMERCIAL ACTIVITIES**

**ACTIVITY 1. Silviculture system.....Working Circle.....**

Item	Plan target	Implemented	Cost (Nu)	Revenue (Nu)	Comments
1. Area harvested (ha) (AAC)					
2. Standing volume harvested ( $m^3$ ) (AAC)					
3. Log volume produced ( $m^3$ )					
4. Value of Log sold from FMU (Nu)					
5. Firewood volume produced ( $m^3$ )					
6. Value of firewood sold (Nu)					
7. Total royalty paid to DoFPS (Nu)					
8. Forest roads constructed (km)					
9. Area regenerated/planted (ha)					method?

**ACTIVITY 2. Silviculture system.....Working Circle.....**

Item	Plan target	Implemented	Cost (Nu)	Revenue (Nu)	Comments
1. Area harvested (ha) (AAC)					
2. Standing volume harvested ( $m^3$ ) (AAC)					
3. Log volume produced ( $m^3$ )					
4. Value of Log sold from FMU (Nu)					
5. Firewood volume produced ( $m^3$ )					
6. Value of firewood sold (Nu)					
7. Total royalty paid to DoFPS (Nu)					
8. Forest roads constructed (km)					
9. Area regenerated (ha)					method?

**ACTIVITY 3. Silviculture system.....Working Circle.....**

Item	Plan target	Implemented	Cost (Nu)	Revenue (Nu)	Comments
1. Area harvested (ha) (AAC)					
2. Standing volume harvested ( $m^3$ ) (AAC)					
3. Log volume produced ( $m^3$ )					
4. Value of Log sold from FMU (Nu)					
5. Firewood volume produced ( $m^3$ )					
6. Value of firewood sold (Nu)					
7. Total royalty paid to DoFPS (Nu)					
8. Forest roads constructed (km)					
9. Area regenerated (ha)					method?

**ACTUAL REVENUE & EXPENDITURE**

1. NRDCL Total Revenue for FMU	
2. Royalty paid by NRDCL	
3. NRDCL expenditure for FMU	
4. NRDCL Net Revenue (1 - (2 + 3))	
5. Royalty paid to DoFPS	
6. DoFPS expenditure for FMU	
7. DoFPS Net Revenue (5 - 6)	
Total Revenue for FMU (4 + 7)	

## **PHYSICAL, FINANCIAL AND ENVIRONMENTAL MONITORING SUMMARY FORM**

### **A. COMMERCIAL ACTIVITIES (Page 1)**

Tables are provided for three different harvesting activities in the FMU, corresponding to the silvicultural systems detailed on Form 1. Fill up the following details in each table:

#### **1. Area harvested.**

‘AAC’ (area) is obtained from the ‘Planned’ column for the silvicultural system, from Form 1, items 2.2, 2.5, 2.7, 2.10, 2.12.

‘Implemented’ (ha) is transferred from Form 1. For thinning or single tree selection treatments, this is the area of forest over which the treatment is being applied – ‘total working area’ items 2.2, 2.5. For group selection, clear cut treatments and seed tree treatments, it is the ‘Total area harvested’ items 2.7, 2.10, 2.12.

#### **2. Standing volume harvested.**

‘AAC’ (Plan Target) is obtained from Form 1, items 2.1, 2.4, 2.6, 2.9, 2.13, ‘Planned’ column.

‘Implemented’ comes from the same items, ‘Implemented’ column.

#### **3. Log volume produced.**

‘Plan Target’ can be obtained from NRDCL.

‘Implemented’ comes from Form 2, the total of column 10, ‘Log volume extracted’. If more than one silvicultural system is in use, separate totals for each will be necessary.

The cost of production for ‘Log volume produced’ (the total of marking, felling and extraction costs to the road head) should be entered in the ‘Cost’ column. Obtain this from NRDCL.

#### **4. Value of log sold from FMU.**

This is the total of sales from the FMU during the year, obtained from NRDCL. It is not the value of the sawlog produced, because it may include some sale of previous stocks. The figure is entered in the ‘Revenue’ column.

#### **5. Firewood volume produced.**

‘Plan Target’ can be obtained from NRDCL.

The ‘Implemented’ comes from Form 2, the total of column 12, ‘Firewood produced’

The cost of production for firewood, obtained from NRDCL, is entered in the ‘Cost’ column.

**6. Value of firewood sold** is obtained from NRDCL and entered in the ‘Revenue’ column.

**7. Total royalty paid to DoFPS** is obtained from NRDCL and entered in the ‘Revenue’ column.

#### **8. Forest roads constructed.**

Obtain the ‘Plan Target’ from NRDCL.

‘Implemented’ is obtained from Form 1, item 5.7, ‘road completed’ and ‘Cost’ from the same form, Roads, ‘Total construction cost’, item 5.8.

## **9. Area regenerated/Planted.**

When natural regeneration is being applied, this area will be the same as the sum of ‘Total harvested area’ from column 7 of Form 2. When plantations are carried out the area comes from, ‘Area planted’ on Form 1, item 4.2.

‘Cost’ comes from ‘Total cost’ on Form 1, under either Natural regeneration (item 3.3) or Plantation, (item 4.4).

## **B. ACTUAL REVENUE AND EXPENDITURE**

### **NRDCL Total Revenue:**

It is the total of ‘Value of Log sold from FMU’ and ‘Value of firewood sold’, (only if sold through NRDCL) items 4 and 6 from the different ‘Activities’ on the Summary Form.

### **Royalty paid by NRDCL:**

It is the total of the ‘Total royalty paid to DoFPS’ items for each ‘Activity’ item 7, Summary Form.

### **NRDCL Net Revenue:**

It is Total Revenue minus the sum of Royalty and NRDCL expenditure from Form 1.

### **Royalty paid to DoFPS:**

It is ‘Royalty paid by NRDCL’ plus ‘Total Royalty’ from the ‘**TERRITORIAL ACTIVITIES, FOREST PRODUCTION**’ table on the second page of the Summary Form (item 1.3).

### **DoFPS expenditure:**

It is the total of the ‘Actual cost’ column on Form 3 (item 8).

### **DoFPS Net Revenue:**

It is ‘Total royalty paid to DoFPS’ minus ‘DoFPS expenditure’.

### **Total Revenue for FMU:**

It is ‘NRDCL Net Revenue’ plus ‘DoFPS Net Revenue’.

PHYSICAL, FINANCIAL AND ENVIRONMENTAL MONITORING SUMMARY FORM (Page 2)					
<b>DIVISIONAL ACTIVITIES</b>					
<b>1. FOREST PRODUCTION</b>					
		Disposal to:			
		Rural		Commercial	
<b>1.1 Wood Products</b>	Quantity	Royalty (Nu)	Quantity	Royalty (Nu)	
Trees		No		No	
Chams		No		No	
Tsim		No		No	
Dang chung		No		No	
Fencing posts		No		No	
Flag posts		No		No	
Firewood		m3		m3	
Other products (royalty only)					
<b>1.2. Non-wood Products</b>					
Bamboo		No		No	
Extractive oils		Kg		Kg	
Resin		Kg		Kg	
Daphne bark		Kg		Kg	
Mushroom		Kg		Kg	
Other products (royalty only)					
<b>1.3. Total royalty</b>					
<b>2. FOREST PROTECTION</b>					
<b>Offences</b>	Number				
Offences detected	No				
<b>Damaging agents</b>					
	Number	Hectares			
Forest fire					
Insect or disease epidemic					
Landslide					
Flood					
Other					
<b>Totals</b>					
<b>3. RESEARCH</b>					
Type					
Achievement					
<b>4. SOCIAL ISSUES</b>					
FMU Steering Comm. Meetings held (No)					
Meetings with CFMU held? (No)					
Meetings for other purposes? (No)					
Meetings for other purposes? (No)					
Comments					
<b>5. ENVIRONMENTAL MONITORING (Scores from Env Mon Forms)</b>					
Purpose	Roads (culverts)	Roads (drains etc)	Streams	Cable lines	Interlines
Form Number	4	5	6	7	8
Progress score*					
*Starting score = 140					
Regeneration stocking for the area assessed this year (from Env Mon Form 10)					



## **PHYSICAL, FINANCIAL AND ENVIRONMENTAL MONITORING SUMMARY**

### **DIVISIONAL ACTIVITIES (Page 2)**

#### **1. FOREST PRODUCTION.**

Add together the quantities and royalties for each item (eg trees, chams etc) to obtain totals for the year.

Enter individual values for the items listed individually in the 'Wood Products' table on the Summary Form.

Add together the totals for the items specified collectively and enter this in the 'Other products (royalty only)' box on the Summary Form.

Do the same for the Non-wood Products, in this case entering the individual items listed and totaling for the remainder.

#### **2. FOREST PROTECTION.**

Offences detected: Add the number of all offences detected.

Damaging agents: Transfer the total number and area from Form 3, for the different items, 'Forest fire' (items 1.4, 1.5), 'Insect or disease epidemic', 'Landslide', 'Flood' (all from item 2.2).

#### **3. RESEARCH.**

This table provides a summary of information on Research Activities in the FMU. Obtain from Form 3 (items 4.1 to 4.4).

#### **4. SOCIAL ISSUES.**

This table provides a summary of information on Social Issues in the FMU. Obtain from Form 3, items 3.1 to 3.5.

#### **5. ENVIRONMENTAL MONITORING.**

Transfer the progress scores from the Environmental Data Collection Forms 4-8. Regeneration stocking is transferred from the Environmental Data Collection Form 10 for the current year. Note that this area will usually be the coupes harvested three years previously.

FORM 4: road drainage by culverts

FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

**Instructions:** Drive along all the roads in the FMU. Select the worst 2 or 3 km for sampling. Then walk the road, pace distance between culverts and measure average road gradient. Also assess, for each culvert, the condition of inlet and outlet and whether they are clear. Use extra sheets as needed.

Distance from last culvert (m)	Road gradient between culverts (%)
AV =	AV =

Inlet protected against erosion? Y/N	Outlet protected against erosion? Y/N	Culvert blocked? Y/N

**STARTING SCORE = 130**  
**Scoring:** Calculate average distance between culverts and average road gradient. Look up the prescribed distance in the table below. If the actual average is more than the prescribed distance: **subtract 10 points.**

Inlets, outlets, blockages and size are *not* scored. The information is collected to show that you need to correct it.

Road gradient (%)	Distance between culverts (m)
4	110
5–8	90
9–10	80
11–12	70

**PROGRESS SCORE:**.....

**FORM 5: ROAD DRAINAGE BY SIDE DRAINS, BATTER & FILL SLOPES**

FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

**Instructions:** Every 50 metres<sup>ø</sup> along the road, assess side drain depths, blockages, road camber, and stability of batter and fill slopes over the whole 50 metre distance. Cover the distance assessed on Form 1.

**PROGRESS SCORE FROM FORM 4 = .....**

Side drain depth (cm)	Side drains free of blockages? Y/N		Road surface cambered* to get drainage? Y/N	Batter slopes stable? Y/N	Fill slopes stable? Y/N
	0-50	5-100			
0-50m	14	Y			
50-100	12	N			

**Scoring:**

Calculate average side drain depth. If it is less than 30 cm:

If side drains are blocked in more than 20% of the samples (>20% N):

If the road surface is not cambered\* in more than 20% of the samples (>20% N):

If batter and fill slopes are not stable in more than 20% of the samples (>20% N):

subtract 10 points

subtract 10 points

subtract 10 points

subtract 5 points

**PROGRESS SCORE = .....**

\* "Cambered" allows water to drain off the road, rather than collecting in puddles.

<sup>ø</sup> Pacing is accurate enough. Lay out a 50m tape and count how many paces, walking normally, you use to cover 50m.

## FORM 6: STREAM CROSSINGS

FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

**Instructions:** When the road crosses a perennial stream, check that a culvert, bridge or concrete ford has been installed to carry the stream. Also that there are culverts within 50m to prevent road drainage from entering the stream. The culvert cross-sectional area or space under a bridge needs to be about 1.5 times the cross-section of the stream channel\*. Assess at least five streams.

For all running streams, as they are found, fill in below:

Stream no.	Culvert or bridge to carry stream under road or concrete ford? Y/N	Culvert pipes or bridge big enough*? Y/N	Culverts within 50m of stream, each way? Y/N
1			
2			
3			
4			
5			
6			
7			

**PROGRESS SCORE FROM FORM 5 = .....**

### **Scoring.**

If there is no culvert, bridge or ford prepared for any of the streams,

**subtract 10 points**

If the culverts or bridges are not big enough for any of the streams,

**subtract 5 points**

If there are no diversion culverts for any of the streams,

**subtract 5 points**

**PROGRESS SCORE = .....**

- \* Commonly use culvert pipes have the following cross sectional areas. 30cm – 0.07m<sup>2</sup>, 60cm – 0.28m<sup>2</sup>, 90cm – 0.64m<sup>2</sup>, 120cm – 1.13m<sup>2</sup>
- \* Stream cross sectional area in square metres = Width of channel (m) x Depth on channel (m) x 0.5

## FORM 7: CABLE LINES

FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

**Instructions:** Walk along the centre of completed (i.e., utilised) cable lines and measure the following in sample sections of 100m. Assess at least half of the length harvested for the year (could be from several lines).

Total length of strip examined \_\_\_\_\_ (m)

Sample Section	Do all streams in cut strip have buffers? Y/N	Are all the buffers wider than 30m? Y/N	Are all the buffers free of lops/tops and stumps? Y/N — If N, say which.	Is the maximum slope in the strip less than 100%?* Y/N	Is the strip free of channels caused by manual extraction of timber? Y/N
1					
2					
3					
4					
5					
6					
7					
8					

**PROGRESS SCORE FROM FORM 6 = .....**

### **Scoring:**

If any of the streams have no buffers (ANY N)

subtract 10 points

If any of the streams have buffers < 30m wide (ANY N)

subtract 6 points

If any of the buffers include stumps (ANY stumps)

subtract 5 points

If any of the buffers have lops/tops (ANY lops/tops)

subtract 4 points

If more than 20% of samples are steeper than 100% (>20% N)

subtract 10 points

If any of the buffers include channels from manual extraction

subtract 5 points

**PROGRESS SCORE = .....**

\* Check the Management Plan. In some localities with unstable terrain the slope limit will have been set at 75%.

**FORM 8: interLINES**

FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

**Instructions:** Walk along the centre of the interline space between cable lines and assess the following in sample sections of 100m (could be from several lines). Assess at least half of the length harvested for the year (could be from several lines).

Total length of strip examined \_\_\_\_\_ (m)

Sample Section	During felling on the cable line, have trees been felled into the uncut strip causing damage to standing trees, saplings, regeneration? (Y/N)	Has felling/pitsawing of large trees (>35cm dbh) occurred in the cut strip since opening the coup? (Y/N)	Has cutting/removal of saplings taken place in the cut strip, for poles, fencing materials or other purposes since opening the coup? (Y/N)	Has lopping for fodder occurred in the uncut strip since opening the coup? (Y/N)	Does the uncut strip show signs of mineral soil disturbance and/or channeling caused by manual extraction of timber, poles and/or fuelwood since opening the coup? (Y/N)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

**PROGRESS SCORE FROM FORM 7 = .....**

**Scoring:**      If any Yes (Y) in column **1**      subtract **5** points  
                      If any Yes (Y) in column **2 or 3**      subtract **10** points  
                      If any Yes (Y) in column **4**      subtract **4** points  
                      If any Yes (Y) in column **5**      subtract **6** points

**FINAL SCORE:** .....



FORM 9: wildlife monitoring: animal (fauna) indicator species

FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

## TRANSECT &amp; NON-TRANSECT DATA SHEETS. (1)

## 1. Transect Data Sheet on Animal (Faunal) Indicator Species (check with original Inventory).

Date:			Team members:		List of Indicator Species for this FMU:
Transect Route:			1.		
Elevational Range:			2.		
Start Time for Transect:			Local Guide:		
End Time for Transect:					
				3.	
				4.	
				5.	

[illegible]

2. Non-transect Data Sheet on Animal (Faunal) Indicator Species (2)

Species	Location	Time	Observation	Group Size	Call	Remarks

3. Notes on Human related Activities (including hunting) on wildlife:

FORM 10: plant indicator species AND REGENERATION STOCKING

FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

**List of Plant (Flora) Indicator Species for this FMU (consult original Inventory for Main Canopy and important Understory Species):**

1.	6.	Team Members:
2.	7.	1.
3.	8.	2.
4.	9.	3.
5.	10.	Local Guide:

**1. Transect Data Sheet on Regeneration of Indicator Species in Cut-over Groups, Patches or Strips:**

**Date:** \_\_\_\_\_ **Transect location & route:** \_\_\_\_\_ **Elevational range:** \_\_\_\_\_

The total length of cable line harvested in the year should be examined. Divide this distance by 50. This is the distance between plots along the transect. Begin the transect along the cut over area(s) starting from a randomly located point, avoiding the cable line corridor. The transect need not be a straight line. At each plot location, consider only the genera/species listed above, both natural regeneration and planted trees combined. Look for established seedlings using a plot radius of 1.26m. If one of the above species is found, write the species number in the 'Stocked' box for that plot. Ignore any of the same species after you have found the first one, but continue to check for the others.

Plot No.	Stocked?	Plot No.	Stocked?	Plot No.	Stocked?	Plot No.	Stocked?	Plot No.	Stocked?	Plot No.	Stocked?
1		11		21		31		41			
2		12		22		32		42			
3		13		23		33		43			
4		14		24		34		44			
5		15		25		35		45			
6		16		26		36		46			
7		17		27		37		47			
8		18		28		38		48			
9		19		29		39		49			
10		20		30		40		50			

Percent Stocking for Indicator Spp
= No. of stocked boxes x 2
= _____ %

Percent Stocking for Commercial Spp
= No. of stocked boxes x 2
= _____ %

☐ 1a. Note whether planted species include any that are not on the list of up to 10 local mature canopy species (indicator species) given above (e.g., *Cupressus* in a broadleaved forest area) (Y/N) Comment: \_\_\_\_\_

☐ 1b. Note also whether planted trees are well mixed by species (i.e., they do not form even small blocks of the same species) (Y/N)

2. Transect Data Sheet on Regeneration of Indicator Species in the Interline (Uncut) Strips:

Date: \_\_\_\_\_ Transect location & route: \_\_\_\_\_ Elevational range: \_\_\_\_\_

(Begin a transect along the centre of the uncut strip, starting from a randomly located point inside the uncut forest. Stay at least half a tree height from any edges. Assess plots systematically, the same distance apart as the plots on page 1 of this form. The transect need not be a straight line. Consider only the genera/species listed on page 1. Count seedlings up to 5 m in height using a plot radius of 2.06 m. (it is intended that seedlings up to 10 years of age will be included in this count). Put the species numbers in the 'Stocked' box when you find them, as for page 1.

Plot No.	Stocked?	Plot No.	Stocked?	Plot No.	Stocked?	Plot No.	Stocked?
1		11		21		31	
2		12		22		32	
3		13		23		33	
4		14		24		34	
5		15		25		35	
6		16		26		36	
7		17		27		37	
8		18		28		38	
9		19		29		39	
10		20		30		40	

Percent Stocking

= No. of stocked boxes x 2

= \_\_\_\_\_ %

☐ 2a. Note intrusion of any 'exotic' 'weed' species (e.g., clover, pasture grasses, shrubs or trees from outside the operational area) (Y/N)

Comment: \_\_\_\_\_

3. Notes on Human-related activities including the incidence and intensity of grazing by domestic livestock, collection of medicinal plants and harvesting of other NWFPs: \_\_\_\_\_

### **Notes to Assist in Completing Form 10**

Regeneration stocking is measured to assess (by comparison with an acceptable standard) whether or not there are enough young trees to develop into a fully stocked mature stand.

Different standards for acceptable stocking will be nominated for plantations and natural stands. For stands that will be regenerated naturally, a standard will usually be nominated through observation of what seem to be well stocked stands of natural regrowth. For plantations, acceptable stocking is usually defined as percentage survival of the planted trees, these having originally been planted at a density thought to be sufficient to develop into a fully stocked mature stand.

For broadleaf forests in Eastern Bhutan, even when a stand is regenerated by planting, natural regeneration may well occur in addition and it is desirable that the standard adopted can assess the total stocking, not just one component or the other.

#### ***Measuring regeneration stocking***

Regeneration stocking can be expressed either as seedling stocking per hectare, or as percentage stocking by quadrats of a nominated area.

Seedling stocking per hectare is estimated by establishing sample plots throughout the area of regeneration, counting the acceptable seedlings on each plot, deriving an average for the sampled area and converting it to per hectare terms. A detailed Guideline for assessing Regeneration in terms of stocking/ha in the Forest Management Units is prescribed in the “Guideline for Regeneration survey in the Forest Management Units” in the following section.

The stocked quadrat method involves the concept that, for acceptable stocking, a certain area of growing space needs to be occupied by at least one free-to-grow individual of a desirable species. To measure regeneration stocking, one would lay out a number of sample plots, each with an area equivalent to this growing space, and look to see if there is **at least one** free-to-grow individual present (i.e., if they are “stocked” or not). One then divides the number of stocked plots by the total number of plots measured to obtain the ‘percentage stocking’ of the site.

The stocked quadrat method is clearly much quicker to apply, since the plot only has to be searched until the **first** acceptable seedling is found. However, there are problems involved with interpreting the results in the context of number per hectare stocking. If it was decided that 1000 stems/ha were the minimum acceptable stocking, and a quadrat size of 0.001 ha were used, it is important to note that 100% stocking by 0.001 ha would **not** be equivalent to 1000 stems/ha, because at least some of the quadrats would have had more than one stem on them, and it is not known how many more, since they were not counted. The actual density is therefore an unknown amount more than 1000 stems/ha. In practice, since it is the **minimum** stocking that is considered important, the disadvantage of not knowing the exact stocking is considered to be out-weighted by the ease of implementing the method. To allow for the fact that actual stocking is almost always going to be greater than the minimum, the acceptable standard used is usually reduced to around 70% for the nominated quadrat size. For example, 70% stocking by 0.001 ha plots is roughly equivalent to a stocking of 1000 stems/ha.

The simplest way to lay out a sample plot (quadrat) is to cut a stick with length equal to the radius of a circle that has the area desired. Taking the example of a target density of 2,000 stems per hectare and, therefore, a growing space of 5 m<sup>2</sup> (10,000 m<sup>2</sup>/2,000), this leads to a plot radius (r) of 1.26 m ( $5 = \pi r^2$ ;  $r^2 = 5/\pi$ ;  $r = \sqrt{5/\pi}$ ).

**The standard proposed for broadleaf forest in Eastern Bhutan is 70% stocking by 5m<sup>2</sup> plots, i.e. approximately 2000 acceptable seedlings per hectare, one year after harvesting.**

FORM 11: – community participation rra checklist

FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

What location for interview? (Tick): ☐ Villa ☐ Telling ☐ Working on ☐ Other \_\_\_\_\_

Community the people come from \_\_\_\_\_ Team Members: 1. \_\_\_\_\_ 2. \_\_\_\_\_

How many MEN in group interviewed? \_\_\_\_\_ WOMEN? \_\_\_\_\_ 3. \_\_\_\_\_ 4. \_\_\_\_\_

**Interviews should be unstructured, using open ended questions (Not Yes/No questions) to obtain the following information. Use one sheet for each interview. These subjects/questions are only a start - ask more to get detail when the opportunity arises. Use the RRA techniques of ‘probing’ to learn more about discussion topics that seem important.**

**A. Local Community Participation (Indicator 1.7)**

1) How did they learn about the existence of the nearby FMU? \_\_\_\_\_

2) What activities do they know about that go on in the FMU? \_\_\_\_\_

3) How have the commercial activities in the FMU affected their traditional resource use? \_\_\_\_\_

4) How and when were they consulted about their use of the FMU? \_\_\_\_\_

5) Were there any village meetings about the activities in the FMU? \_\_\_\_\_

- When? \_\_\_\_\_
  - Who went to the meeting from the village? \_\_\_\_\_
  - How were they involved in the meetings? \_\_\_\_\_
  - What were the results of going to the meeting? \_\_\_\_\_
- 6) Is there a Management Committee (or similar forum) for the FMU on which communities are represented? \_\_\_\_\_
- When was the Committee formed? \_\_\_\_\_
  - Who is on the Committee from the village? \_\_\_\_\_
  - What are the results of being on the Committee? \_\_\_\_\_

7) Other Observations or Comments on Participation... : \_\_\_\_\_



**B. Extent to Which Community Needs are Met from the FMU (Indicator 1.8)**

1) What products does the community get from the FMU?

---

2) How often?

---

3) Which products are needed annually, biennially, occasionally?

---

---

4) Which products can be obtained from elsewhere? Where?

---

---

5) If some or all products were not available from the FMU, what would you do?

---

---

6) Which products can still be obtained from the FMU?

---

7) Which products can't be obtained from the FMU now?

---

8) Other Observations or Comments about the FMU Meeting Local Needs...

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MONITORING FORM **A** (ANNUAL) FMU \_\_\_\_\_ Filled in by \_\_\_\_\_ Date \_\_\_\_\_

Responsibility: Chief Forestry Officer

**Instructions:** Each indicator is in a separate box. Read the bold type describing the indicator in the top left hand corner, then the Standard in the next cell to the right. Then do the Calculations in the cell below. Then update the Progress Score. Do this for every indicator.

Abbreviations: **CFO** = Chief Forestry Officer

**UIC** = Unit in Charge

**FMU** = Forest Management Unit

**NRDCL** = Natural Resources Development Corporation Limited.

**AAC** = Annual Allowable Cut

**FINAL SCORE** = ..... (Transfer from end of form)

**INITIAL SCORE** = 0

Indicator	Standard	Progress score	Corrective action required, if any
<b>1.1. Annual wood volume removed compared with AAC</b>	Annual removal not greater than AAC +/- 10%	If the removal is less than the AAC +10%, add 10 points to the initial score.	
Calculations Total of all Timber cut this year by NRDCL = _____ Any other wood or timber removed = _____ Any timber left in the forest = _____ Total timber removed from Production WC= _____ AAC from FMU plan + 10% = _____ Difference = _____		<b>PROGRESS SCORE</b> = .....	
<b>1.2. Annual removal of NWFP cf sustainable cut</b>	Annual removal not greater than AAC +/- 10%	If the removal is less than the AAC +10%, add 10 points to the Progress score If an AAC has not yet been calculated, carry the score forward unchanged.	
Calculations Total of all NWFP cut this year from permit statistics for the whole FMU = _____ Any other known removals = _____ Total for the FMU for the year = _____ AAC from FMU plan + 10% = _____ Difference = _____		<b>PROGRESS SCORE</b> = .....	

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Indicator	Standard	Progress score	Corrective action required, if any
1.3. Percent of area of cut stands successfully regenerated  (See Note No.3, under: 'Notes to Assist in Completing the Forms', attached below)	Not less than current standard (70%). If natural regeneration has occurred, include it.	If the stocking is more than 70%, add 10 points to the Progress score	
Calculations  Stocking percent for the area utilised the previous year = _____ =.....		PROGRESS SCORE = .....	
1.4. Area of forest with significant soil erosion or risk to water quality	Assessment of roads and stream buffers via FORM 4-8		
Calculations  Divide the Final Score by 13 and add the result to the Progress Score		PROGRESS SCORE = .....	
1.5. Area of forest managed to protect cultural, social, spiritual values	Not less than at FMU establishment	If new provisions are made to protect these values, add 10 points to the Progress Score.	
Calculations  Obtain area data through RRA during the preparation of Operational Plans.		PROGRESS SCORE = .....	
1.6. Extent to which community needs are met from FMU.	No decrease on base-line at creation of FMU.	If needs are still met, add 5 points to the Progress Score	
Calculations  Determine through RRA whether community needs are still being met this year to the same extent they were at the start of the FMU Plan		PROGRESS SCORE = .....	

1.7. Extent of involvement of local communities in forest management	1. Village meetings held this year? 2. Application form in? 3. Community involvement in FMU Mgmt or Steering Committee?	Add 5 points to the Progress Score for every Yes answer	
Calculations Review these four questions every year.		PROGRESS SCORE = .....	
1.9. Institutions provide for forest planning including periodic review and cross sector coordination	1. FMU plan current? 2. Operational plan current? 3. Steering Committee convened?	Add 5 points to the Progress Score for every Yes answer	
Calculations Review these three questions every year.		<b>FINAL SCORE</b> =.....	

# EVALUATION FORM A (FIVE-YEAR) FMU \_\_\_\_\_ Filled in by \_\_\_\_\_

Date \_\_\_\_\_

**Responsibility:** Evaluation Team

**Instructions:** Each indicator is in a separate box. Read the bold type describing the indicator in the top left hand corner, then the Standard in the next cell to the right. Then do the Calculations in the cell below. Then update the Progress Score. Do this for every indicator.

Abbreviations: **CFO** = Chief Forestry Officer

**UIC** = Unit in Charge

**FMU** = Forest Management Unit

**NRDCL** = Natural Resources Development Corporation Limited

**AAC** = Annual Allowable Cut

**FINAL SCORE** = ..... (Transfer from end of form) **INITIAL SCORE** = 0

Indicator	Standard	Progress score	Corrective action required, if any
<b>1.1. Annual timber volume removed compared with AAC</b>	Removal not greater than AAC on 5 year average	If the removal is less than the AAC, add 10 points to the Initial Score	
<u>Calculations</u> Total timber removed from Production WC over the last five years (Get this from the last five annual monitoring Form A) Divide by five to give 5 year average AAC from FMU plan		PROGRESS SCORE = .....	
<b>1.2. Annual removal of NWFP sustainable cut</b>	Removal not greater than AAC on 5 year average	If the removal is less than the AAC, add 10 points to the Progress Score.	
<u>Calculations</u> Total NWFP removed from the FMU over the last five years = ..... (Get this from the last five Form A) Divide by five to give 5 year average = ..... AAC from FMU plan = .....		If an AAC has not yet been calculated, carry the score forward unchanged. PROGRESS SCORE = .....	
<b>1.3. Percent of area of cut stands successfully regenerated.</b>	Not less than current standard (70%). If natural regeneration has occurred, include it.	If the stocking is more than 70%, add 10 points to the Progress Score.	
<u>Calculations</u> Average stocking for the areas utilised in the last five years = ..... (See Note No.3, under: 'Notes to Assist in Completing the Forms').		PROGRESS SCORE = .....	
<b>1.6. Extent to which community needs are met from FMU.</b>	No decrease on baseline at creation of FMU.	If there is no decrease, add 5 points to the Progress Score.	

<u>Calculations</u> Use the data from the last five Form A to determine whether community needs are still being met to the same extent they were at the start of the FMU Plan.		PROGRESS SCORE = .....	
Indicator	Standard	Progress score	Corrective action required, if any
1.7. Extent of community participation in forest management	Demonstrable progress towards a Community involvement based on the Form A indicators.	If the fifth year Form A score for this indicator is higher than the first year, add 10 to the Progress Score. PROGRESS SCORE = .....	
<u>Calculations</u> Increasing frequency of meetings, application made, management plan being prepared. (See Note No.5, under: 'Notes to Assist in Completing the Forms').			
2.1. Forest type area as a % of total forest area	Not less than at FMU establishment (pre-harvest).	If none of the forest type areas have been reduced, add 10 points to the Progress Score.  PROGRESS SCORE = .....	
<u>Calculations</u> Update area statements for forest types in the FMU either from remote sensing or ground survey of forest types. See Note 1 re planted forest. Has utilisation reduced the area of any forest type compared with the area at FMU establishment? What % reduction? FT1..... FT2..... FT3..... FT4..... FT5..... FT: Forest Type.			
2.2. Forest type area by age class	Not less than 15% of total forest type area in FMU to be mature class. See Note 2.	If the percentage of mature forest for all forest types is greater than 15%, add 5 points to the Progress Score.  PROGRESS SCORE = .....	
<u>Calculations</u> New forest type mature area = initial area for whole FMU - area of mature forest utilised. Calculate %. FT1..... FT2..... FT3..... FT4..... FT5.....			
2.3. Forest type area reserved from timber utilisation	Not less than 15% of area at FMU establishment. See Note 2.	If the percentage of all forest types in the Protection WC is greater than 15%, add 5 points to the Progress Score. PROGRESS SCORE = .....	
<u>Calculations</u> Forest type area in Protection WC still > 15% of forest type area in FMU? FT1..... FT2..... FT3..... FT4..... FT5.....			
2.4. Protection WC connects within FMU and to external Protected Areas	Yes/No	If connectivity has <b>not</b> been reduced, add 5 points to the Progress Score. PROGRESS SCORE = .....	
<u>Calculations</u> Examine FMU maps and external land use maps. Have new Operational Plans over the last five years reduced connectivity?			



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Indicator	Standard	Progress score	Corrective action required, if any
<b>2.5. List of forest dwelling species, both flora and fauna. Indicators only</b>	No significant decrease from FMU start	Add 10 points to the Progress Score for no decrease in Wildlife and a further 10 points for no decrease in Flora. PROGRESS SCORE = .....	
<u>Calculations</u> Examine trend in observations made on the Wildlife and Flora Monitoring Forms for the last five years- consult with wildlife and flora experts.			
<b>2.6. Net area of forest available for production</b>	No reduction from baseline at FMU start except for changes needed to maintain conservation values	If net area has <b>not</b> been reduced, add 5 points to the Progress Score.  PROGRESS SCORE = .....	
<u>Calculations</u> Any reduction in total Net Productive Area for the FMU over the five year period ( <b>except</b> for new conservation reserves)?			
<b>2.7. Total area of plantations</b>	Increase in total net forest area through plantations is appropriate. But the regeneration of utilised forest by plantation is only acceptable in the short term until natural regeneration techniques can be developed.	If net area of plantations has <b>increased</b> , add 5 points to the Progress Score.  PROGRESS SCORE = .....	
<u>Calculations</u> What is the area of new plantations? Include replanting of utilised areas if they failed the test given in Note 1.			
<b>2.8. Area of forest managed for protective functions; watershed, landslide protection, riparian zones</b>	No decrease on baseline at creation of FMU	If area of the Protection WC has <b>not</b> been reduced, add 5 points to the Progress Score. PROGRESS SCORE = .....	
<u>Calculations</u> Area of Protection WC in FMU plan =..... New area =.....			
<b>2.9. Calculation of AAC</b>	Area only? Area/volume?	Add points to the Progress Score according to the following. 5 points for Area only 10 points for Area and Volume FINAL SCORE =.....	
<u>Calculations</u> Examine the FMU plan to determine the basis of calculating the AAC (See Note 6)			

# EVALUATION FORM B – (1<sup>ST</sup> FIVE-YEAR) FMU \_\_\_\_\_ Filled in by \_\_\_\_\_

Date \_\_\_\_\_

Responsibility: Evaluation Team

**Instructions:** The Evaluation Team should study the documents relating to policy, legislation, institutional procedures and Departmental guidelines that apply to forest management and form an opinion as to whether each indicator is covered. If the characteristics required by the indicator are present, the Progress Score should be incremented for that indicator.

**FINAL SCORE** = ..... (Transfer from end of form)

**INITIAL SCORE** = 0

- Extent to which the legal framework (laws, regulations, MoAF policy) supports the conservation and sustainable management of forests, including the extent to which it:

Indicator	Standard	Progress Score	Corrective action required, if any
3.1. Clarifies property rights, provides for appropriate land tenure arrangements, recognises customary and traditional rights of indigenous people, and provides means of resolving property disputes by due process;	Presence / Absence	+5 for Presence PROGRESS SCORE = .....	
3.2. Provides for periodic forest related planning, assessment and policy review that recognises the range of forest values, including co-ordination with relevant sectors	Presence / Absence	+5 for Presence PROGRESS SCORE = .....	
3.3. Provides opportunities for public participation in public policy and decision making related to forests and public access to information	Presence / Absence	+5 for Presence PROGRESS SCORE = .....	
3.4. Encourages best practice codes for forest management;	Presence / Absence	+5 for Presence PROGRESS SCORE = .....	
3.5. Provides for the management of forests to conserve special environmental, cultural, social and/or scientific values.	Presence/ Absence	+5 for Presence PROGRESS SCORE = .....	

- Extent to which the institutional framework (departmental guidelines) supports the conservation and sustainable management of forests, including the capacity to:

Indicator	Standard	Progress Score	Corrective action required, if any
3.6. Provide for public involvement activities and public education, awareness and extension of programs, and make available forest related information;	Presence/ Absence	+5 for Presence PROGRESS SCORE = .....	
3.7. Develop and maintain human resource skills across relevant disciplines	Presence/ Absence	+5 for Presence PROGRESS SCORE = .....	
3.8. Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management	Presence/ Absence	+5 for Presence PROGRESS SCORE = .....	
3.9. Enforce laws, regulations and guidelines	Presence/ Absence	+5 for Presence FINAL SCORE = .....	

**Notes to Assist in Completing Monitoring Form A, and Evaluation Forms A and B**

**1. When does re-establishment by planting change the forest type?**

This is important both for the conservation of biodiversity and of forest types (indicators 1.1, 2.1, 2.2, 2.3). The important consideration is to what degree the composition of the tree strata has been changed (it is also important that the understory species have been relatively undisturbed by the utilisation operation). A list to compare number of tree species would be the simplest, but would ignore the fact that the number of stems (and basal area) is different for different species. This concept is difficult to implement because year zero stem densities would have to be compared with mature age stem densities. The simple solution is therefore adopted: plantations do not replace the biodiversity of the existing forest unless more than 80% of the original tree species are replaced by planted **and** naturally regenerated trees. It is important that when a mixture of species is used that they are actually mixed up together on a tree by tree basis, not planted in blocks of single species.

**2. Why is 15% an adequate reserve for forest types?**

The IUCN has adopted 10% as a reasonable standard for retention of protected areas. Bhutan has already set aside 26% of its land area as 'protected'. However, these are concentrated blocks of forest of high conservation value. It is also necessary to set aside a reasonable proportion of forest outside reserves to provide connection corridors and refuge habitat within forest production areas. Given that Bhutan has a wealth of forest resources, it is reasonable to increase the IUCN proportion in anticipation that the long term situation will not be so advantageous. Most FMUs already exceed this proportion anyway through protection of stream-side buffers, water catchments and inaccessible forest.

'Mature' age class means forest that is approaching the oldest that the particular species gets before it dies. It is necessary to maintain a proportion of this sort of forest because it is usually the most diverse in terms of the species present and the habitats that are available for animals. Trees have large spreading crowns, sometimes broken and dead branches, large stem diameters, epiphytes may be common. Actual age may be from 150 to several hundred years.

**3. How will successful regeneration of utilised stands be judged?**

In eastern Bhutan, stocking estimates of harvested stands are first taken in the year following utilisation when it is still possible to refill any failed areas. Stocking is checked again three years after harvesting, by which time it is too late to establish new seedlings. For annual monitoring, the indicator is to be assessed using stocking for the area planted in the previous year. For five-year evaluations, the most up to date estimates of stocking for each area utilised in the last five years are to be averaged and compared to the standard.

**4. How is the actual cut calculated (for comparison with the AAC)?**

FMU plans calculate an Allowable Annual Cut on the basis of the **whole** productive area and the expected rotation. Thus, **all** material that comes out of the Production Working Circle, not just the volumes that come from clear felling along cable lines, must be included in the removal that is compared with the AAC. This includes timber cut for rural use, either as timber trees or as fuel wood, by single tree or group selection. It is also crucial that all material **felled but not removed** is included in the 'actual cut'. An estimate of what the removal should be can be made from the utilised area (hectares) multiplied by the average total volume from the Operational Inventory. If there is a large difference between this estimate and the actual removal, there is something wrong with either the inventory or the actual removal.

Some FMU Plans allow removal of forest produce from working circles (other than the Production Working Circle) for community use. These removals cannot be checked using the process described here because they are not included in the AAC. This is unlikely to be a problem because the removals should be small. However, the Unit-in-Charge should monitor community activities outside the the Production Working Circle to ensure that they are not locally concentrated to the extent that they affect biodiversity, water quality or soil stability.

## 5. What is 'Demonstrable progression' towards a CFMU?

The initial step towards a CFMU is an expression of interest by a community, probably following RRA activities associated with the establishment of the FMU. A series of meetings would be necessary to explain the responsibilities and benefits involved and to determine the boundaries of the area needed. This is followed by the submission of an application form and a continued series of meetings and negotiations. The necessary elements for 'Demonstrable progress' are the application form and the continuation of meetings to work towards the CFMU.

## 6. What are the different ways to calculate AAC?

The two methods considered are defined, as follows:

- **Area Only.** The total area of the Production WC is divided by the rotation to give an area to be harvested every year. This results in variation in the volume harvested per year, because of variation in stocking among different stands in the forest.
- **Area and Volume.** The area calculated above is multiplied by the average total volume per hectare to give a volume figure. This volume is the AAC. When this is used, the area utilised will be lower than average in well stocked stands and higher than average in poorly stocked stands. Planning for regeneration treatments need to take this variation into account.

### Box 1.15 Regeneration Survey Guidelines

#### REGENERATION SURVEY GUIDELINES

##### BACKGROUND

Timber harvesting is permitted by management plans with the assumption that operated areas are successfully regenerated. An important condition in plans is that harvested areas are regularly surveyed and timely remedial action taken in the event the regeneration fails. The guidelines for regeneration survey have been developed to enable the field staff to quickly and reliably analyze the regeneration status to ensure timely action is taken in case of insufficient regeneration.

##### REGENERATION SURVEY AREAS

Regeneration survey is required in forest areas harvested under different silvicultural systems. The main silvicultural systems that are being prescribed in management plans are:

- a) **Group Selection System** - Small group openings of around 0.15 ha. Regeneration openings are arranged along cable crane corridors so that the timber can be easily extracted. The opening and corridors account for about one third the standing volume in the annual coupe. The group openings and the cable crane corridors have to be regenerated.
- b) **Seed Tree System** - In this system, around 20 seed trees per ha. are retained and the rest of the crop removed from annual coupe. This system is usually prescribed for Chir and Blue pine forests.
- c) **Selection System** - In this system about the growing stock is removed from the annual coupes giving preference to over mature and deformed trees.
- d) **Clear Felling / Strip Felling System** - The annual coupes are clear cut and replanted.

##### TERMS AND DEFINITIONS

In order to understand and facilitate easy explanation of the survey method, it is necessary to standardize terms and definitions. The terms mostly involve various parts of an annual coupe. The type of annual coupes can be divided into two distinct groups for the purpose of regeneration survey:

1) Group Selection Coupes

2) Clear Felling Coupes, Shelterwood Coupes, or Seed Tree Coupes.

The survey procedure discussed in this paper is not suited for selection coupes.

Layout of a group selection coupe

After the harvesting operations are over, an annual coupe in a group selection system appears as given in the diagrams. Various parts relevant to regeneration survey are marked and the terminology defined as follows:

a) Cable line no.: The specific number given to each cable crane line in a coupe. Cable lines are numbered from 1 to the number of cable crane lines in sequence.

b) Base line: The starting point of a cable crane line on either end of the corridor from where regeneration survey is started.

c) Group opening: The area clear felled to create the regeneration opening including the portion of the corridor crossing the group opening. Group openings are numbered serially from one to the number of openings starting closest to the base line.

d) Corridor Section: The part of the corridor between the base line and the closest group opening, between the groups, or between the last group and the end of the corridor. For the purpose of reference they are numbered serially from the base line to the other end.

Lay out of a clear cutting or Shelterwood annual coupe

All are familiar with a clear cutting or shelterwood coupe. However, for the purpose of regeneration survey of a large area the annual coupes have to be sub-divided into smaller units. This division should be divided considering natural features, aspect, soil conditions etc. The definitions employed are as follows: a) Sub Coupe: Part of an annual coupe of not more than 2 ha which is divided by natural features or permanent manmade features such as roads, of uniform topography, aspect, soil conditions etc. The annual coupe is divided into a number of sub coupes for the purpose of regeneration survey and given specific numbers and mapped for reference (see Figure 1).

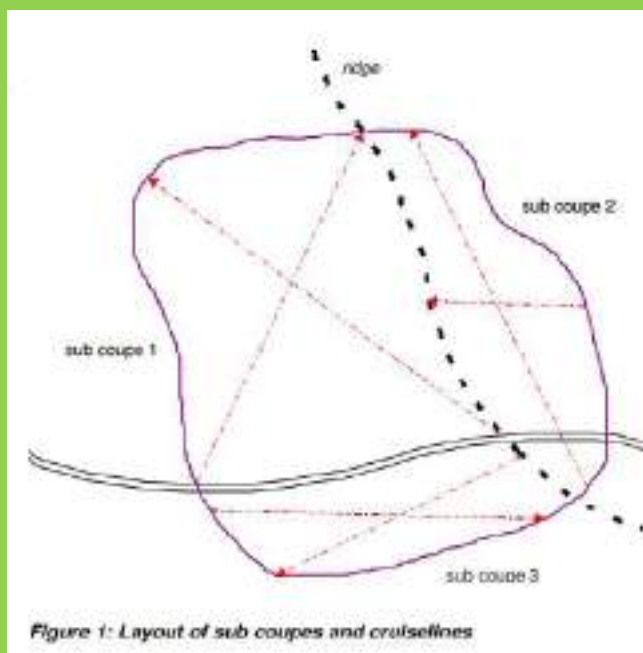


Figure 1: Layout of sub coupes and cruiselines

Others

a) **Cruiseline** - This is a straight line located in a sub coupe, group opening or a cable line along which regeneration survey is conducted.

b) **Quadrant** - It is a regeneration plot of 2 m x 2 m measured on either side of the cruiseline. The plots on the left side are called the (a) quadrants and the plots on the right side of the cruiseline are called the (b) quadrants. They are numbered serially as (a) and (b) quadrants from the start to the end of the cruiseline.

**c) Regeneration count** - Regeneration count is the number of seedlings found in the quadrant. A seedling of 5 cm height and above is counted as 1. Seedlings of below 5 cm height are counted 1 for three numbers only.

#### Equipment

1. Compass
2. Altimeter
3. Clinometer
4. Map
5. 2 meters length pole/stick
6. Scale for measuring seedling height
7. Regeneration survey form
8. Species Codes list

#### LAYING OUT OF THE CRUISELINES

##### Corridors

In each section of the corridor between the groups, stand in the middle and lay a line along the length of the corridor. The starting point in each section should be indicated with a stick and the compass direction noted.

**Group openings and or coupes** Inspect the group openings or sub coupes and decide on the two best diagonal lines as indicated in the diagram. The diagonal lines should be of maximum possible lengths given the shape of the survey area and the terrain. The compass direction of each cruiseline should be noted (see Figure 2).

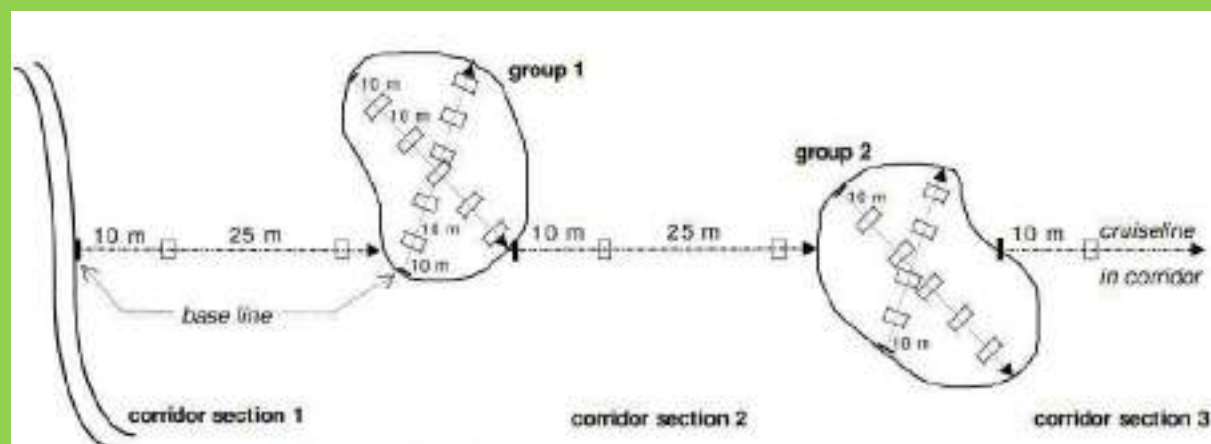


Figure 2: Layout of cruiselines and quadrants

#### MEASUREMENTS

Start with recording the general information in the top of the form. Also tick the appropriate silvicultural system. For Clear Cutting and other systems, use the appropriate form. For Group Selection System there is a separate form. Slope correction should be done by holding the tape or measuring stick as much as possible horizontal, thereby eliminating the need for a slope correction table. In steep terrain, the tape length should be adjusted accordingly with the above in mind.



### Corridor

In a corridor, record the cableline number and start from the baseline line (which is usually at the edge of the road) and record the compass direction of the corridor. Proceed 10 meter into the corridor to the first quadrant. After recording the first quadrant, proceed 25 meter along the cruiseline to the next quadrant (2a and 2b etc.) and continue in this way until the end of the cruiseline is reached (i.e. upon reaching a group opening or at the end of the corridor, see Figure 2). After completion of survey of a group, the cruiseline in the corridor should be continued. Make a new baseline at the edge of the group and proceed in the right bearing for first 10 meter and after that every time 25 meter until again at the end of the cruiseline.

### Group

In a group, start the first quadrant 10 meters from the baseline (i.e. the edge of the group opening). This will be quadrant 1a and 1b. Continue moving along the cruiseline 10 meters at a time and lay out quadrant 2a and 2b, etc. Continue in this manner until the end of the cruiseline is reached (i.e. at the end of the group). Repeat the procedure on the other diagonal cruiseline.

### Sub coupe

In a sub coupe, start from the baseline line at the edge of the sub coupe and record the compass direction of the cruiseline. Proceed 25 meter into the coupe to the first quadrant. After recording the first quadrant, proceed 50 meters along the cruiseline to the next quadrant (2a and 2b etc.) and continue in this way until the end of the cruiseline is reached at the end of the sub coupe. Repeat the procedure on the other diagonal cruiseline.

### Quadrant

Take the 2-meter stick. Place one end to your body and hold it horizontal. Standing on the starting point of the cruiseline, hold the stick perpendicular to the cruiseline on the left side and then direct the stick along the cruiseline. Approximately note the square area (quadrant 1a) covered by the stick (see Figure 3). Count the number of seedlings and enter the number in the form (refer to seedling count below). Repeat the procedure on the right side of the cruiseline (quadrant 1b).

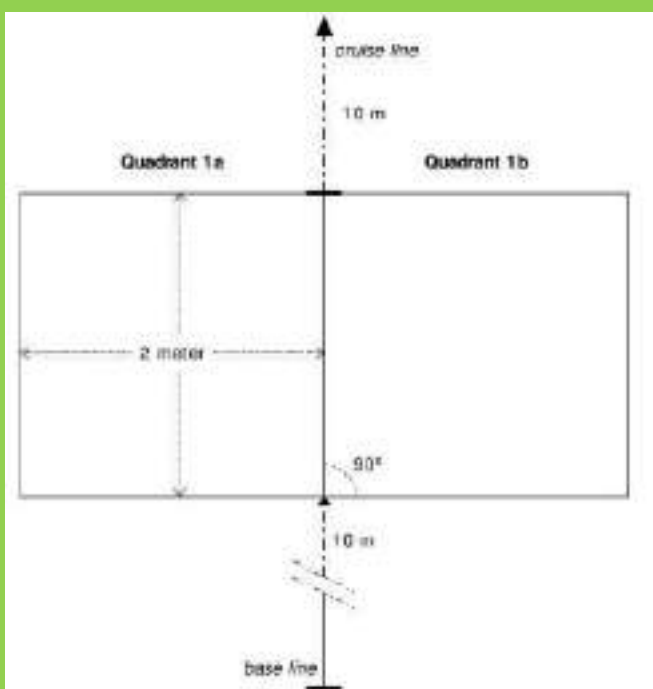


Figure 3: Design of the quadrants

### SEEDLING COUNT

Record the number of seedlings of the main commercial species in the quadrant 1. Give one point to each seedling of more than 5 cm height and one point to every 3 seedlings with less than 5 cm height or to seedlings of inferior quality (broken top, trampled, browsed, etc.). Subsequently, give one point for 2 seedlings and zero points for 1 seedling. For instance, if one finds 1 seedling of 10 cm and 6 seedlings of 3 cm, the number to be recorded on the form is 3. Seedlings on stumps or stones should not be included in the counting. While counting in this way, 1 seedling per quadrant will give 2,500 seedlings per ha of more than 5 cm or 7,500 seedlings per ha of less than 5 cm. If one is interested to find out the success or failure of the planted seedlings in a plantation, the plants and natural regeneration can be recorded separately, e.g. by

dividing the regeneration count column in 2. Also analyze the main specie(s) of the quadrant by noting down the species codes 2 .

## SITE CONDITIONS

The site conditions should be recorded in the appropriate columns in order to try to analyze possible relationships with the regeneration status.

### Weed assessment

- a) Light weed growth = L (no need for weeding)
- b) Medium weed growth = M (weeding necessary)
- c) Heavy weed growth = H (weeding necessary)

You may add B if the weed is predominantly bamboo.

### Grazing/Trampling

- a) Light grazing/trampling = L (fencing not required)
- b) Moderate grazing/trampling = M (fencing required)
- c) Heavy grazing/trampling = H (fencing required)

## CALCULATIONS

Calculations must be done for each group opening, sub-coupe or corridor section separately according to the following formula:

$$\frac{(C1 + C2)}{(Q1 + Q2) \times 8} \times 10,000$$

Where C1 and C2 is the total number of seedlings in the quadrants of each cruiseline. Q1 is the total number of quadrants in cruiseline 1 (A + B = 1) and accordingly for Q2.

While recording in a corridor, there will only be one cruiseline. Therefore the formula will be adjusted in the following way:

$$\frac{C}{Q \times 8} \times 10,000$$

### Analysis of results

1. If the regeneration is more than 2,000 per ha, then the area is successfully regenerating.
2. If the regeneration is 1,000 up to 2,000 per ha, the regeneration is doubtful. The area should be resurveyed in the fifth year. Some immediate action could be taken up, e.g. soil scarification, seed broadcasting, grazing control, etc.
3. If the regeneration is less than 1,000 per ha, the area is not regenerating adequately. Immediate action is required in the blank areas (see above). If the status remains as it is till 5 years after the area was harvested, the area should be planted up.
4. The distribution of the seedlings should also be analyzed. If several quadrants in a cruiseline have a value of 0 and some a high value, then the overall number per ha can still give a satisfying picture. However, regeneration is doubtful because some areas are blank. In this case action could

also be taken to promote regeneration in the blank areas. The area should be resurveyed in the fifth year.

#### **TIME OF SURVEY**

Regeneration survey should be conducted 3 years after harvesting or planting of the area. If the result is not satisfactory, it should be repeated in the 5th year after which a decision is made on whether the area has adequately regenerated or action is necessary. The best time of the year seems to be right after the winter when snow has melted and before the new growing season for conifer and temperate broadleaved forests. Depending on the site, the timing will vary slightly. For (sub-) tropical rainforest, the time of survey should preferably be done before the monsoon season so immediate action can be taken in case of unsatisfactory results.

#### **ACCURACY**

One way to improve the accuracy of the results is by making a survey unit small as possible. In the case of group openings, the survey unit is only around 0.15 ha in area. A reconnaissance survey of the area may reveal areas that are definitely not regenerated. Such areas can be separated out from the survey and mapped as unregenerate. The accuracy can be improved by putting in more cruiselines if needed. In this case systematic grid lines at regular intervals would be more appropriate. The parallel grid lines may run in any convenient direction.

### **1.15 Bibliography**

- Laumans, P. (1991) Inventories for forest resources management in Bhutan. A handbook for field implementation, Working Document No. 8, DP/BHU/85/016, Department of Forests, Royal Government of Bhutan and FAO.
- Laumans (1992) Use of plot system, FAO DP/BHU/91/002, UNDP/FAO Forest Resources Management and Institutional Development Project, Royal Government of Bhutan, Ministry of Agriculture, Department of Forestry.
- Laumans, P. (1994a) Guidelines for Forest Management Inventory Fieldwork. Working Document No.4, FAO DP/BHU/91/002, UNDP/FAO Forest Resources Management and Institutional Development Project, Royal Government of Bhutan, Ministry of Agriculture, Department of Forestry.
- Laumans, P. (1994b) Height-Diameter Functions from PIS for Country-Level Site Classification and Local Volume Table Selection, FAO DP/BHU/91/002, UNDP/FAO Forest Resources Management and Institutional Development Project, Royal Government of Bhutan, Ministry of Agriculture, Department of Forestry.
- Leech, J.W. (1997) Report on forest inventory and data processing consultancy, UNDP/FAO Forest Resources Management and Institutional Development Project and Forest Services Division, ministry of Agriculture, Royal Government of Bhutan..
- Määttä (1993) Plot system programme, FAO DP/BHU/91/002, UNDP/FAO Forest Resources Management and Institutional Development Project, Royal Government of Bhutan, Ministry of Agriculture, Department of Forestry.
- Schieler, K. (1991) Local Forest Inventory, Bumthang, Wangtha-La Thrumsing-La. Volume 1, Integrated Forest Management Project.
- Whitfield, P. (2001) Planning and implementation for sustainable FMU management, Wang Watershed Management Project ALA/97/50.
- Armitage, I. (1998) Guidelines for the management of tropical forests 1. The production of wood. FAO forestry paper 135, FAO Forestry Department, Forest Resources Division. Available online at <http://www.fao.org/docrep/W8212E/w8212e00.htm> (date accessed 27 February 2003).

- Branney, P. (2002) Guidelines for forest management planning and operational planning (draft), Wang Watershed Management Project ALA/97/50.
- Dhital, D.B., M. Pushparajah & M. Maatta (1992) Management plan for Gidakom forest management unit: Thimphu District. Period of the plan: April 1992 to March 2002. Royal Government of Bhutan, Ministry of Agriculture, Department of Forestry, Forest Resources Management Division.
- Dhital, D.B. (1998) Forest management plan for Kotokha forest management unit: Wangdue-Phodrang Dzongkhag, period of the plan: July 1998 to June 2008, Royal Government of Bhutan, Ministry of Agriculture, Forestry Services Division, Forest Resources Development Section.
- Dorji, D. & W. Incoll (2001) Management plan for Dongdechu forest management unit: Yangtse Dzongkhag. Period of the plan: July 2001 to June 2011, Royal Government of Bhutan, Ministry of Agriculture, Department of Forestry Services.
- Osmaston, F.C. (1984) The management of forests, Commonwealth Forestry Institute, Oxford, International Book Distributors, Dehra Dun, India.
- Parkash, R. (1986) Forest management, International Book Distributors, Dehra Dun, India.
- Slavicky, J. (1992) Management plan for Paro-Zonglela forest management unit: Paro District. Royal Government of Bhutan, Ministry of Agriculture, Department of Forestry, Forest Resources Management Division.
- Whitfield, P. (2001) Planning and implementation for sustainable FMU management, Wang Watershed Management Project ALA/97/50.
- Branney P (2002) Guidelines for Forest Management Planning and Operational Planning (draft), Wang Watershed Management Project ALA/97/50.
- Dearden, P., Centre for International Development and Training, S. Jones and R. Sartorius (2002) Tools for development; a handbook for those engaged in development activity, Department for International Development, Performance and Effectiveness Department, UK.
- Nepal, S.K. (2002) Socio-economic study for the proposed FMU at Gogona, Royal Government of Bhutan, Ministry Of Agriculture, Department Of Forestry Services, Bhutan-German – Sustainable RNR Development Project (BG-SRDP–GTZ) Project Document No. 68.
- Lawrence M., R. Bone & M. Jones (2001) Natural resource assessment; a distance learning module, University of Central Lancashire, Cumbria Campus at Newton Rigg, Penrith, UK.
- National Environment Commission (1999) Forestry: Bhutanese environmental assessment sectoral guidelines, National Environment Commission, Thimphu, Bhutan.
- National Environment Commission (2002) Regulation for the Environmental Clearance of Projects and Regulation on Strategic Environmental Assessment, National Environment Commission Secretariat, Thimphu, Bhutan.
- Wood C (1993) Environmental impact assessment in Victoria; Australian discretion rules on environmental assessment, in *Journal of Environmental Management*, 39 (4), pp 281-295.
- Forest Management Code of Bhutan, Forest Resources Development Division, July 2004.
- Forestry Field Manual for Bhutan, Community Forestry Manual, Third Edition, 2018.





## 2. Community Forest Management

**Author:**

Tashi Wangchuk, Dy. Chief Forestry Officer, Social Forestry and Extension Division

**Contributors:**

1. Karma Jigme Tempel, Chief Forestry Officer, Social Forestry and Extension Division
2. Kinley Dorji, Principle Forestry Officer, Social Forestry and Extension Division



## **2. Community Forest Management**

### **2.1 Background**

The concept of peoples' participation in sustainable forest management (SFM) in Bhutan started where Social forestry made its first appearance in Bhutan in 1979 when His Majesty King Jigme Singye Wangchuck proclaimed that *"The participation of the local community is the key to conservation and utilization of forest resources"*. Peoples' participation in forest management became more evident when the community forestry program featured prominently in the Forest and Nature Conservation Act of Bhutan, 1995.

Community Forest (CF) is a form of forestry practice wherein the forest resource management authority is given to rural communities. The CF program is relatively new management regime compared to other forestry programs such as plantation, forest management unit (FMU) and protected area (PA) management. The CF program seeks to strengthen link between people and forests. Rural people usually live near forests and rely heavily on them for their basic needs. Forests provide them with products and services such as firewood, timber, fodder and pasture, foods, medicines, leaf litter, water for drinking and irrigation and spiritual grounds (SFED 2018).

CF is one of the key components of Bhutan's forest policy and is aimed at contributing to overall sustainable management of forests. CF contributes to conservation, reducing illegal activities, poverty reduction, improvement in rural household livelihood and many more benefits. Community Forestry is now firmly on the agenda for Bhutan as part of the Five-Year Plans and it forms part of the National Forest Policy 2011 (SFED 2018).

### **2.2 Objective**

The broad objectives are to:

- empower rural communities to manage CF areas sustainably;
- provide socio-economic and environmental benefits;
- alleviate poverty and improve livelihoods;
- contribute to overall sustainable forest management at national level; and
- promote good governance to ensure transparency, accountability, participation, predictability, empowerment, inclusiveness, equity and benefit sharing, and in line with decentralization and devolution policies.

### **2.3 The Community Forestry Processes**

There are four main processes in community forestry program.

1. Application process
2. CF management planning process
3. Approval process
4. Implementation process

These processes are mostly participatory involving local communities and other stakeholders. Participatory Rural Appraisal (PRA) tools are used in different processes. The flow chart (Figure 2.1) shows the whole processes starting from establishment to implementation and revision. The processes are further divided into several steps.



Figure 2.1 Community Forestry Process flowchart

## 2.3.1 CF Application Processes

### 2.3.1.1 Formation of CFMG and Submission of Application

In accordance with Section 78 (1) of FNCRR 2017, a village with at least five households willing to establish and manage a community forest can form a Community Forest Management Group (CFMG). The CFMG submits application (Annexure VI of FNCRR 2017) to the Gup, who shall review and recommend to the CFO.

### **2.3.1.2 Field Verification of the proposed CF area**

Upon receipt of the CF application from the Gup, the CFO shall form a field verification committee. The committee shall comprise of CFMG representatives, CFO, Dzongkhag Land Record Officer, Gup and adjacent community among other relevant agencies and officials. The team shall check whether or not the proposed CF area fulfils the criteria mentioned in FNCRR 2017 (Box 2.1 **Error! Reference source not found.**) or any revisions hereafter.

*Box 2.1 Selection criteria of CF sites as per FNCRR 2017*

The selection criteria for CF sites are:

- (1) Any area of State Reserved Forest Land, including degraded and barren areas for improvement, in the vicinity of human settlement, suitable for control and management by Community Forestry Management Group, as Community Forest. The designation of an area as CF shall comply to the following procedures and criteria:
  - a. the area is traditionally used and managed by the community;
  - b. the area has production potential to meet subsistence requirement of forest produce and income generation for CFMG members. Tsamdro /Sokshing land reverted to SRF Land shall not be designated as Community Forest unless the reverted Tsamdro /Sokshing is no longer required for lease as Tsamdro /Sokshing by the individual/community;
  - c. the area is suitable for sustainable management and utilization of forest produce;
  - d. the local household are willing to form and cooperate as a CFMG to manage the forest in accordance with the following conditions:
    - i. establishment of CF in the PA and Biological Corridor within the vicinity of the existing settlement may be allowed, if feasible;
    - ii. sacred forests or tree, significant Wetland, Heritage forests or any forest area of cultural and religious importance shall be protected from designation as CF;
    - iii. any area of government plantation in small patch less than three years or plantation area measuring less than five hectares located within the proposed CF, shall be included in the CF for better management by the CFMG after obtaining clearance from the Department.
  - e. the boundary and size of CF area shall be determined by the following criteria:
    - (i) availability of SRF Land excluding FMUs;
    - (ii) traditional and natural boundary within the village;
    - (iii) customary rights and practices of resource utilization;
    - (iv) level of dependence of the community on such forests;
    - (v) availability of adequate area to meet the resource needs of neighboring communities;
    - (vi) the maximum ceiling of CF area to be allotted to individual household (hh) shall be as follows:
      - (1) Mixed conifer/blue pine forest 3 ha/hh.
      - (2) Chir pine forest 4 ha/hh.
      - (3) Mixed broadleaved and other forest type 5 ha/hh.
  - f. (f) the proposed area decided by the committee comprising of representative of CFMG, CFO, DLRO, Gup and adjacent community shall be endorsed and shall form the basis for the CF establishment.

Net operable (production) area for community forests should be calculated after determining the important areas (water source, wetland, cliff, rock outcrops, etc.) and deducting them from the overall CF area. However, those areas should be brought under appropriate management regime within the CFMP.

### 2.3.1.3 Approval of CF Application

The CFO, upon field verification by the committee, approves/rejects the application for establishment of the CF. The CFO then instructs the concerned Forestry Official (s) to facilitate the community forest management exercises and framing of CFMG By-laws.

## 2.3.2 Community Forest Management Planning Process

### 2.3.2.1 Principles of the CF Management Planning

The following principles should be followed during Community Forest Management Plan (CFMP) preparation (Figure 2.2 **Error! Reference source not found.**).

The CFMP should:

- Contain all the information the CFMG needs to manage their CF.
- Not contain extra information (not actually required for managing the CF).
- Be prepared by the CFMG with concerned Forestry Officials as facilitators and trainers.
- Be “owned” by the CFMG.
- Be written in a national language
- Include maps, diagrams, charts and drawings to be easily understood.
- Include all the actual activities which the CFMG agree to implement.
- Contain agreed responsibilities for implementation and procedures which the CFMG can follow.



Figure 2.2 Principles of Community Forest Management Plan

### 2.3.2.2 CFMP preparation process

The CFMP shall be prepared by the CFMG with technical support and facilitation by field forestry staff. Detailed steps for preparation of the management plan are described below:

#### Step 1. CF Boundary Survey and Demarcation

CF boundary needs to be clearly demarcated and mapped. Boundary survey is done by GPS involving the CFMG representatives and communities from adjacent villages. For boundary survey, a checklist of suggested equipment is mentioned in Box 2.2.

#### Box 2.2 Equipment

Equipment: GPS (e.g. Garmin), spare batteries, Compass, GPS Survey Sheet, clipboards, pen/pencils, permanent marker (Paints), knives.

#### How to do a boundary survey with GPS

- Agree on the starting point for the traverse of the CF boundary with CFMG members. This should be an accessible and easily locatable point e.g. on a roadside/Chorten/Lhakhang or river/stream/cliff, etc.
- Set the reference point as the starting point on your GPS. Make notes on your GPS Survey Sheet (referring to the point number or name). Or record the corresponding Waypoint ID in the GPS Survey Sheet.

- Setup GPS position format in decimal degrees (hddd.ddddd°).
- Before starting to walk the boundary, make sure the GPS is set up properly to record the Track.
- Turn on the Track log and mark Waypoints while walking along the CF boundary. If the area is too large, we may have to set the Track log recording method into auto. We also have options to record the Track log by distance, time and its corresponding recording intervals. If the Track logs are more than 700, we face some problem while digitizing in ArcMap.
- Explain to the CFMG members that you are going to record the CF boundary with the GPS. Show some tracks and waypoints already stored on the GPS and explain the importance of following the exact (proposed) boundary of the CF without taking shortcuts (the GPS shall only record the places you have actually been).
- Stop at each locatable point e.g. path junctions, rock outcrops, gullies, streams and houses or specific forest areas and store a Waypoint on your GPS.
- Write the GPS ID names using permanent marker or paints on the trees, rocks to help CFMG members in identifying the CF boundaries in future.
- Note down any features and area names on your Form 2.1

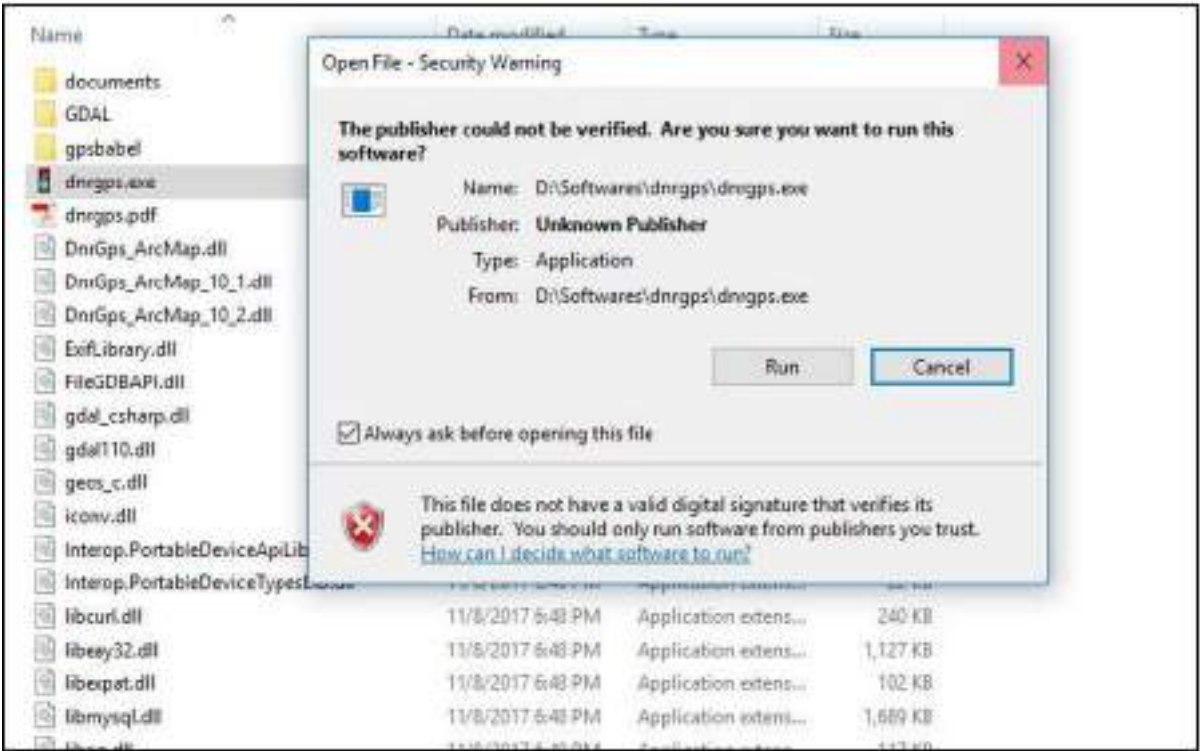
*Form 2.1 GPS Survey Sheet*

GPS Survey Sheet		
Survey team members:		Name of forest:
Date:		
GPS ID	Features	Remarks
(WPT No./Name)	(Ridges, paths, road, boundaries of cultivated land, power line, etc.)	(Name, condition, use, etc.)

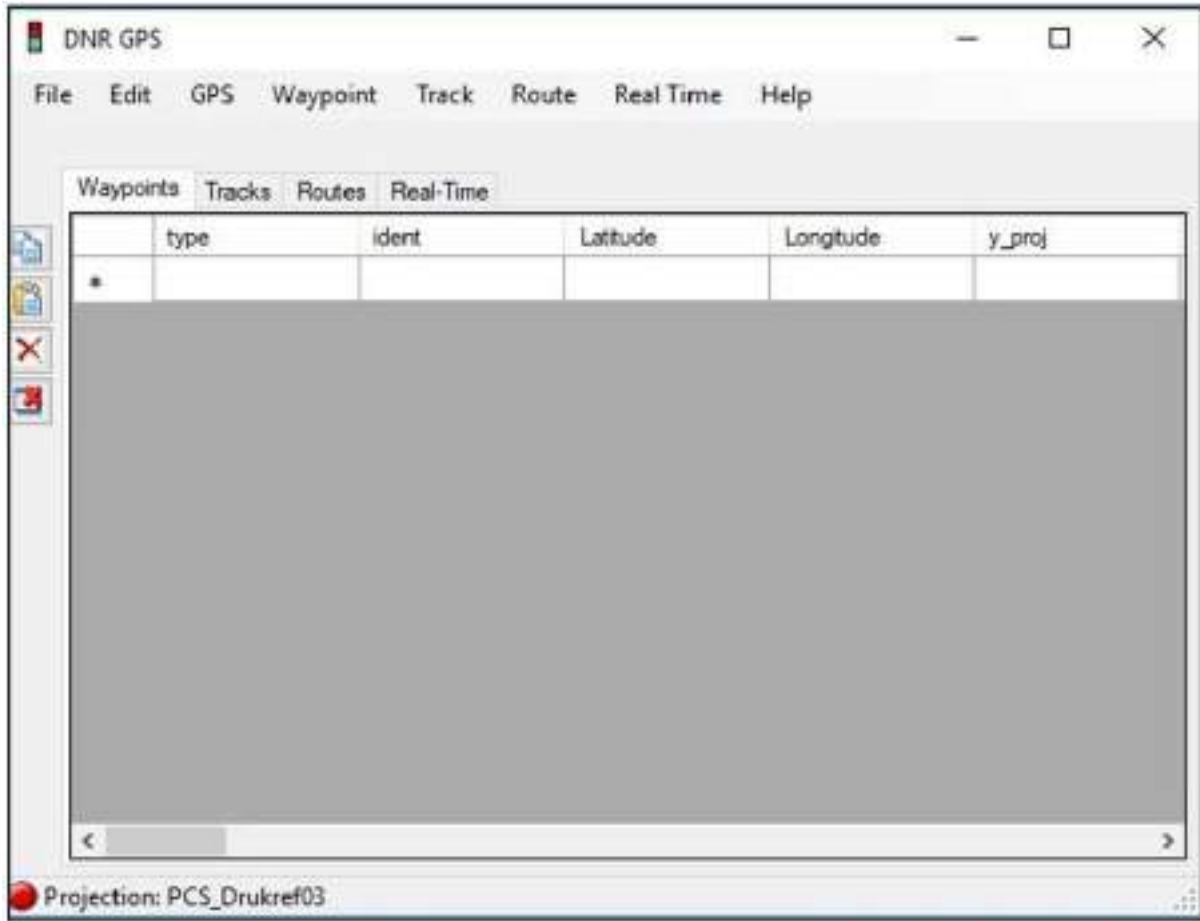
- Continue around the entire CF boundary. As far as possible try to have the boundary following recognizable features like ridges, paths, roads, boundaries of cultivated land, etc.
- When you regain the starting point you shall have a complete GPS survey of the boundary. It is usually convenient to upload Waypoints and Tracks through OziExplorer as you can view time, date and geo-coordinates you travelled from that place in its Track log. You also have other options to upload GPS data onto your PC (DNRGPS, QGIS software, etc.).

### **Steps to upload GIS data in GPS**

Open DNRGPS software from the file directory, run the exe. file

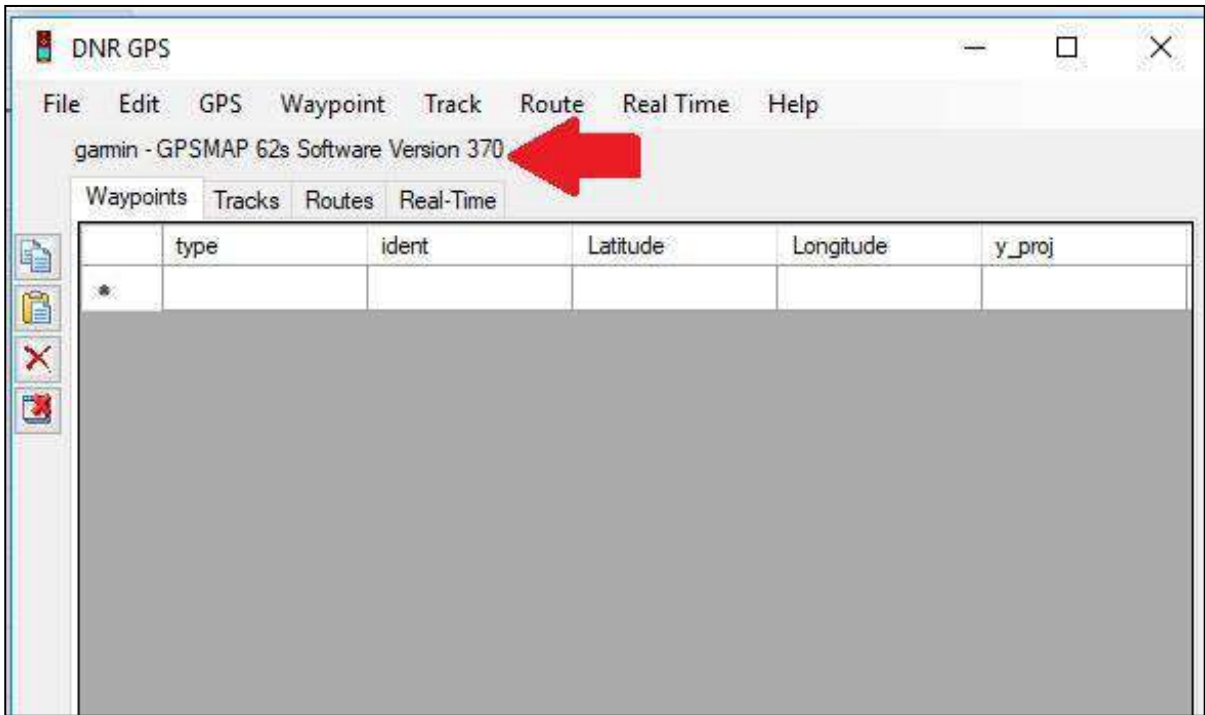
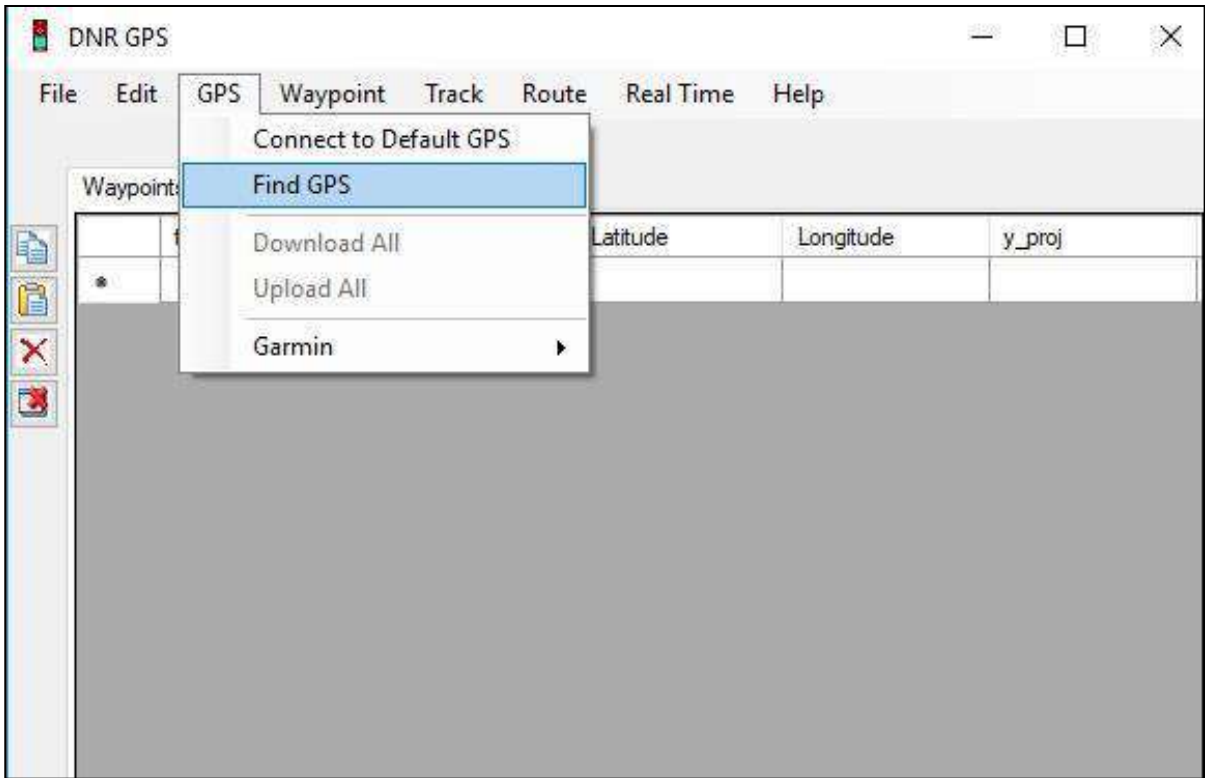


When you run the exe. file , you shall see the screen below.

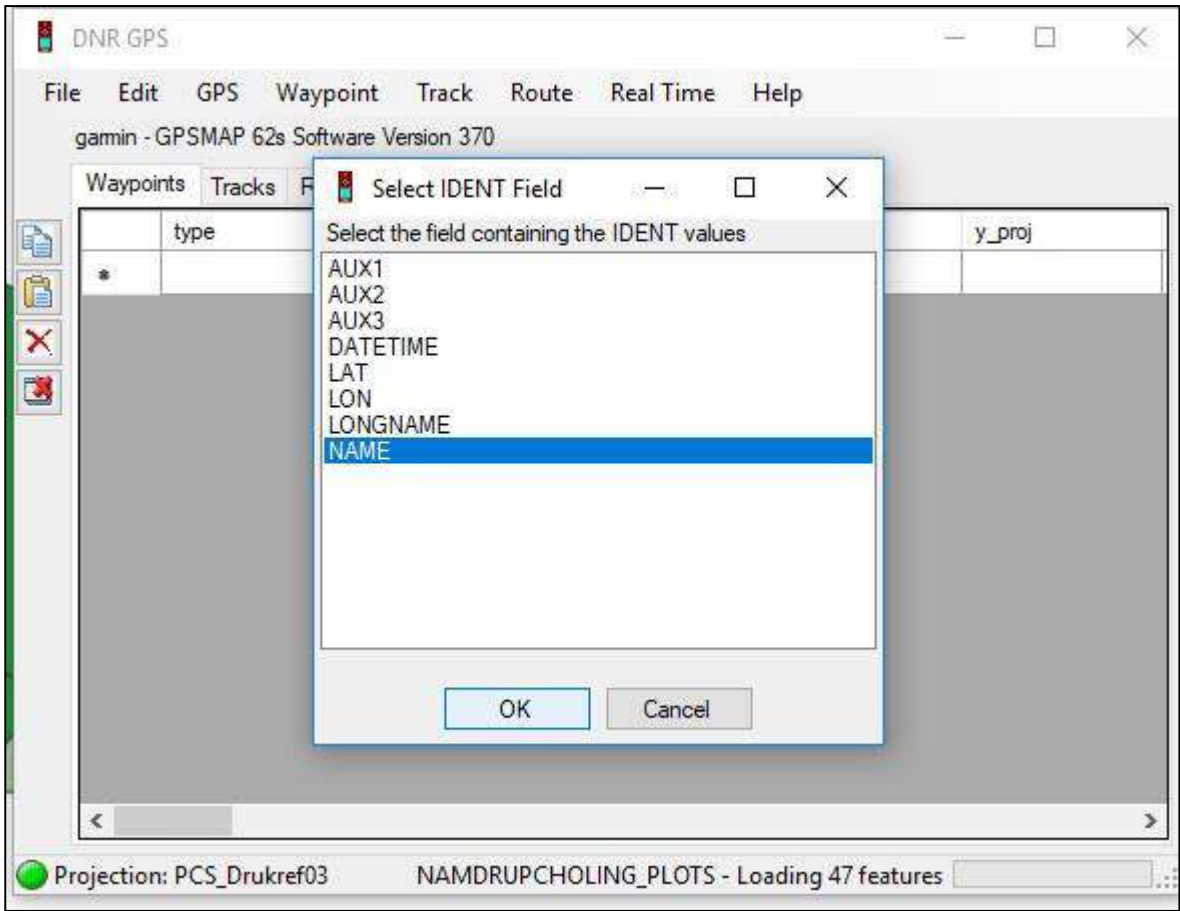
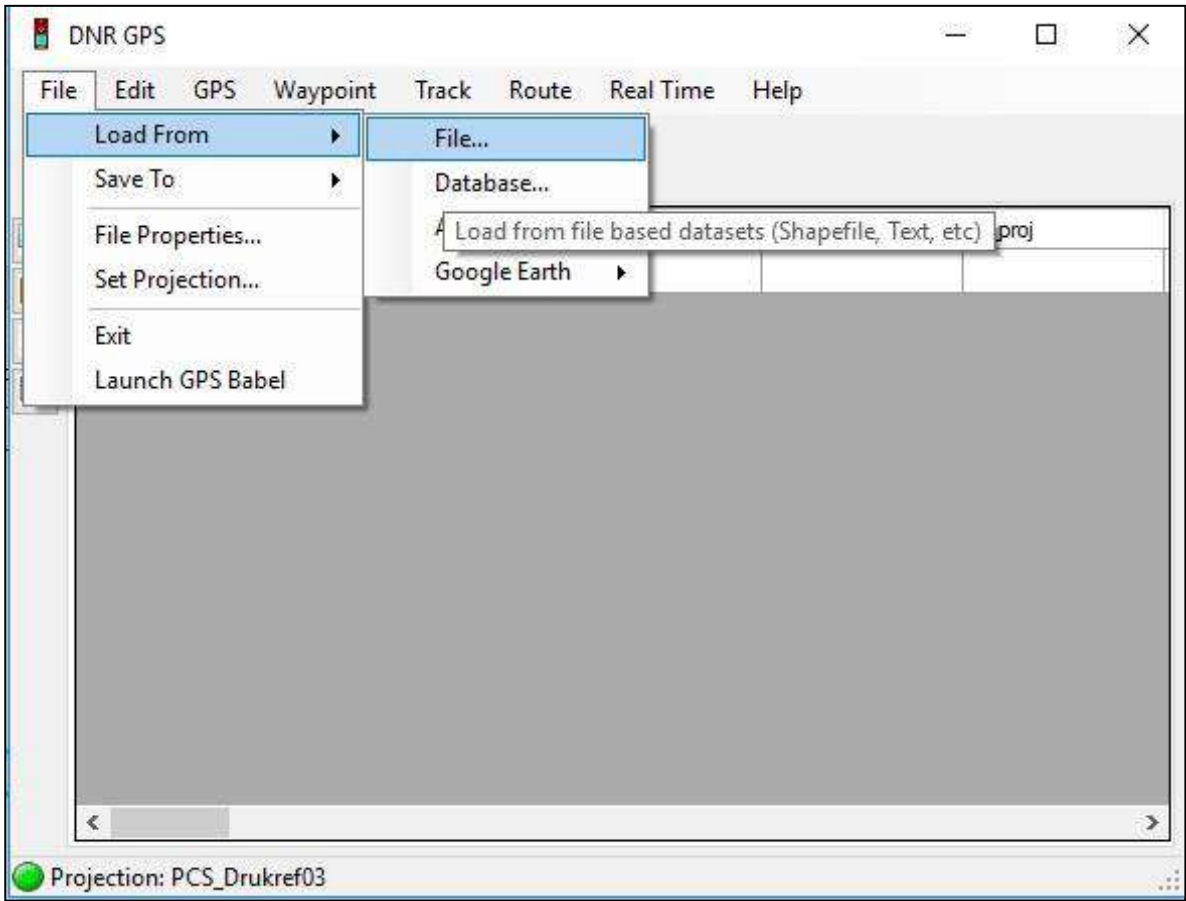


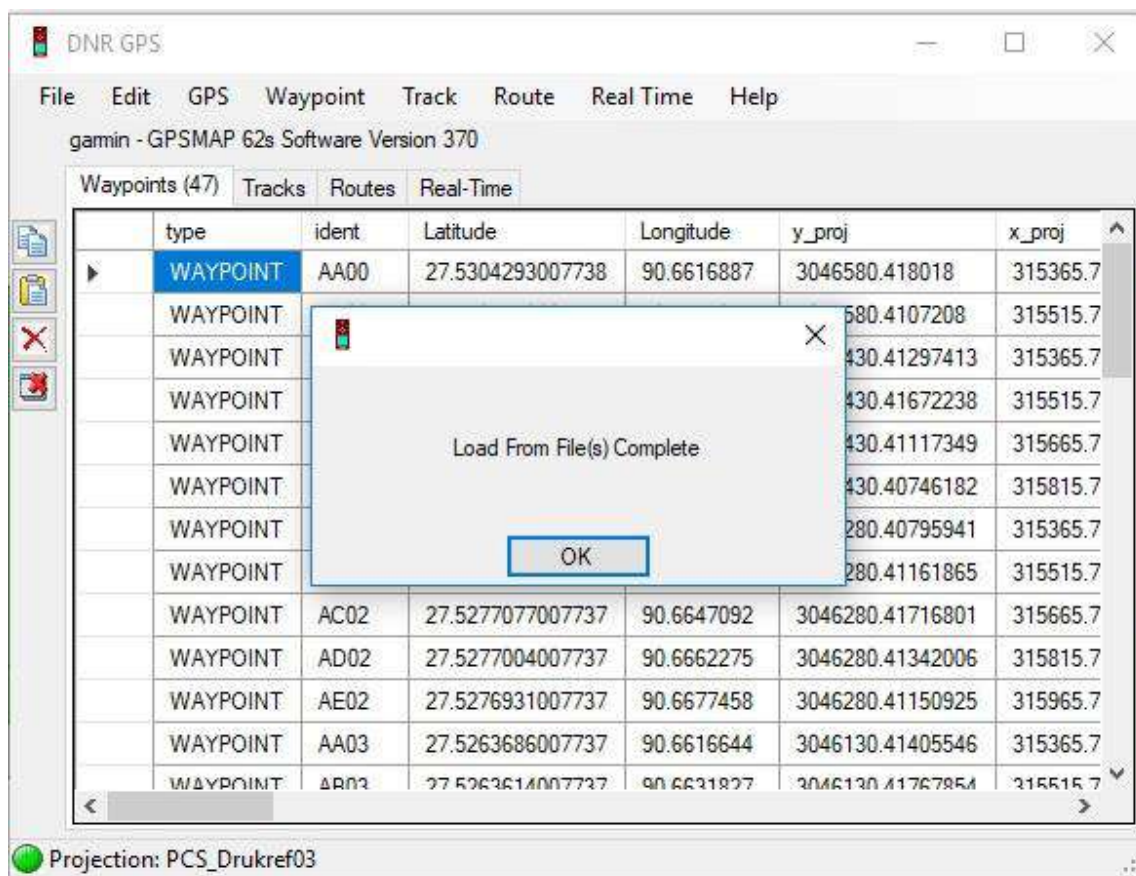


Now connect your GPS and find GPS from the top menu. It shall take some time to find your GPS and name of GPS occurs above the screen box as indicated in the figures below.

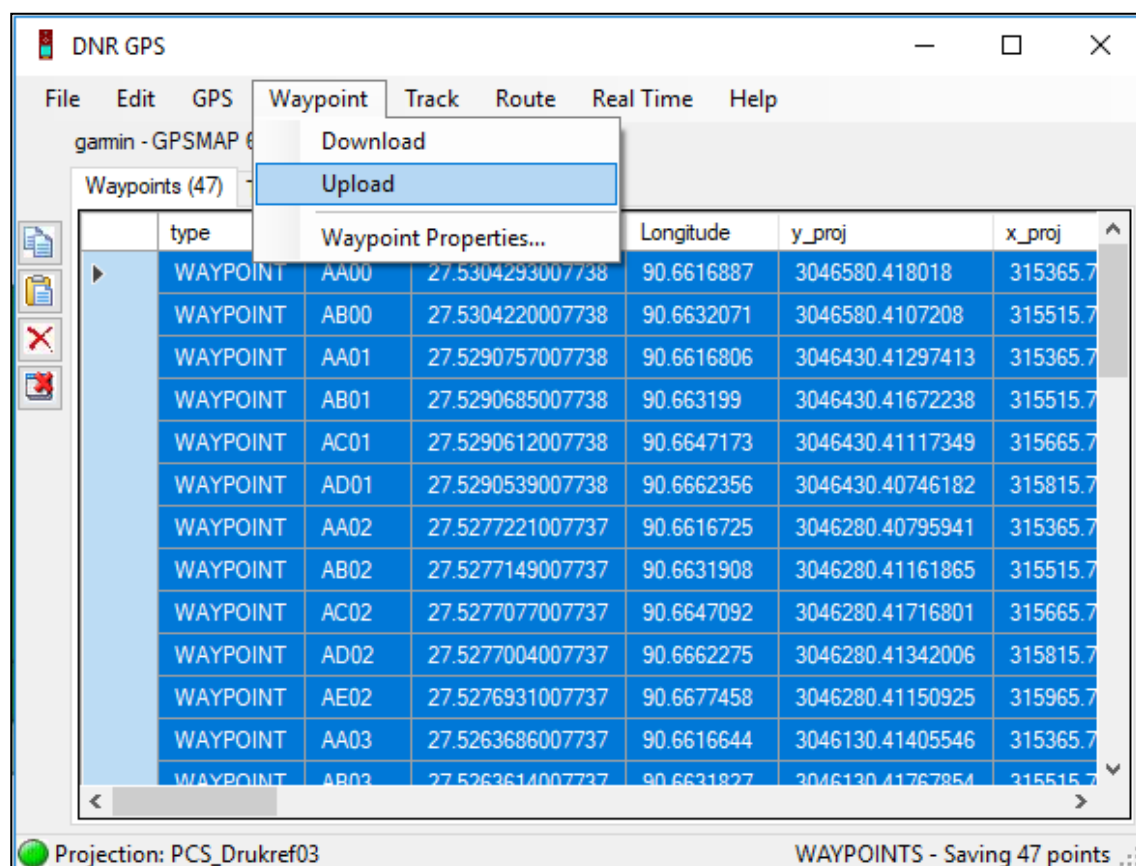


Now load the waypoints/plots from the file directory as mentioned in the figure below.





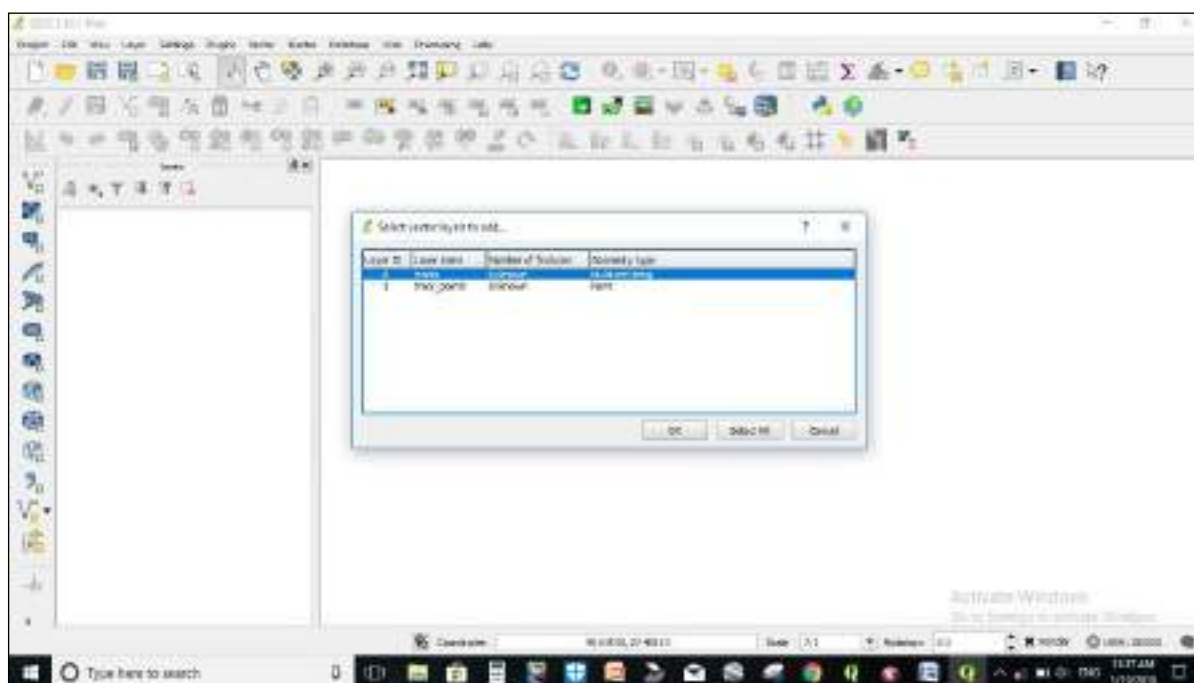
Now upload the Waypoint to GPS from the waypoint menu and upload the waypoints until it is complete.



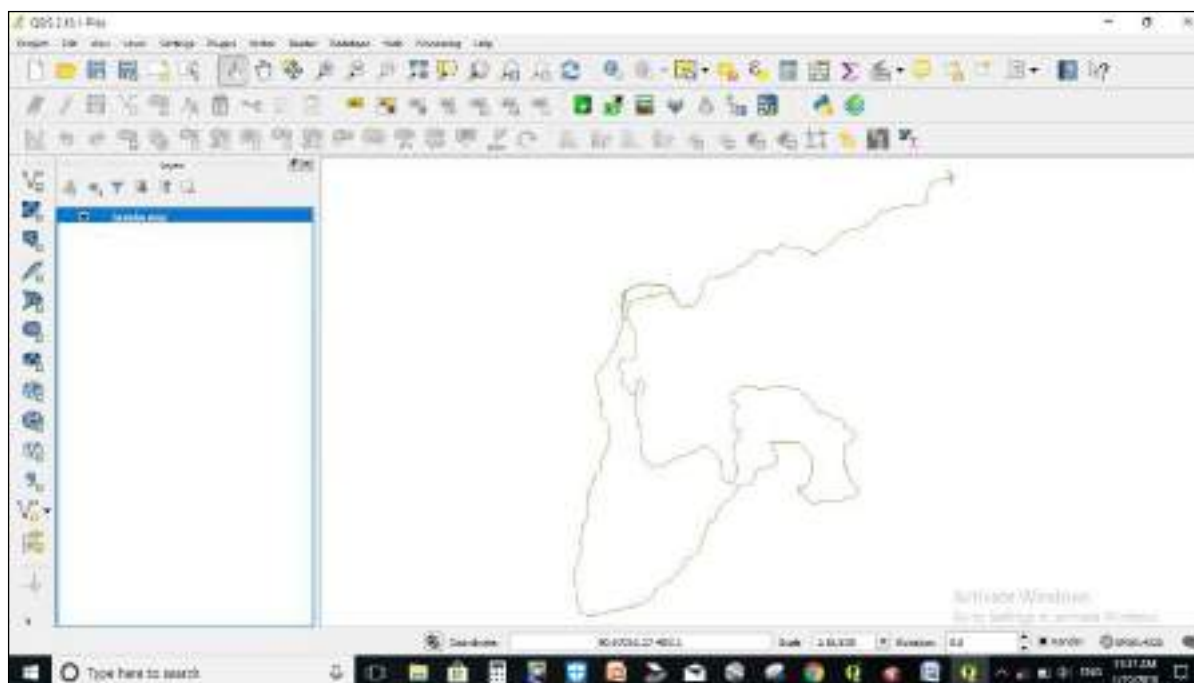
The Waypoints/plot identity is now ready for use in the field







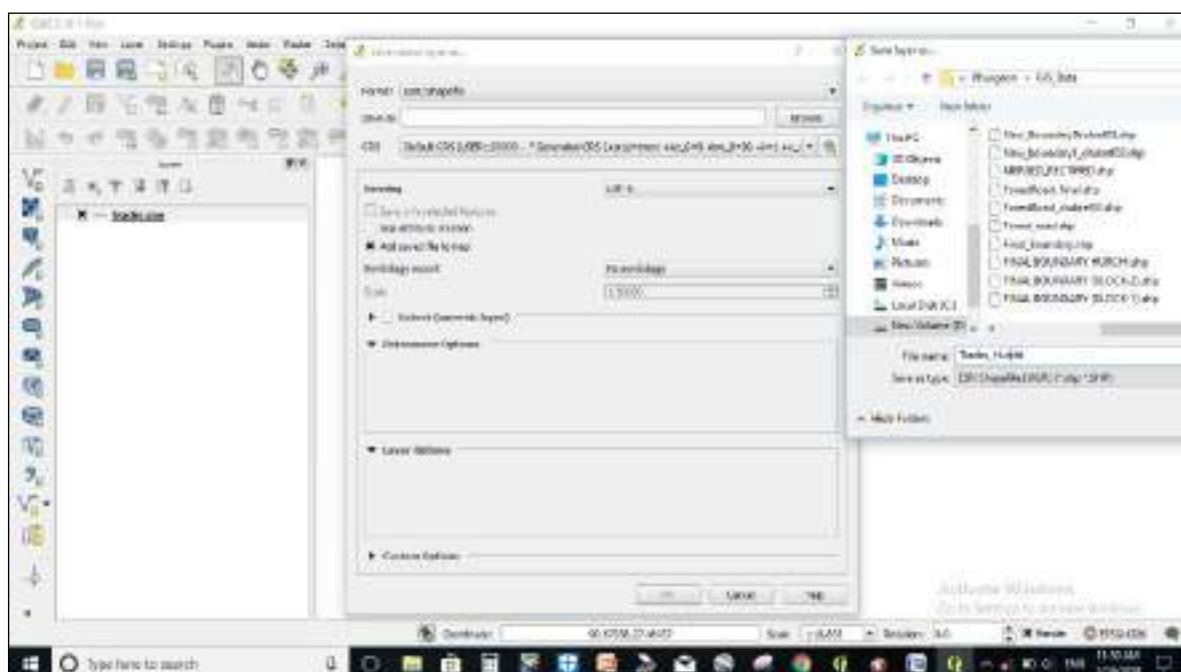
- d. The boundary shall be displayed in the main screen. You shall see the layer file as track any in the layer menu.



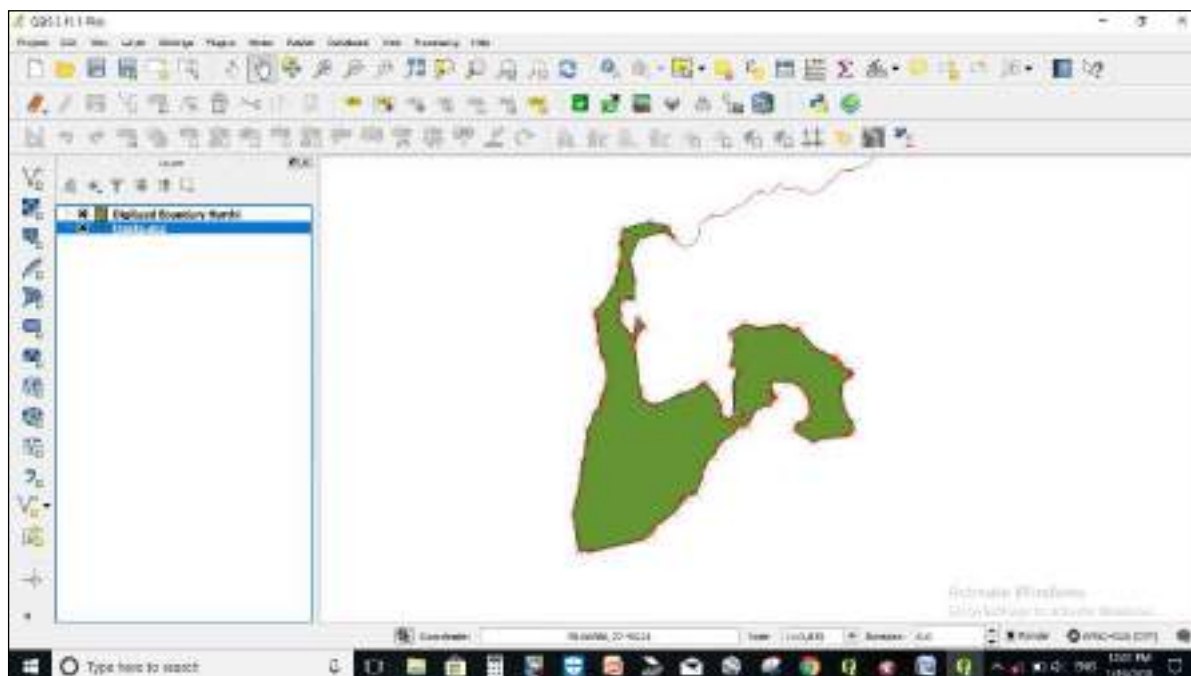
- e. Now we have to project the raw data by saving as project file



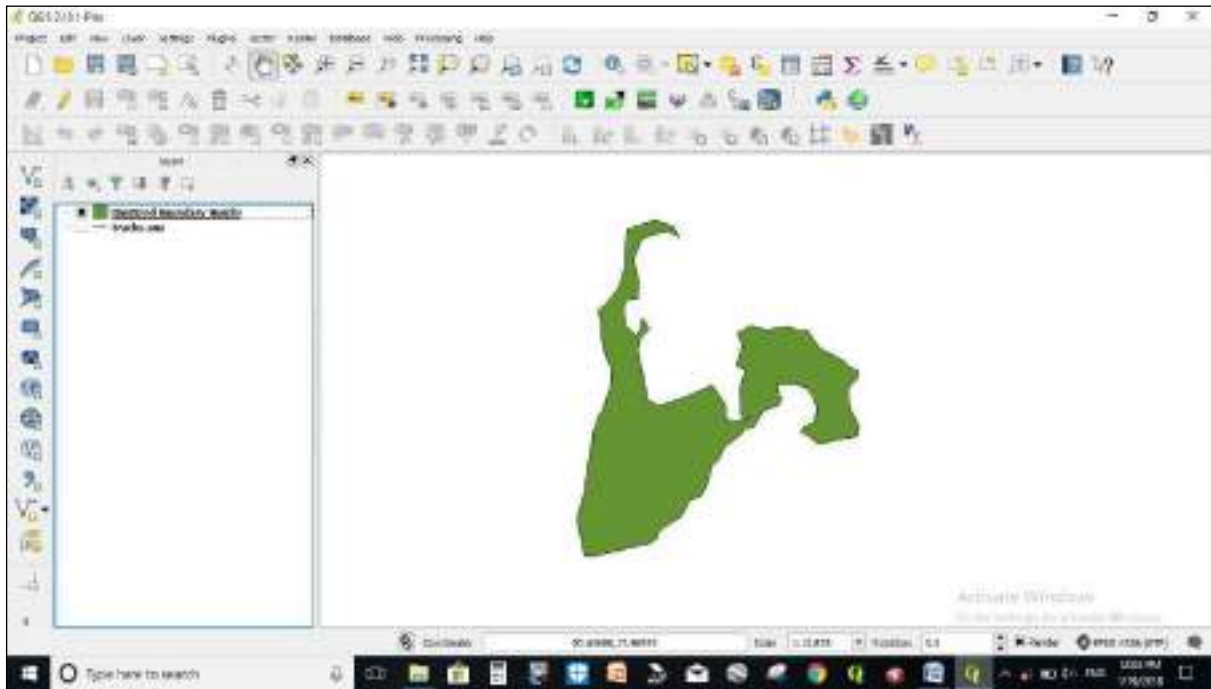




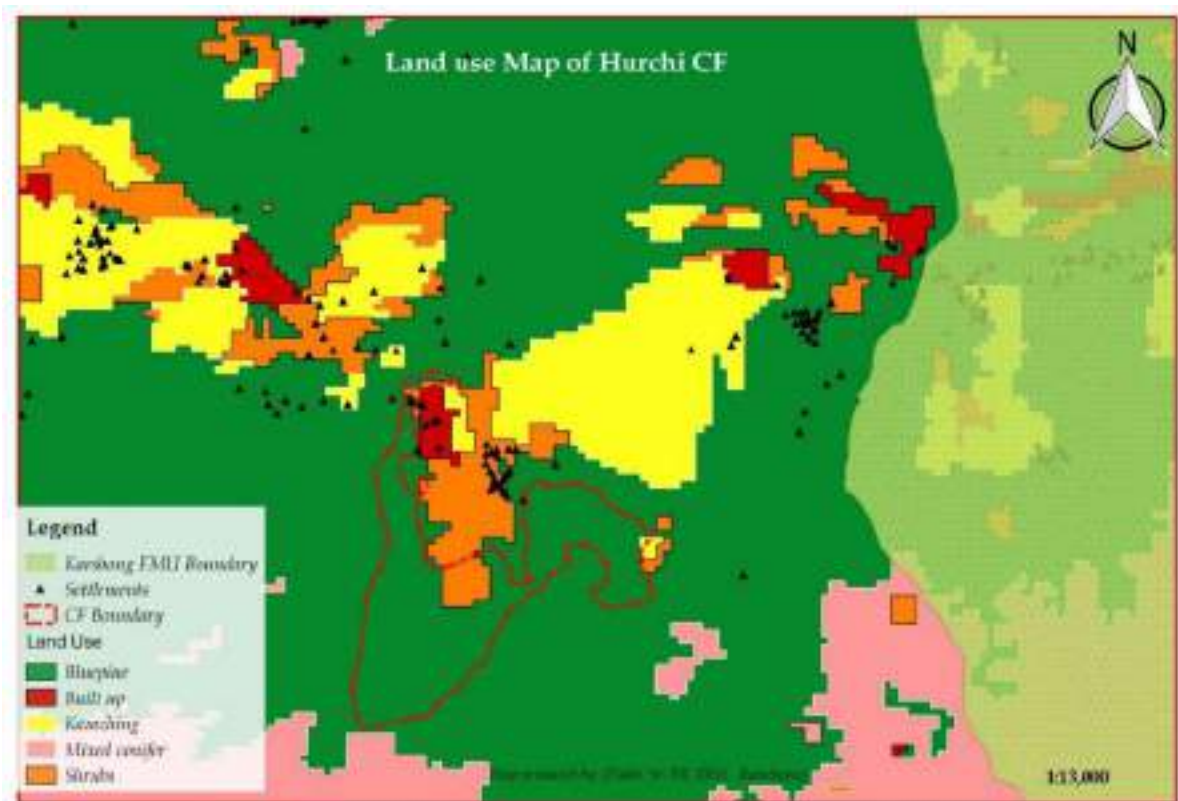
h. Digitize the data using add new shape file layer as indicated in the figure below.



i. Disable the original boundary file and select the new boundary.



- j. Add land use data and finalize the map, see figure 4i below (Google map superimposed with required attributes and Land use map which can be incorporated in the management plan).



In order to identify land use around the proposed CF area, you may officially write to National Land Commission Secretariat or Dzongkhag Administration to consider providing the private land Shape files and their details so as to avoid boundary issues with private land owners in future. It is convenient to superimpose on Google map as it is more convincing to the CFMG members and other relevant stakeholders.

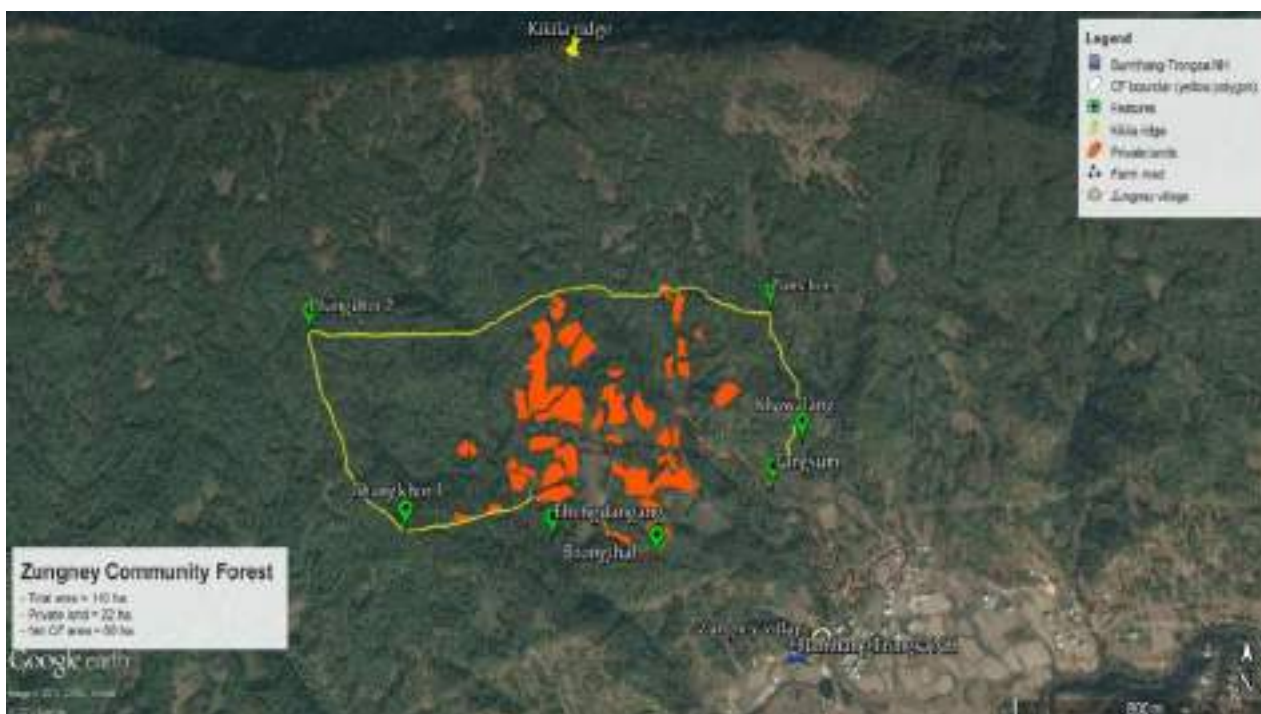


Figure above shows Google image with superimposed private lands. Figure below shows CF boundary with private lands, settlements and other features



We can produce GIS map with recent land cover map (LULC 2016) or any other update herewith. The map must have several features like scale, direction marker showing North and legend. You need to print the map, as large as possible and preferably in color. Few copies may be needed. Calculate the area enclosed by the GPS survey (your GPS/GIS software shall do this). After preparation of Google/GIS map, ask CFMG members if the features are complete. If not, add features that they feel are important for them. The following layers are mandatory in google maps:

- Private land shape files
- Show settlements
- Show Protected Areas, Biological Corridors, FMUs or any other forest management regime boundaries if available.
- Using the **add placemark** function in the Google Earth; level the important features (Chorten, Lhakhang, Road, rivers, Gewog Administration Office, drinking water source, etc.).



- Update settlements using GPS (marking Waypoints) since the older versions are not accurate.

## **Step 2. Participatory Forest Resource Mapping**

This PRA tool helps to get a better understanding about how forests are used by different people in the village, where different forest produce come from. From this exercise, a participatory forest resource map can be developed by villagers using google map.

### **How to do Participatory Forest Resource Mapping using google earth**

- Show google earth map printed in color or over a projector if you are equipped with to the CFMG.
- Let them locate and name the areas of specific resource collection and use. Also mark other important features (water source, sacred sites, etc.) on the map.
- Let them copy on the chart and locate the resources simultaneously from the Google map (barren land, *Tsamdro*, *Sokshing*, water sources, forest types, plantations, etc.).
- In the areas where electricity is not accessible, concerned Forest Officer may invite their CF Management Committee in the office and discuss the above steps and take a printed copy of Google map for discussion with their members in the field.
- As a facilitator stay in the background and only get involved if there is a problem or for clarification. Your role at this point is to listen carefully.
- The groups may debate which characteristics are important, and as result, a wide variety of relevant and unexpected information may emerge.
- At the end of this stage, the google map shows the resources collection location, boundaries, and the names of important physical features, including the village (Figure 2.3)
- This provides the basic framework on which the rest of the map is constructed.
- Keep the legends as clear as possible.
- Remember that this is not supposed to be a highly ‘accurate’ map.



Figure 2.3 Participatory Forest Resource Map transferred from Google map

Table 2.1 Checklist for Participatory Forest Resource Mapping

<b>Checklist for Participatory Forest Resource Mapping</b>	
Who?	Who are the forest users and what are their names? Who collects the forest produce? Do outsiders use the forest resources around the village? Who are they, where do they come from, what do they use, when, where, how? Are there any conflicts between users?
What?	What products are readily available and what are scarce? Where are they? What are the forest produce they use? What are their requirements and needs from the forest? What do they use these products for? What other forest use problems do they have?
Where?	Where are the forest produce found? Where do the users live? Which areas are used for different produce e.g. grazing, NWFP collection, fuelwood collection, etc.? Where other forest use areas are located e.g. FMU, Buffer Zone, PAs, Wetland, Biological corridors, water source, religious areas, etc.? Where are the “degraded” forest areas? Why are they degraded? Are there any areas for carrying out improvement work?
When?	When are different kind of forest produce available? When (in a year) are different produce collected? Does the village population change during the year? Does this affect use of the forest? How has the forest changed over the years?
How?	How much time does it take to collect different produce? How does the village collect forest produce? What system is used for collecting and distributing forest produce? Are there limits on how much can be collected at any time? Are there any issues on how the forest is used?

### Step 3. Division of CF into Blocks

CF areas may be divided into blocks to make forest resource assessment (inventory) easier and to make the management plan more site-specific. It is not necessary that all CFs must be divided into blocks. Blocks are made when there is distinct forest type and condition which may require separate management regimes.

Net operable (production) area for CF should be calculated after determining the important areas (water source, wetland, inaccessible area, etc.) and deducting them from the overall CF area. However, those areas should be brought under appropriate management regime within the CFMP.

#### How to divide the CF into Blocks

- Divide CFMG members into small groups
- Show the CF resource use map produced in Step 2, above.

#### Box 2.3 Criteria for Dividing CF into Blocks

**Forest type** - each block could have a different forest type e.g. broadleaved, conifer, etc.  
**Forest condition** - each block is in a different condition e.g. degraded, dense, etc.  
**Use patterns** - different blocks accessible to or used by different households or villages  
**Natural features** - so that boundaries of blocks follow clear features that can be seen on the ground e.g. ridges, streams, rivers, footpaths, roads, cliffs, power lines.  
**Number** - do not have too many blocks otherwise the management plan will become very complicated.

- Ask each group how they would use the listed criteria to divide the CF into blocks.
- To divide the CF into blocks, you can use Google earth and confirm through field verification.
- Choose someone from each group to present the block map to the whole group.
- When the whole group agree on where the block boundaries should lie and mark them permanently on the map. This is now your CF map (base map) showing blocks. It shall be the main map for management purposes.
- Describe the boundaries of each block and write these down e.g. describe what actually lies to the North, South, East and West of each block.

### **Measuring block areas**

**There are two options to measure block area.**

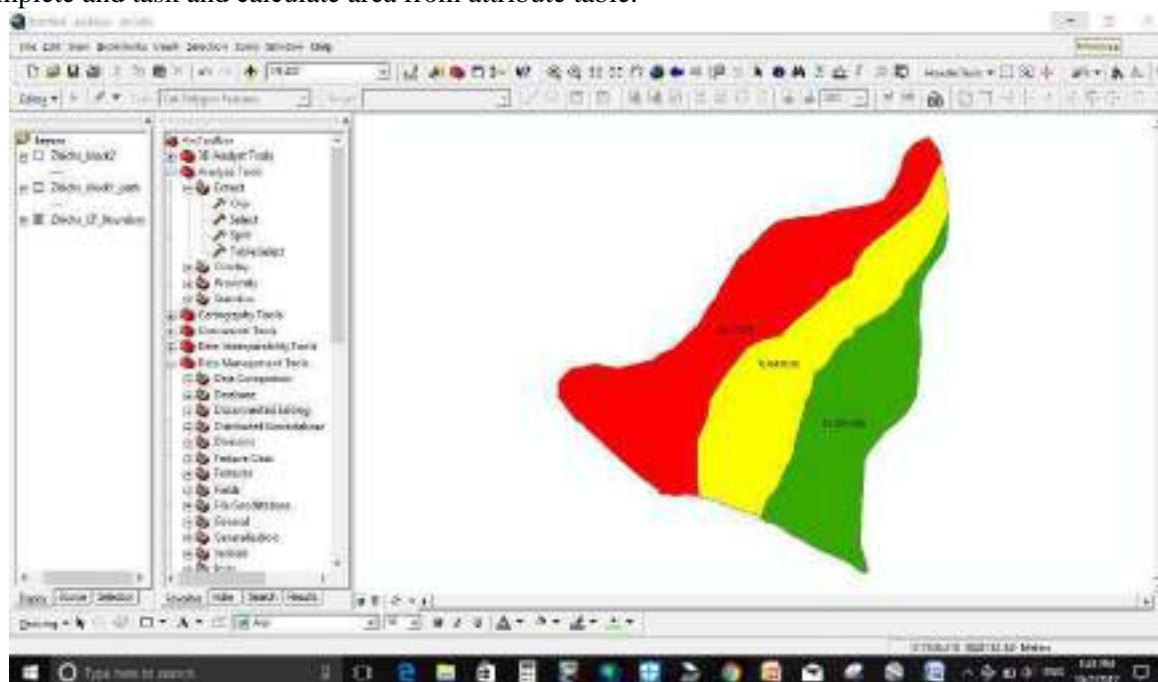
#### **(a) Measuring block area by using a GPS**

You can measure the area of each block by GPS. To do this you must walk along the boundaries of each block and take GPS readings.

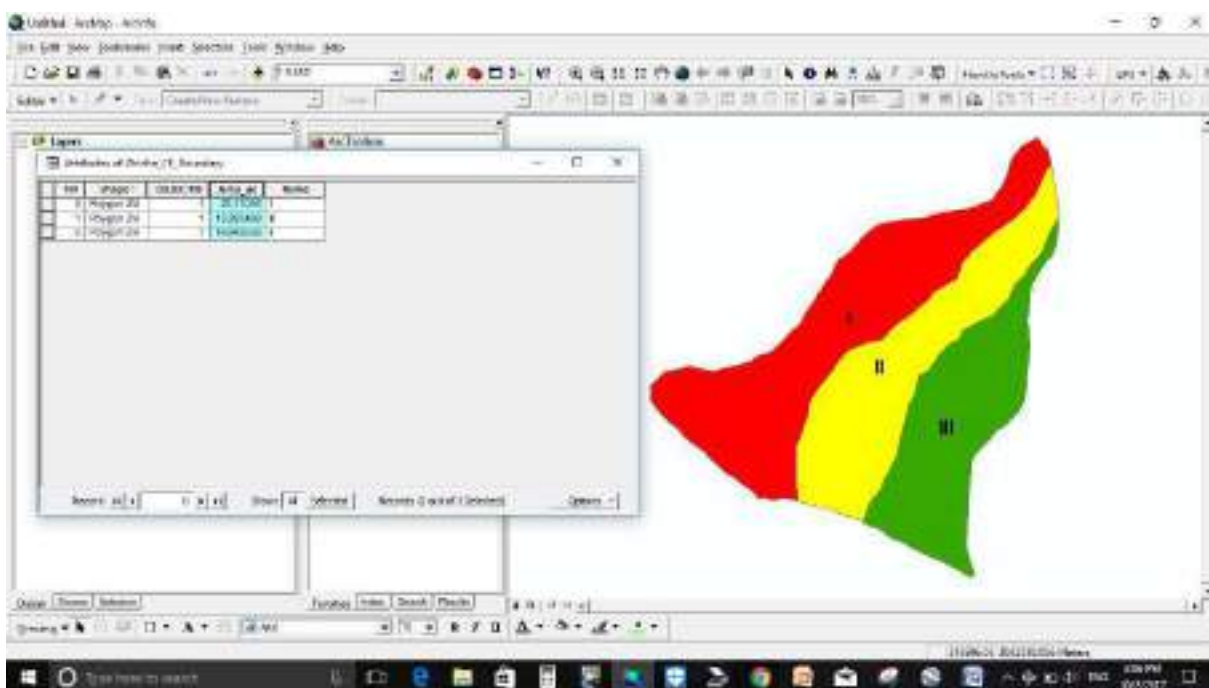
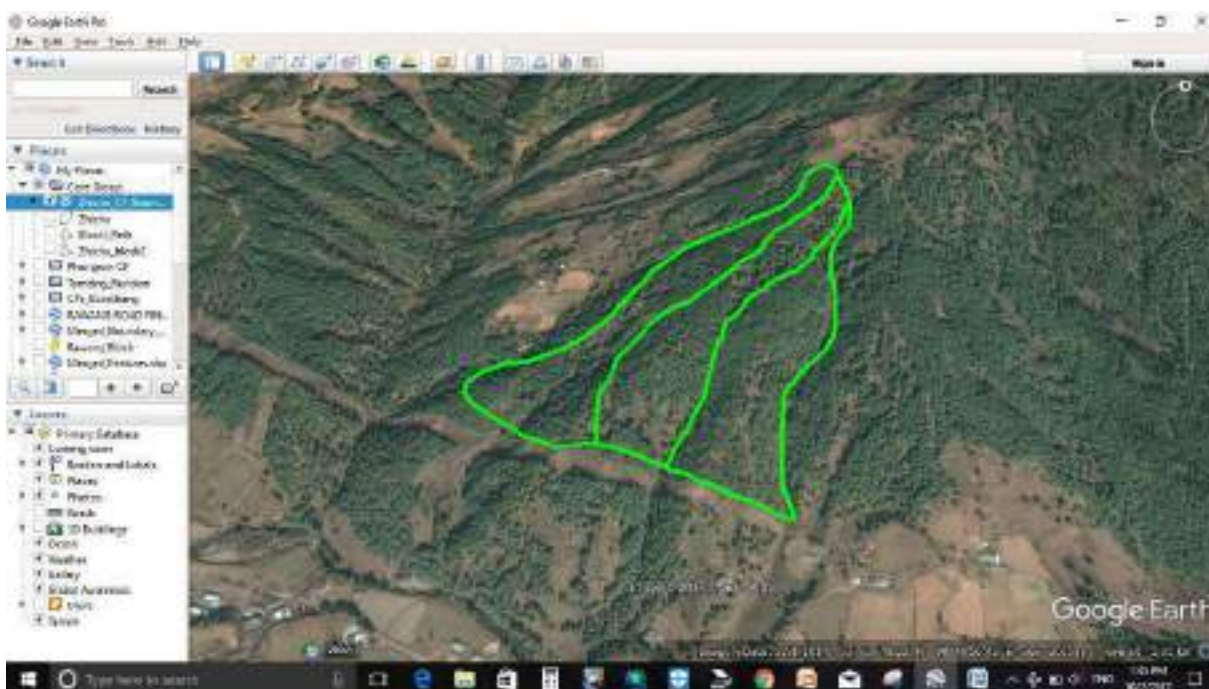
#### **(b) Measuring block area by Google Earth/ArcGIS**

Once the CFMG has demarcated the block boundaries, we can follow following steps to calculate the block areas:

1. Using **add path** function in Google earth, draw path on the Google map as desired by the CFMG members.
2. Save the path in a given directory. From the side bar, right click and save place mark as .kml file in the given folder directory.
3. Import into ArcMap and project the kml file to drukref03.
4. Using **split tool** under Analysis Tools, split the polygon on the path file we have created and save it. Complete and task and calculate area from attribute table.







Box 2.4 Equipment

#### Step 4. Forest Resource Assessment

Forest resource assessment means describing and measuring forest to find out what resources it contains (Format 1)

Some suggested equipment for forest resource assessment are listed in the Box 2.4.

Hypsometer, compass, measuring tape and thick measuring rope, diameter tape, map, tally sheets,

### Why is forest resource assessment needed?

- To provide information about the forest so that appropriate forest management prescriptions can be adopted
- To provide information for calculating the quantities of timber and other forest produce (NWFPs, sand, stone and boulders, etc.) that can be sustainably harvested.
- To provide a baseline for monitoring and evaluation.

**Forest resource assessment is conducted using sample plots involving the CFMG members. This will show the growing stock (of timber) in the block in order to calculate the timber available for harvesting during the CF Management Plan period. It will also assess the stock of any NWFPs that may be prescribed for sustainable management. Complete forms below, one form for each sample plot in the CF/block.**

#### **Format 1. Forest Resource Assessment Format (Complete this format for each block)**

Name of Community Forest	
Date of Assessment	
Name of block	
Block area	
Name of recorder	

#### **Forest & Habitat Type (tick all those present, Refer definition below)**

Forest <input type="checkbox"/>	Thicket/pole stage <input type="checkbox"/>	Shrubland <input type="checkbox"/>	
Grassland <input type="checkbox"/>	Plantation <input type="checkbox"/>	Other <input type="checkbox"/>	
Vegetation type			
Subtropical forest <input type="checkbox"/>	Chir pine forest <input type="checkbox"/>	Warm broad-leaved forest <input type="checkbox"/>	Blue pine forest <input type="checkbox"/>
Cool broad-leaved forest <input type="checkbox"/>	Mixed conifer forest <input type="checkbox"/>	Fir forest <input type="checkbox"/>	OTHER <input type="checkbox"/>

#### **Definitions**

Broadleaf forest	75% or more of the tree species present are hardwoods
Conifer forest	75% or more of the tree species present are coniferous
Mixed forest	All other combinations of tree species
Mature Forest	Vegetation dominated by mature trees (trees > 40 cm dbh)
Thicket/pole stage	Vegetation > 3m in height consisting of young trees usually < 40cm dbh
Shrubs	Non-tree species > 2m in height (often thorny and multi-stemmed)
Shrub-land	Vegetation dominated by woody multi-stemmed plants or single stemmed plants and regeneration mostly < 3 m tall

Grassland	Vegetation dominated by grass species and where only a small part of the area is covered by trees or shrubs.
Crown cover	The percentage of the area covered by the crowns of trees forming the main canopy (usually mature trees)
Regeneration	Seedlings, saplings and coppice regrowth of naturally occurring tree species that are less than 1.3 metres tall but greater than 30cm tall
Seed trees	Mature trees with healthy crowns capable of producing flowers and seed
Soil Cover	The percentage of the area with soil surface covered either by live vegetation or a layer of other plant vegetation

Forest Condition (complete if the block is mainly forest)			
Write the names of main tree species			
Local name		Scientific name	
Plantation			
Is there any plantation?	Yes <input type="checkbox"/>	Approximate height of planted trees (m)	
	No <input type="checkbox"/>		
Year planted	Is the plantation?	Under stocked	<input type="checkbox"/>
		Stocked	<input type="checkbox"/>
		Overstocked	<input type="checkbox"/>

Forest Condition -Age			
Mature <input type="checkbox"/>	Pole stage <input type="checkbox"/>	Shrubland <input type="checkbox"/>	Any <input type="checkbox"/>
Main canopy of mature trees	Main canopy of pole-stage trees	Main canopy of shrubs, young trees or regeneration	No continuous canopy. Isolated trees only

Forest Condition - Canopy density (tick main canopy)		
Dense <input type="checkbox"/>	Open <input type="checkbox"/>	Very open <input type="checkbox"/>
Canopy density > 70%	Canopy density < 70%	No real canopy. Isolated trees only

Forest Condition – Regeneration (including coppice regrowth)		
Abundant <input type="checkbox"/>	Scattered/few <input type="checkbox"/>	None <input type="checkbox"/>
Regeneration easy to find in most places	Regeneration only in some places and hard to find	No regeneration
Write the names of the 3 main tree species in the regeneration		
1)	2)	3)
Regeneration: Seedlings > 30cm and < 1.3m height		

Forest Condition – Approximate density of seed trees		
High <input type="checkbox"/>	Moderate <input type="checkbox"/>	Low <input type="checkbox"/>
> 50 seed trees per ha	10 – 50 seed trees per ha	< 10 seed trees per ha

Block Condition – Summary			
(Use the forest condition class box below to get an average condition for the block)			
Poor <input type="checkbox"/>	Average <input type="checkbox"/>	Good <input type="checkbox"/>	Very Good <input type="checkbox"/>
Does the main forest canopy consist of large, mature trees?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	

Forest Condition Class Box				
Age	Canopy density	Regeneration & coppice	Seed tree class	Condition
Mature forest	Dense	Abundant		Very good
		Scattered/few		Good
	Open	Abundant		Good
		Scattered/few		Average
Pole stage forest	Dense	Abundant		Good
		Scattered/few		Average
	Open	Abundant		Average
		Scattered/few		Poor
Shrubland and young growth	Dense		Moderate or High	Average
	Dense		Low	Average
	Open		Low	Poor
Any	Very open	None		Poor

Open spaces (complete if there are significant open spaces in the block)	
Approximate total open space area (ha)	
Dominant vegetation type in the open space	
Cause of open space e.g. grazing, fire, harvesting, etc.	

Grazing and fodder (complete if the forest block is used for grazing or fodder)			
Grassland type			
Natural <input type="checkbox"/>	Man-made <input type="checkbox"/>	Mixture <input type="checkbox"/>	Predominantly forest <input type="checkbox"/>
Main fodder species being used ( <i>list 3 only</i> )			
Local name		Scientific name	
Pasture quality (list the 3 dominant species in the grassland)			
Local name		Scientific name	
Use pattern		Seasonal <input type="checkbox"/>	All year <input type="checkbox"/>
Type of user	Migratory <input type="checkbox"/>	Local <input type="checkbox"/>	Both <input type="checkbox"/>

Catchment Condition (use catchment condition class box below)	
(i) Catchment condition – soil cover	
Soil cover	Soil cover class
> 50% of the soils are covered by vegetation	high <input type="checkbox"/>
25 – 50% of the soils are covered by vegetation	moderate <input type="checkbox"/>
< 25% of the soils are covered by vegetation	low <input type="checkbox"/>
(ii) Catchment Condition - Soil type and erosivity	
Soil type (colour, texture and type)	
Erosive <input type="checkbox"/>	Non-erosive <input type="checkbox"/>
disperses and/or breaks up in water easily	stable to water flow
(iii) Catchment Condition - Slope	

Slope (degrees)	Slope steepness class		
<10°	Gentle		<input type="checkbox"/>
10° – 30°	Moderate		<input type="checkbox"/>
> 30°	Steep		<input type="checkbox"/>
Catchment Condition – Summary (Use the catchment condition class box below to get the average condition for the block)			
Less critical	<input type="checkbox"/>	Moderately critical	<input type="checkbox"/>
		Highly critical	<input type="checkbox"/>

Catchment Condition Class Box			
Slope category	Soil erosivity	Cover class	Condition class
Flat	Erosive	Moderate or high	Moderately critical
		Low	Highly critical
	Non erosive	any	Less critical
Moderate	Erosive	Moderate or high	Moderately critical
		Low	Highly critical
	Non erosive	Moderate or high	Less critical
		Low	Moderately critical
Steep	Erosive	Moderate or high	Moderately critical
		Low	Highly critical
	Non erosive	Moderate or high	Moderately critical
		Low	Highly critical

Fauna (List any animal or bird species seen or which are known from the block)	
Local Name	Scientific name




Biotic Pressures (tick those present)			
Fire	Common <input type="checkbox"/>	Occasional <input type="checkbox"/>	Absent <input type="checkbox"/>
Grazing	Heavy <input type="checkbox"/>	Limited <input type="checkbox"/>	Absent <input type="checkbox"/>
Fodder collection (list main species used)	Common <input type="checkbox"/>	Limited <input type="checkbox"/>	Absent <input type="checkbox"/>
NWFP collection (list the main products including bamboo & cane)	Common <input type="checkbox"/>	Limited <input type="checkbox"/>	Absent <input type="checkbox"/>
Leaf litter collection	Common <input type="checkbox"/>	Limited <input type="checkbox"/>	Absent <input type="checkbox"/>
Encroachment	Common <input type="checkbox"/>	Occasional <input type="checkbox"/>	Absent <input type="checkbox"/>
Pole harvesting	Common <input type="checkbox"/>	Occasional <input type="checkbox"/>	Absent <input type="checkbox"/>
Fuelwood harvesting	Common <input type="checkbox"/>	Occasional <input type="checkbox"/>	Absent <input type="checkbox"/>
Timber harvesting	Common <input type="checkbox"/>	Occasional <input type="checkbox"/>	Absent <input type="checkbox"/>
Hunting	Common <input type="checkbox"/>	Occasional <input type="checkbox"/>	Absent <input type="checkbox"/>
Others (describe)			

Potential Management Options (list any potential management options for the CF/block)	
1	
2	
3	
4	
5	

Forest resource assessment is conducted using sample plots involving the CFMG members. This shall show the growing stock (of timber) in the block in order to calculate the timber available for harvesting during the CF Management Plan period. It shall also assess the stock of any NWFPs that may be prescribed for sustainable management. Complete tally sheets (Format 2 below), one sheet for each sample plot in the CF/block.

1.4.4. Format 2. Quantitative Forest Resource Assessment - Tally Sheet													
CF Name		Date											
		Canopy height	<5, <10, <20, <30, 30+										
Block name		Canopy closure	<10, <40, 40+										
Plot number		Altitude											
Name of recorder		T = suitable for timber: N = Not suitable for timber											
		Dbh (cm)											
Species (local name)	Suitability	< 10 cm (seedlings)	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100+	
	T												
	N												
	T												
	N												
	T												
	N												
	T												
	N												
	T												
	N												
	T												
	N												
	T												
	N												
Total	T												
	N												
	% N												

## How to conduct Forest Resource Assessment

### a. Calculation of number of plots and determining the grid lengths

The forest type needs to be pre-stratified as per the Coefficient of Variation (CV) % of different forest types prior to determining the number of sample plots. For example, the total gross area of a CF is 600 ha (Table 2.2).

*Table 2.2 Net production of a CF by forest type*

Forest Types	Net Production Area (Ha)
Fir	100
Mixed Conifer	200
Blue Pine	300
Total	600

Table 2.3 below shows the CV for typical forest types obtained on 0.05 – 0.1 ha fixed plot size. However, it is recommended to calculate CV % for each CF based on field available data instead of using default value.

*Table 2.3 CV for typical forest types*

Forest type	CV%
Fir	50
Spruce	70
Blue Pine	105
Mixed Conifer	70
Combined conifer	80
Oak (Q. semicarpifolia)	65
Mixed Broadleaf	85
Combined Broadleaf	85
Combined all	85

### Example of pre-stratification and generation of number of plots

Suppose there are three strata with the following areas and estimated CV% (Table 2.4).

*Table 2.4 CV % of different forest type of a CF*

Forest Type	Area (Ha)	CV%	Weighted CV
Mixed Broadleaf	100	85%	$(85/100 \times 100) = 85$
Mixed Conifer	200	70%	$(70/100 \times 200) = 140$
Blue Pine	300	105%	$(105/100 \times 300) = 315$
	600		540

The weighted average CV% =  $(540/600) \times 100$  is therefore 90%.

The number of plots required in each to achieve a target sampling error of 10% at 95% confidence level over the whole area can be calculated as under;

$$n = \frac{t^2 \times CV\%^2}{SE^2} \quad (20)$$

Where:

n = number of sample plots

t = value of t distribution (see Table 2.5)

CV% = coefficient of variation (in %) for the forest, using the same type of sample plot

SE% = the target sampling error (in %) to be attained

Therefore, from above example,  $(2)^2 \times (90)^2 / (10)^2 = 324$  plots

*Table 2.5 t-table*

df	Probability								
	0.5	0.4	0.3	0.2	0.1	0.05	0.02	0.01	0.001
1	1.000	1.376	1.963	3.078	6.314	12.706	31.821	63.657	636.619
2	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	31.598
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	12.941
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	6.859
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	5.405
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.922
19	0.688	0.861	1.066	1.326	1.729	2.093	2.539	2.861	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.767
24	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.725
26	0.684	0.856	1.056	1.315	1.706	2.056	2.479	2.779	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.551
60	0.679	0.848	1.046	1.295	1.671	2.000	2.390	2.660	3.460
120	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617	3.373
∞	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.291

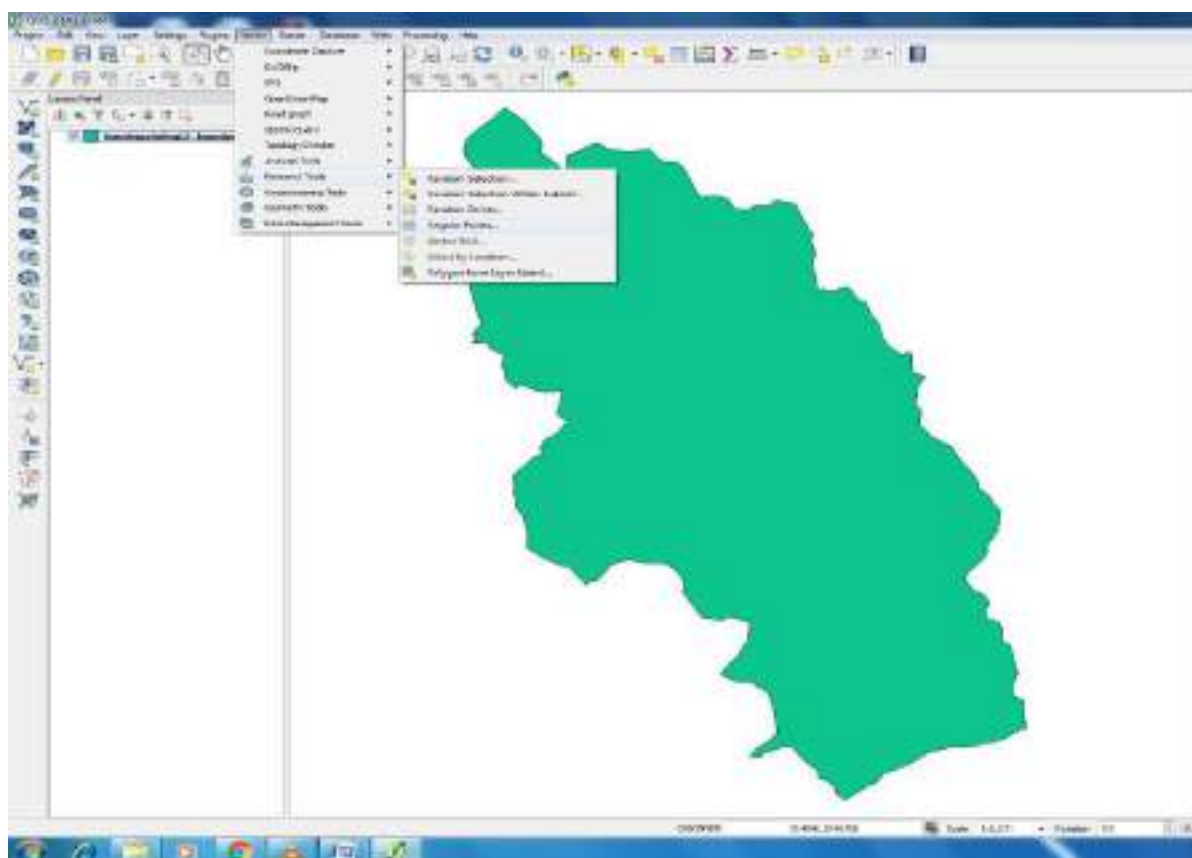
The target *sampling error* to be attained has been set at +/- 10% (SE % = 10%) of the average gross volume per ha, given a confidence level of 95%. The *t-value* is obtained from a *t-table*, using the correct number of degrees of freedom *df* ( $df = n - 1$ ), and probability level *p*. The probability level, or risk level, is the opposite of the confidence level: if we are 95% confident, we run a risk of  $100\% - 95\% = 5\%$ . Our probability level is then  $p=0.05$ .

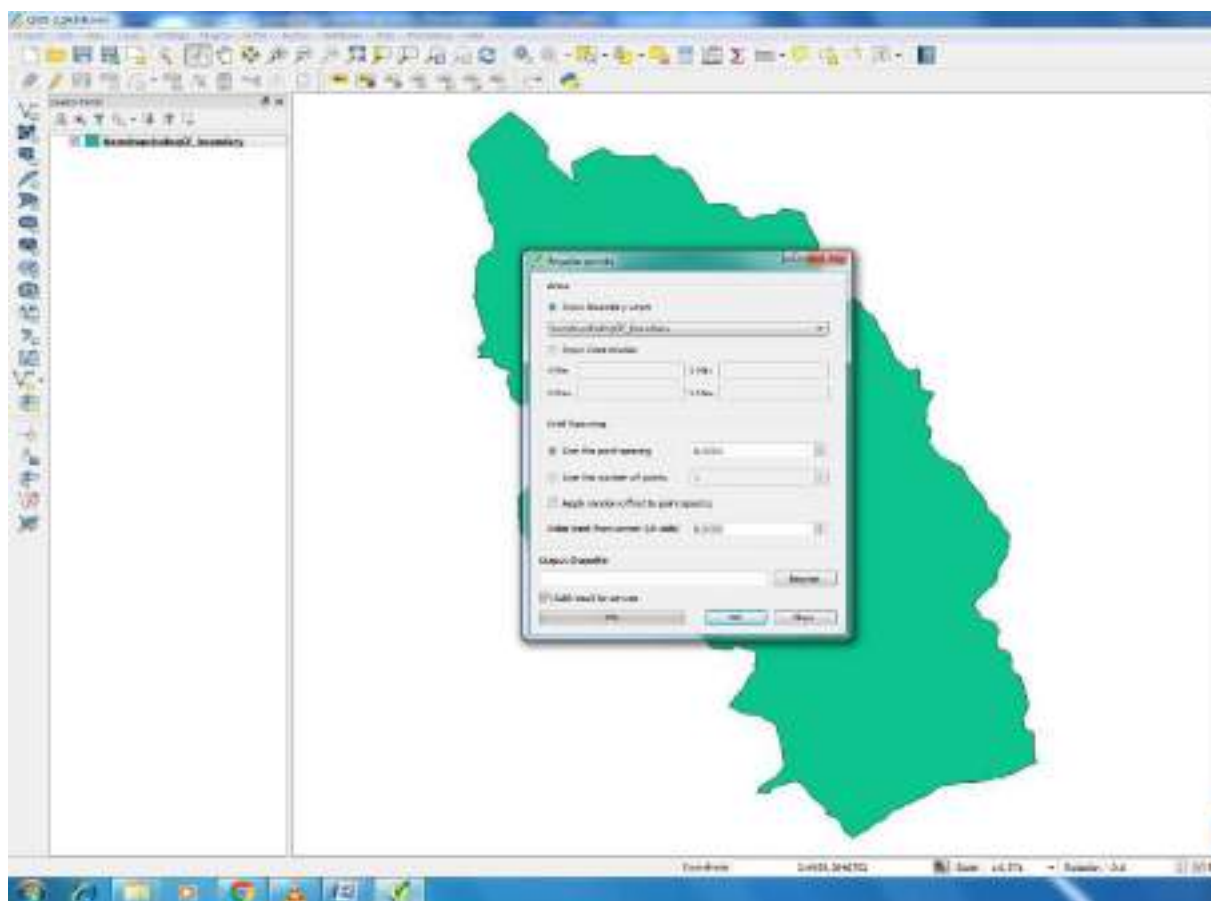
Each plot should represent an average area of 1.85 ha ( $600/324$ ) to proportionately allocate 324 plots within a CF of 600 ha. Given the many practical advantages, it is recommended to follow systematic sampling resulting square sampling grid. A square grid would have sides of 136 m calculated as follows ( $1.85 \times 10,000 \text{ m}^2 = 18,500 \text{ m}^2$ , and square root of 18,500 = 136 m). Thus, a systematic sampling grid of 136 m between plots on a line, with each plot representing  $(600/324) = 1.85$  ha shall be considered for creating the sampling design for the CF area (plot to plot is also 136 m).

#### Preparation of Sampling Design

Preparation of sampling design can be carried out in GIS. The following steps may be followed for designing a sampling design of a CF area:

- i. Load the shape file of the CF in QGIS. Please note that the file must be ESRI shape file and NOT other types of file. Go to tab 'vector' as shown in the Figure below and select Research tools on the drop down. Under the Research tools, select Regular points in the drop down.





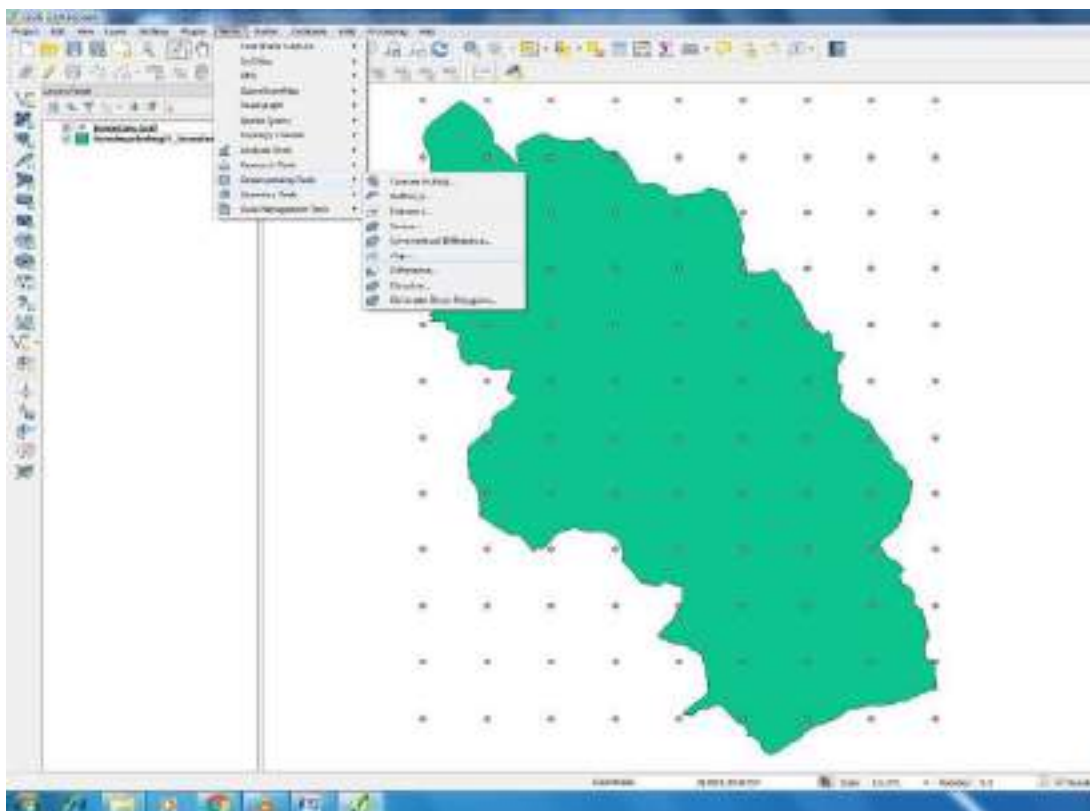
ii. Once you click on the Regular Points, a window “**Regular Points**” shall pop up as shown in the Figure 8b above. The “**input boundary layer**” shall be the shape file of the CF for which the sampling design is prepared. The **Grid spacing** shall be the spacing that is calculated in previous step (i). The grid thus created needs to be saved by giving a file name (e.g. Grid name of the CF) and saving in an appropriate folder. The file can be saved by choosing the appropriate folder using “**Browse**” tap in the window. After filling up all the requirements, click “**OK**” to generate the grid.

iii. Once you click “OK”, a grid with spacing you provided shall be created as shown in the figure. For now, the name of the grid is given as Grid CF. However, since you need the grid just within the CF boundary, the grid thus created (Grid-CF) needs to be clipped with the CF boundary to get the final grid of the community Forest.

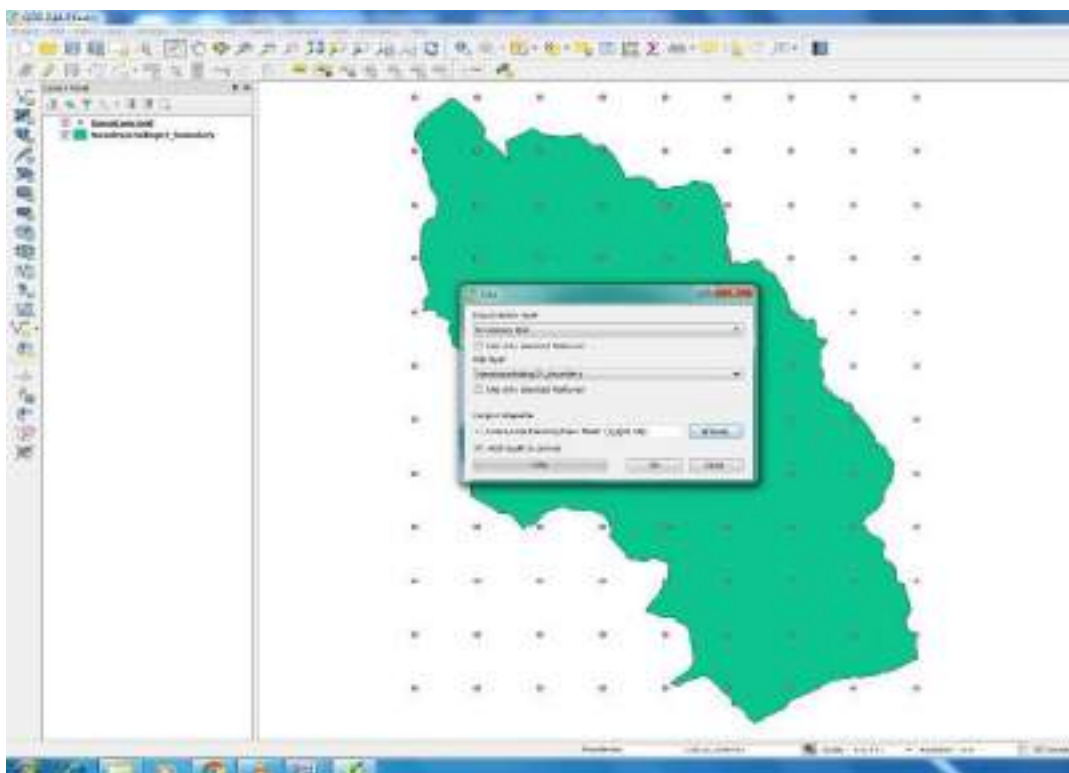
How to do:

- Go to the tap “**Vector**”. Click on “**Geoprocessing tools**” on the drop down and subsequently click on “**Clip**” as shown in the Figure 8c.

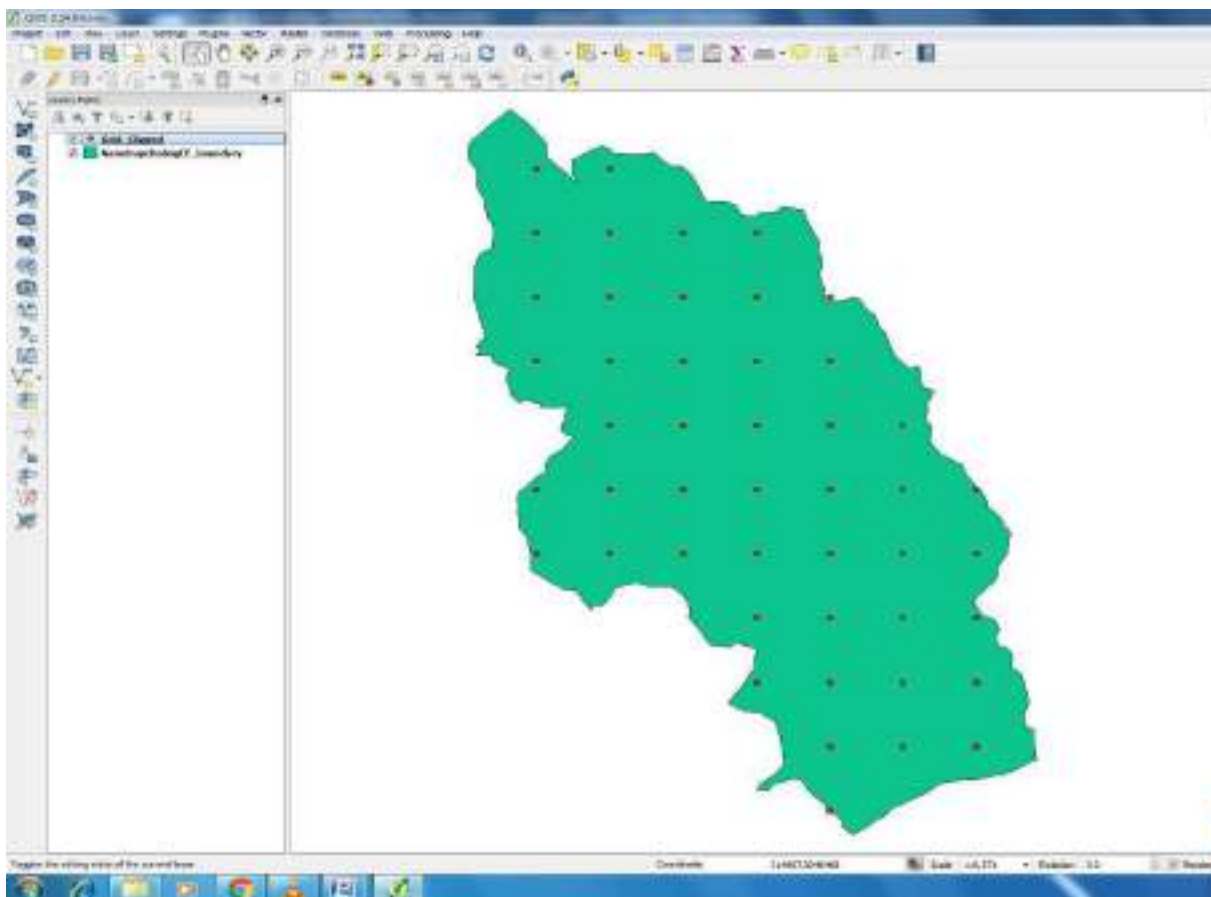




- A window “Clip” shall appear as shown in the Figure. “**The input vector layer**” shall be the Grid that is just created which is “**Grid\_CF**” for this case. “**The Clip layer**” shall be the CF boundary shape file for which the sampling design is being created. The grid thus clipped needs to be saved by giving a file name (e.g. Grid name of the CF Final) and saving in an appropriate folder. The file can be saved by choosing the appropriate folder using “**Browse**” tap in the window. After filling up all the requirements, click “**OK**” to generate the final grid.

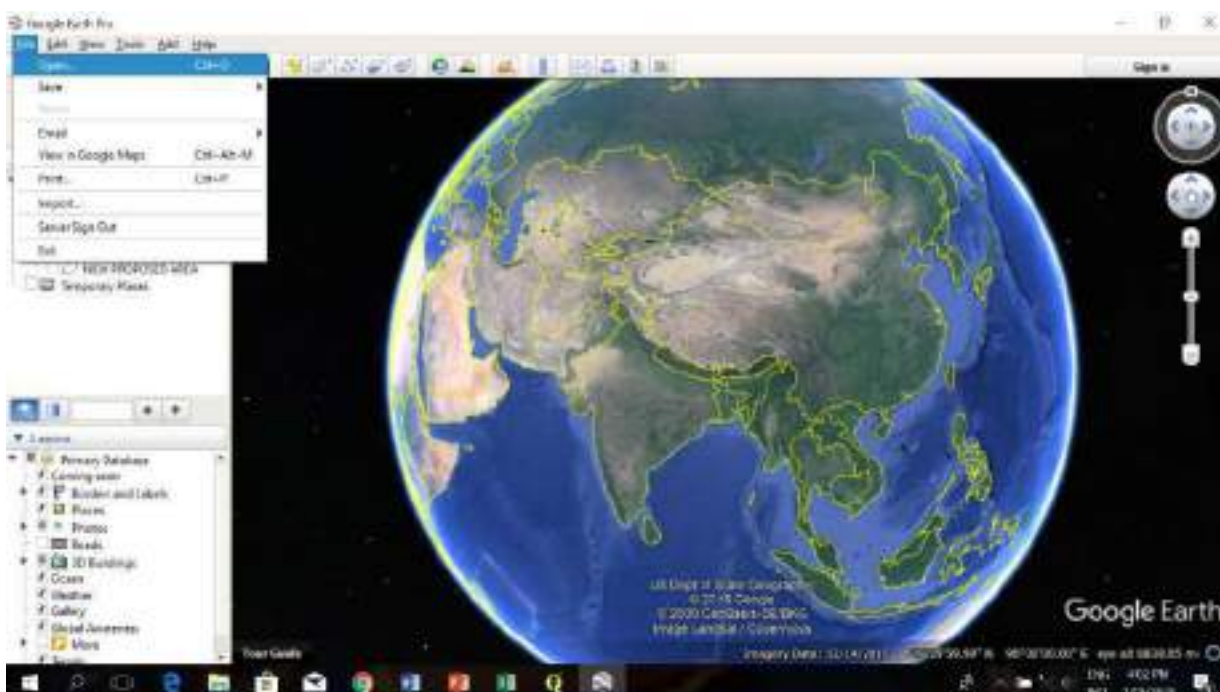


- The final grid of the CF is created as shown in the Figure below.



**b. Overlay the Grid in Google Earth**

The shape file of the Final Grid of the CF thus created can be transferred to Google Earth to have better view. Upon importing the shape file to Google earth, you can view the plots.





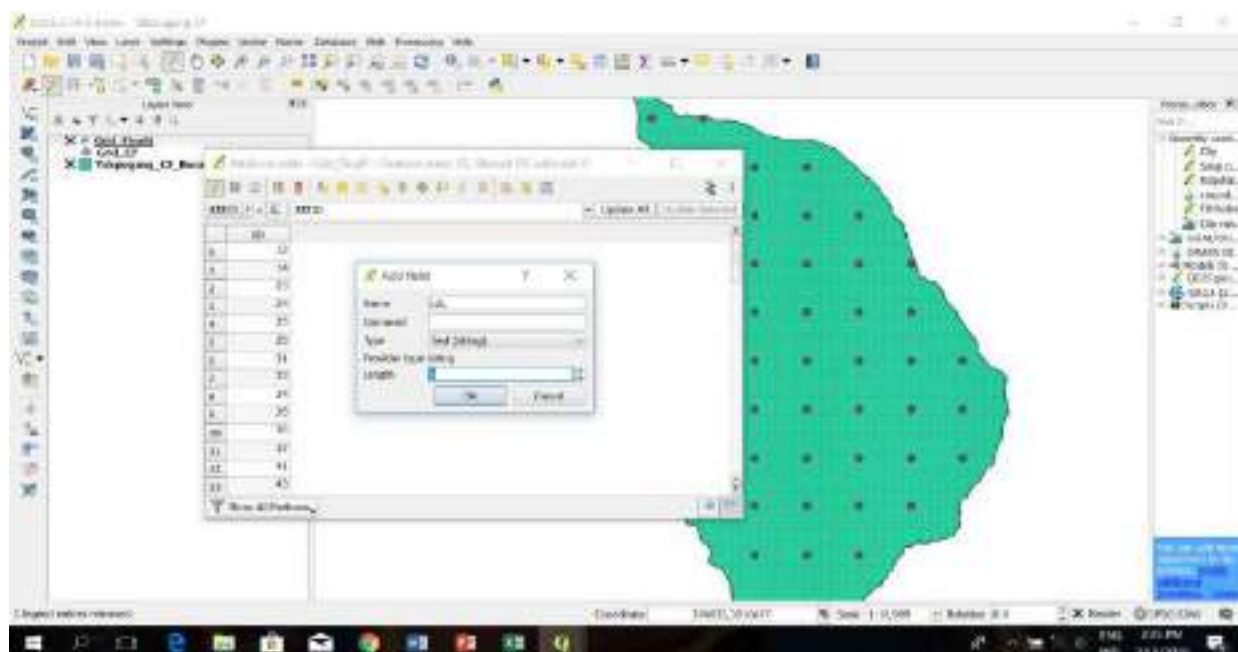
## **2) Allocation of plot ID and determining Geographical coordinates for individual plot**

Allocation of plot ID and determining Geographical coordinates for individual plot must be carried out in GIS.

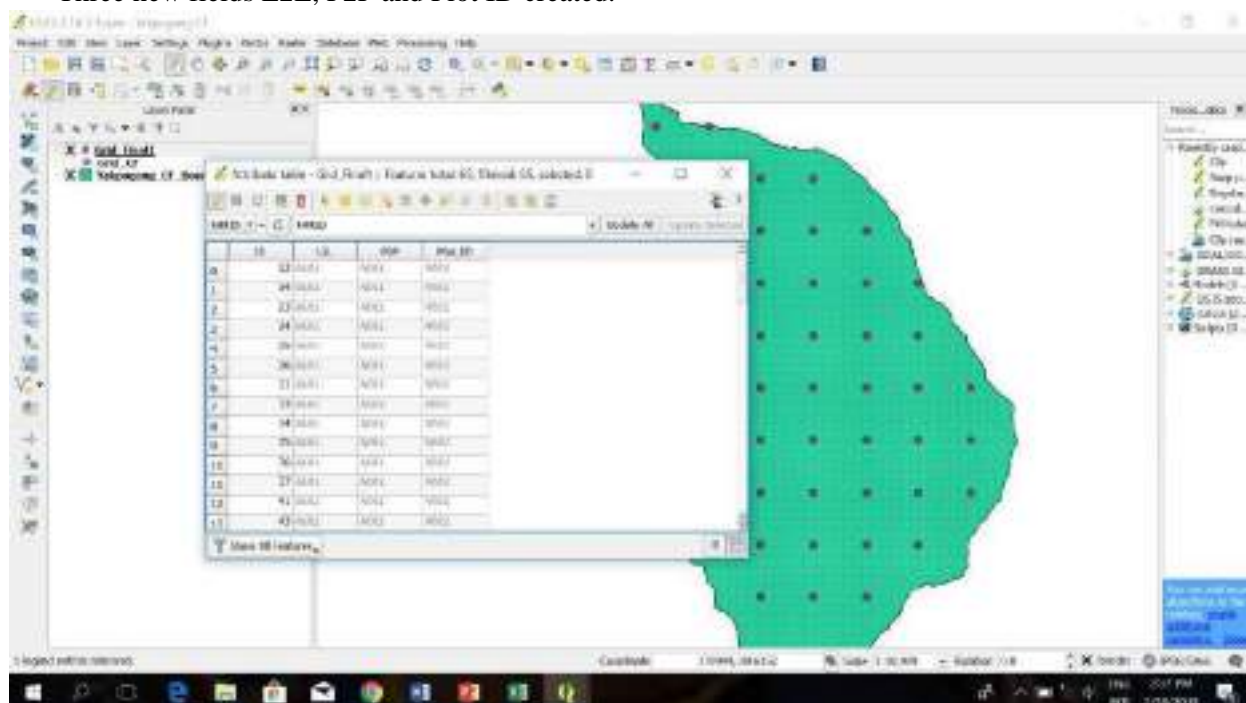
How to do:

- Open the attribute table of the Gird CF final shape file.
- Create three new fields named L2L (line to line), P2P (Point to Point) and Plot ID in the attribute table as shown in the Figure by using add field window.
- Creating new fields in the attribute table.



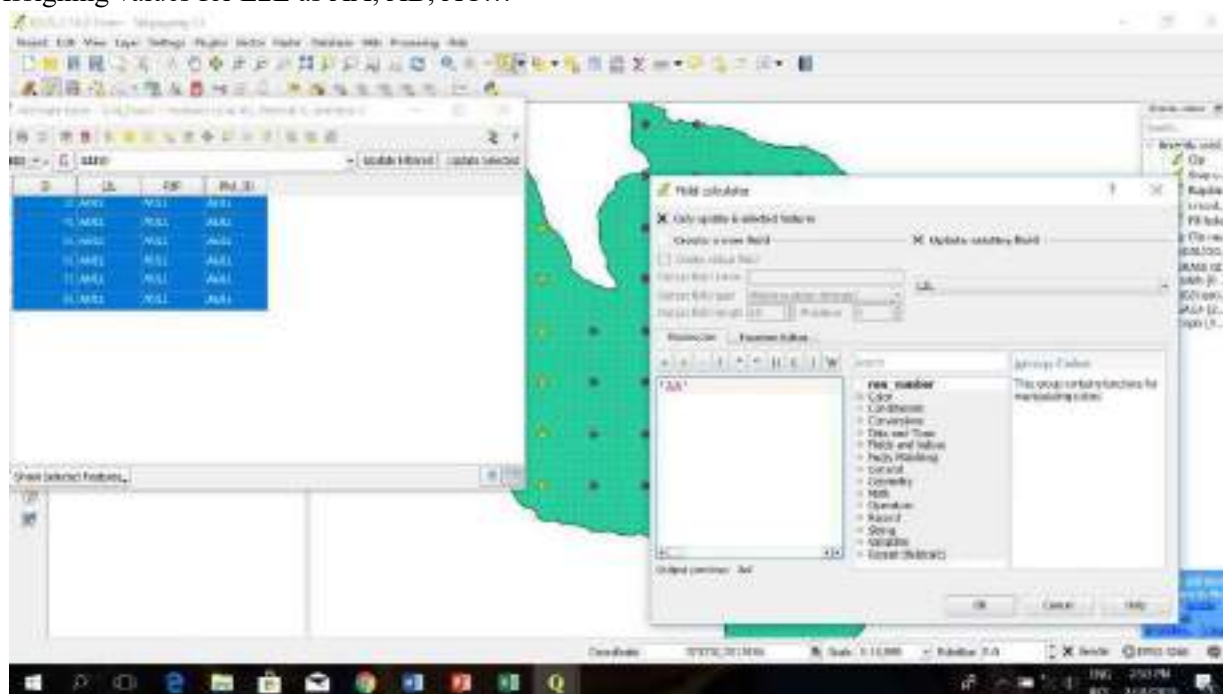


- Three new fields L2L, P2P and Plot ID created.

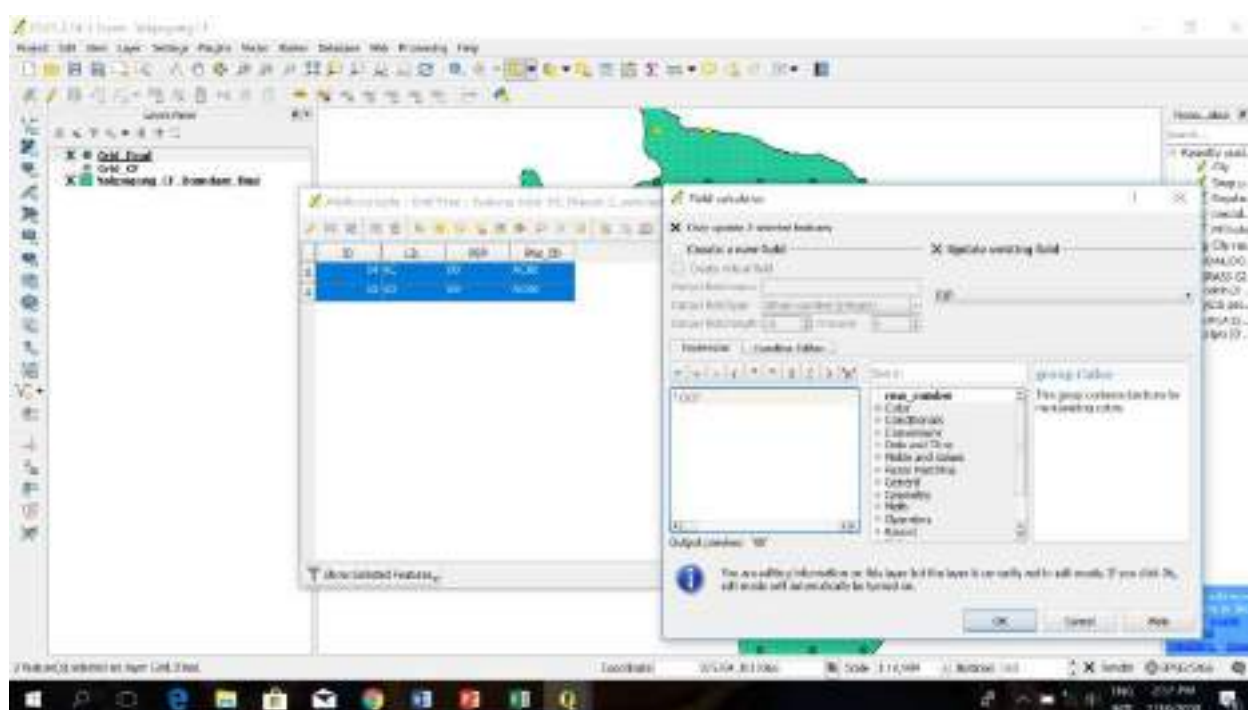


- Assign the values for L2L as AA, AB, AC, AD..... along the points vertically and P2P as 00, 01, 02, 03, 04 ... along the points horizontally. And finally generate the Plot ID by combining L2L and P2P as shown in the figures below.

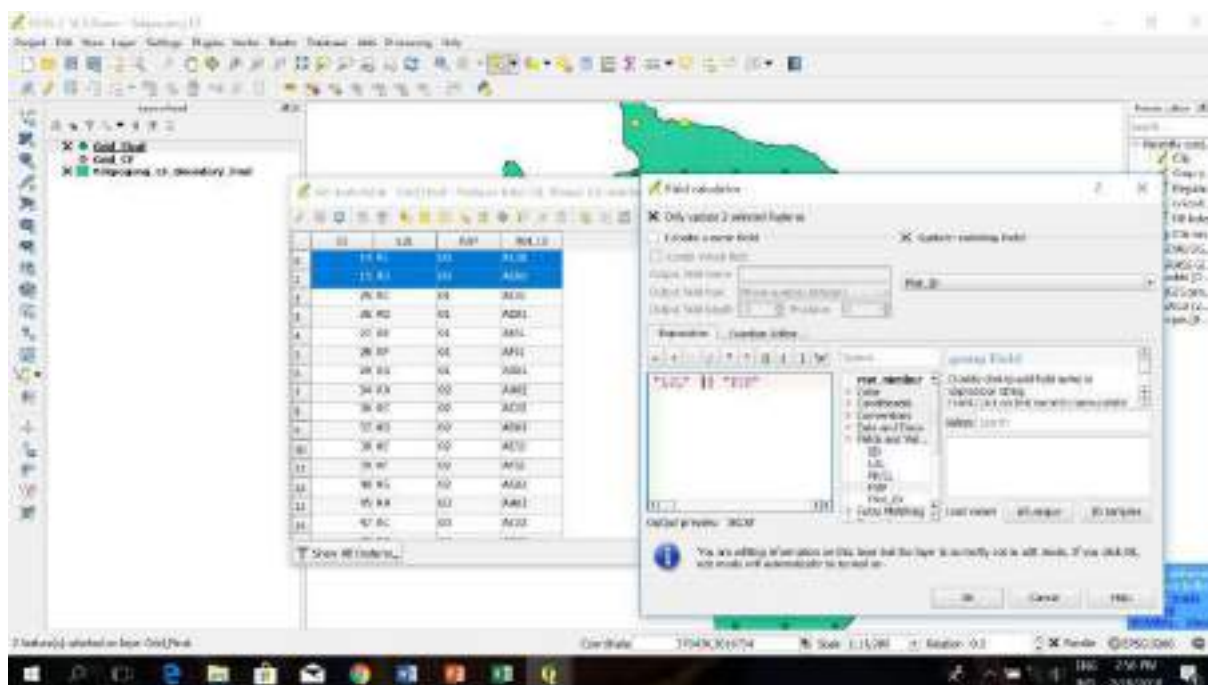
Assigning values for L2L as AA, AB, AC...



- Assigning values for P2P as 00, 01, 02, 03, 04

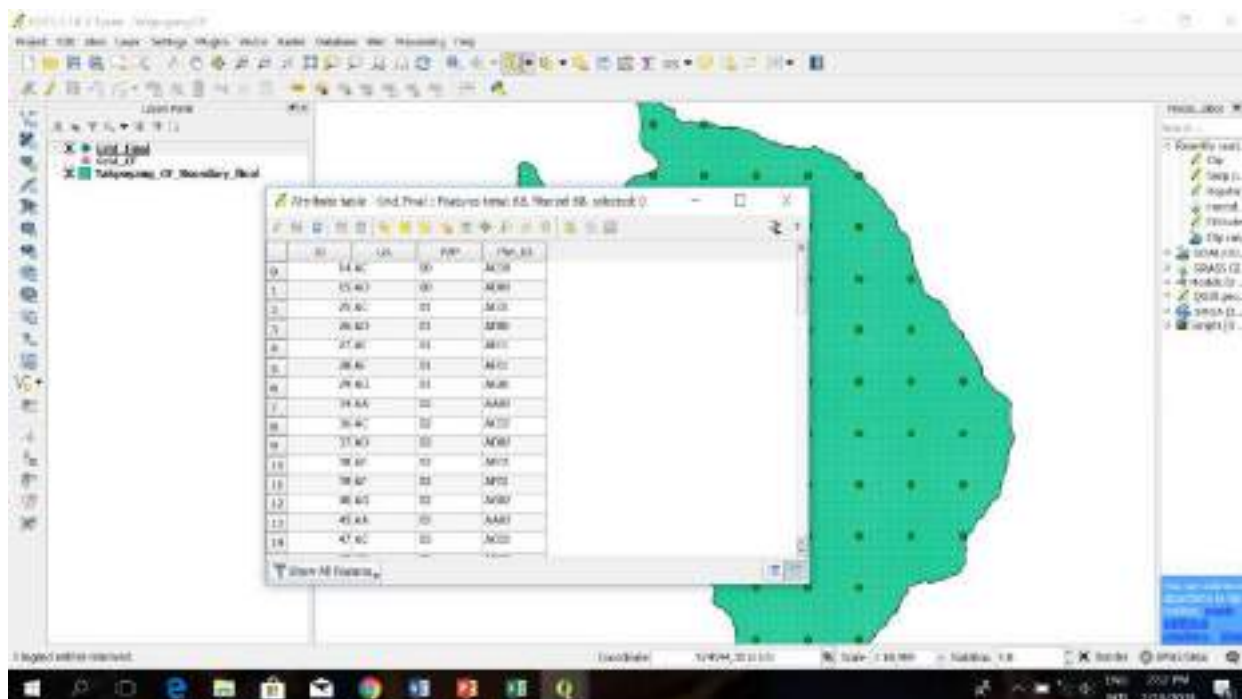


- Generating plot ID by combining L2L and P2P



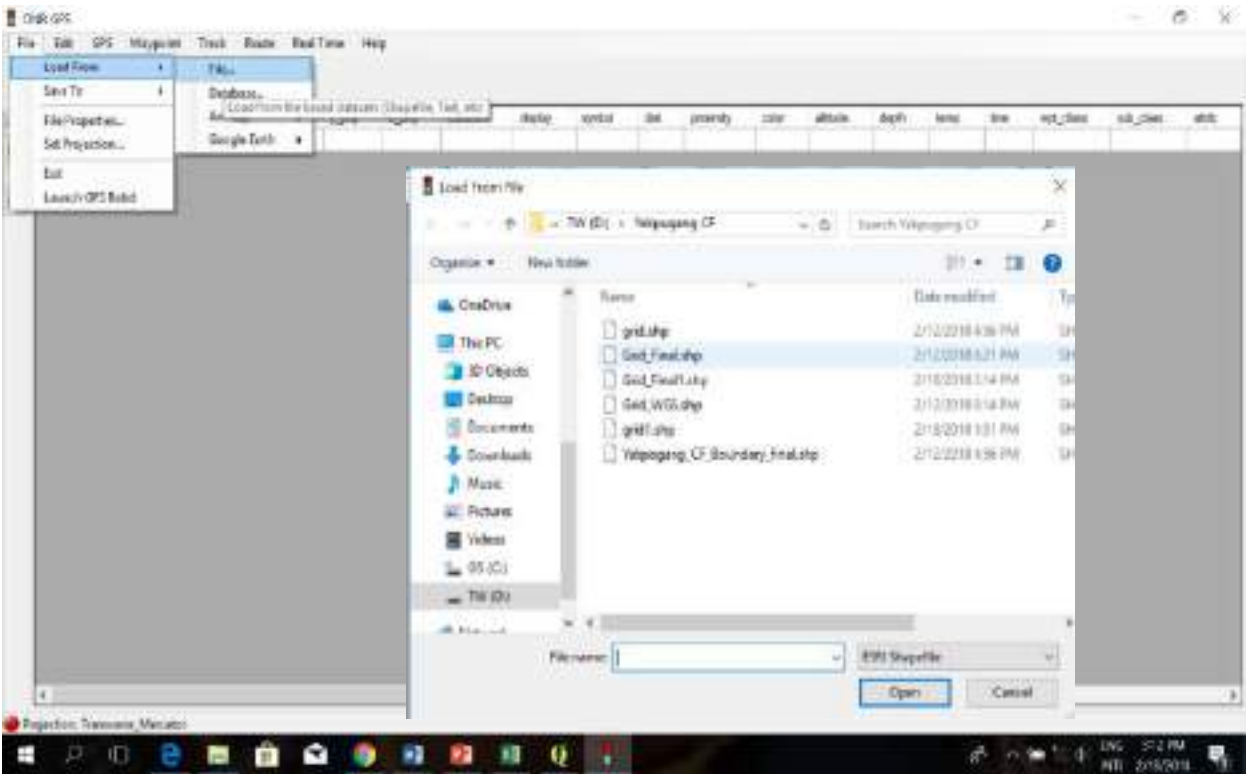
The

- Plot IDs for individual plots generated.
- 

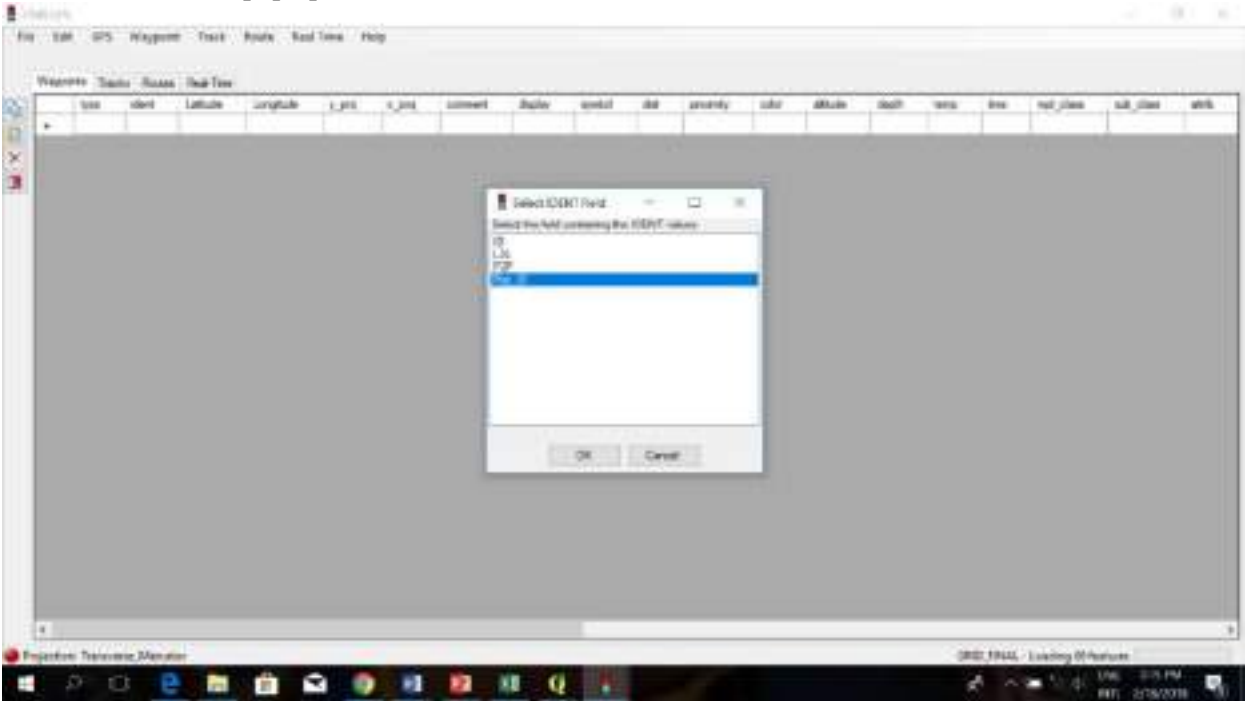


- Generate the Geo-coordinates for the plots by uploading the Plots in the DNR GPS (a software for generating the plot geo-coordinates)
- Upload the Grid CF Final in the DNR GPS.

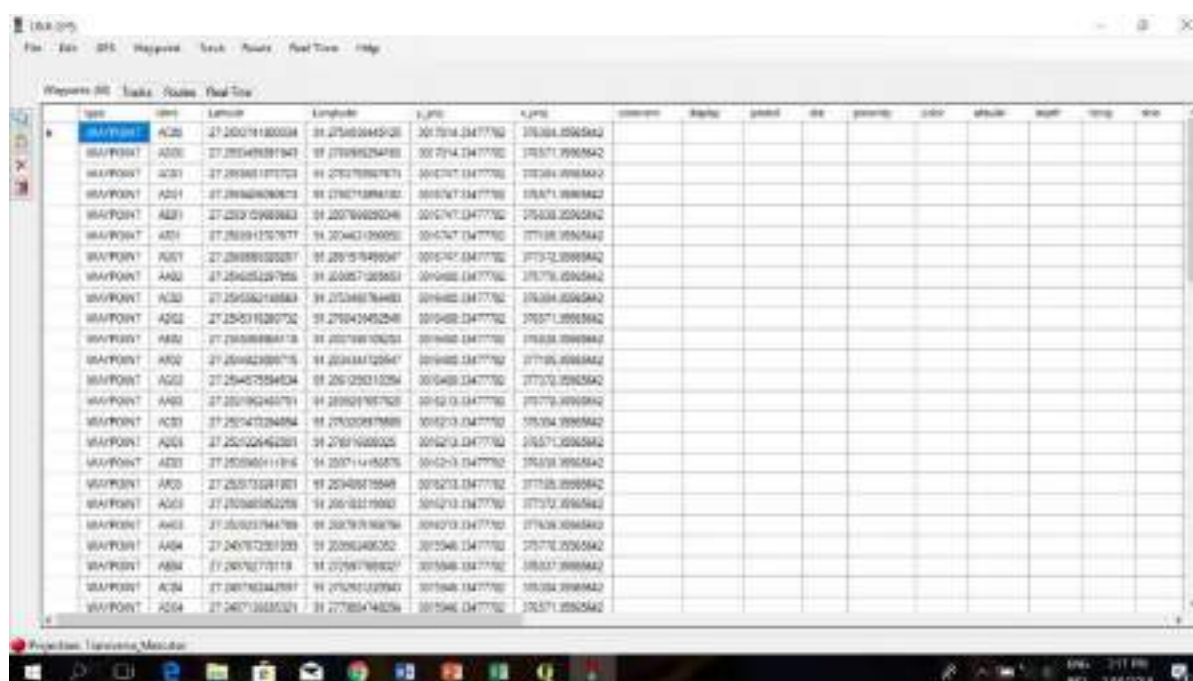




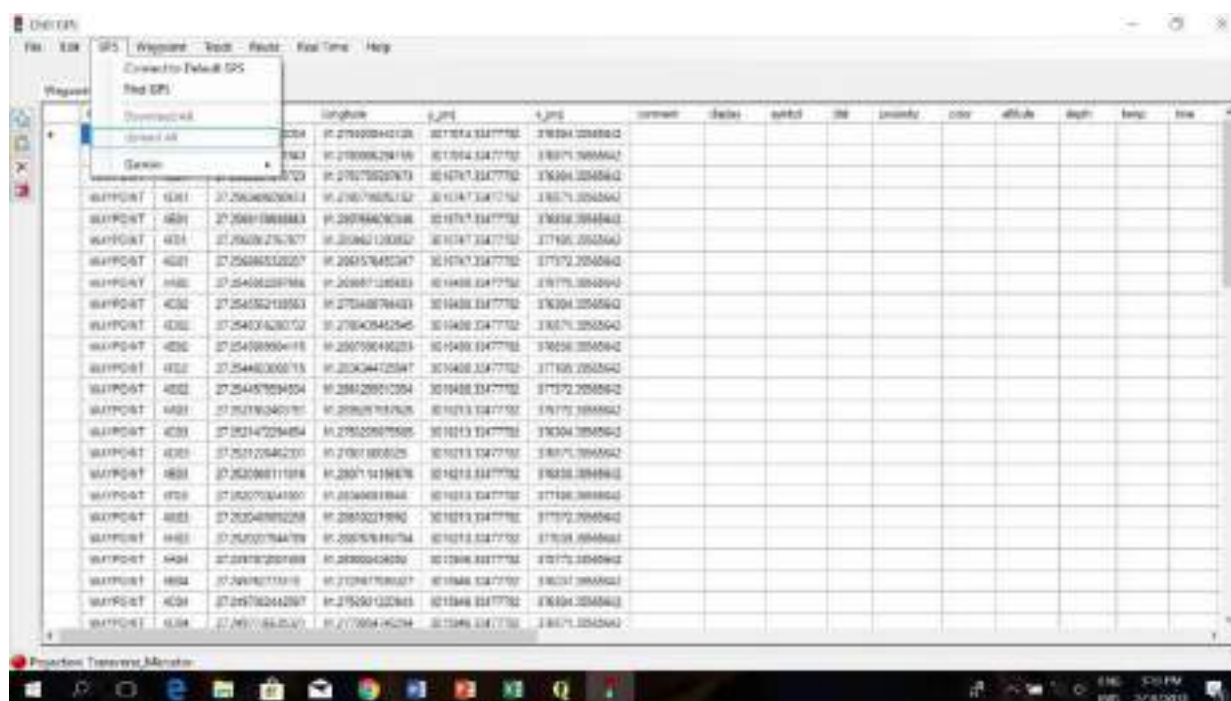
- A window shall pop up where Plot ID needs to be selected and then click OK.



- Plot geo-coordinates are generated as shown in the figure below.



- Load the Plots along with its geo-coordinates in GPS



### 3) Navigating to the plot by using the GPS with loaded plot IDs.

To navigate to the plot, use the GPS which has loaded plot IDs as waypoints. Upon reaching the plot within a distance of less than 10m, the GPS shall emit 'BEEP' sound indicating that you are approaching the plot center.

### 4) Laying out of sample plots

Mark the centre of the plot with a peg and write the plot number. Each plot shall consist of two circular plots. Major plot of 12.62 m radius (0.05 ha) and regeneration plot of 3.57 m radius (0.004 ha) are measured from the plot centre (Figure 2.4). The major plot shall be used for collecting tree data with dbh measuring

more than 10 cm. The regeneration plot shall be used for regeneration count with dbh less than 10 cm. Trees within the regeneration plot but measuring more than 10 cm dbh shall be counted as in major plot.

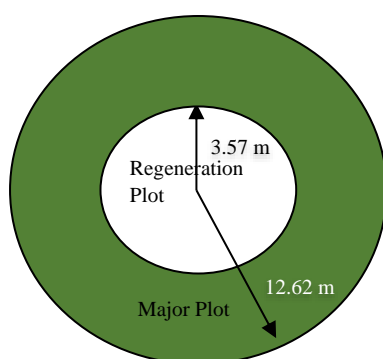


Figure 2.4 Plot Design

Table 2.6 Major and Regeneration plots

Plots	Radius (m)	Area (m <sup>2</sup> )	Area (ha)	dbh
Regeneration	3.57	40	0.004	< 5 cm
Major	12.62	500	0.05	≥ 10 cm

## 5) Data collection

All recordings of the plot are entered into the tally sheet as per Format 2 given below.

1.4.5. Format 2. Quantitative Forest Resource Assessment - Tally Sheet												
CF Name				Date								
				Canopy height		<5, <10, <20, <30, 30+						
Block name				Canopy closure		<10, <40, 40+						
Plot number				Altitude								
Name of re-corder				T = suitable for timber: N = Not suitable for timber								
		Dbh (cm)										
Species (local name)	Suitability	< 10 cm (seedlings)	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100+
	T											
	N											
	T											
	N											
	T											
	N											
	T											
	N											
	T											
	N											
	T											
	N											
	T											
	N											
Total	T											
	N											
	% N											

Proceeding clockwise, start enumeration of the plot from the north. Record the species and the dbh (to the nearest cm) of any live trees above 10 cm. Mark it by removing a small piece of bark/slashing the bark facing the plot centre. Make sure only trees with dbh above 10 cm is considered for enumeration in major plot and below 10 cm dbh for regeneration plot.

## **6) Compilation**

After completion of the resource assessment, all data in the tally sheets must be transferred to compilation sheet (Format 4). The compilation sheet is filled based on the local volume table (Table 2.7) and dbh class. Compilation of the resources assessment data shall generate results for each species or group of species separately. For example, for a CF in temperate region all Broad leaves could be grouped together since they do not occur in sufficient numbers. However, other conifer species like Fir, Blue Pine, Hemlock, Spruce, etc. can be grouped separately as they are found in large numbers. Then start filling the compilation form (Format 4, Format 5, Format 6, and Format 7).

- Col 1, 2 & 3 are the values from selected Local Volume Table.
- Col 4 is the size of the plot in hectares.
- Col 5 is the expansion factor for each dbh class which is calculated by using the expression  $EF = (1/\text{size of the plot}) / \text{number of plots}$ .
- Col 6 is the values for the total number of trees found for each diameter class which can be done by searching through the tally sheet.
- Col 7 is filled by multiplying col 5 and col 6.
- Col 8 is filled by multiplying col 7 and col 2.
- Col 9 is filled by multiplying col 7 and col 3.
- Finally add the values column 7-9. These are the sums for all the dbh classes combined.

Format 4: Forest Resource Assessment: Compilation Sheet								
1. CF Name : .....				4. Block Area : .....				
2. Block Name : .....				5. Compiling date : .....				
3. Number of plots : .....								
col1	col2	col3 (3 deci- mals)	col4 (3 deci- mals)	col5 (3 deci- mals)	col6 (0 deci- mals)	col7 (2 deci- mals)	col8 (2 deci- mals)	col9 (2 deci- mals)
dbh class (cm)	basal area (m <sup>2</sup> )	class volume (m <sup>3</sup> )	plot size (ha)	expansion factor	Tally	nrha (stems/ha)	basha (m <sup>2</sup> /ha)	volha (m <sup>3</sup> /ha)
10-19	0.017							
20-29	0.047							
30-39	0.093							
40-49	0.156							
50-59	0.233							
60-69	0.327							
70-79	0.436							
80-89	0.561							
90-99	0.701							
100-109	0.858							
110-119	1.030							
120-129	1.217							
130-139	1.421							
140-149	1.640							
150-159	1.875							
160-169	2.125							
170-179	2.392							
180-189	2.674							
190-199	2.971							
sum for all dbh classes								
<b>Explanation:</b>  <div style="display: flex; justify-content: space-between;"> <div> <p><b>col3</b> : look up in volume table, for given species group and dbh class</p> <p><b>col4</b> : plot size for given dbh class</p> <p><b>col5</b> : (1/col4) / (nr. of plots) (when rounding: round to the nearest EVEN digit; e.g. 0.635 to 0.64 but 0.665 to 0.66)</p> </div> <div> <p><b>col6</b> : count and fill in : col5 *</p> <p><b>col7</b> : col6 : col7 *</p> <p><b>col8</b> : col2 : col7 *</p> <p><b>col9</b> : col3</p> </div> </div>								

Table 2.7 Local Volume Table

Royal Government of Bhutan						Ministry of Agriculture and Forests				Volume Table (m³)																
Department of Forests and Park Services						Forest Resources Management Division																				
dbh (cm)	Conifers					Broadleaves																				
	Bluepine	Chirpine	Fir	Hemlock	Juniper	Larch	Spruce	Oth. Conif.	Acer	Betula	Beilschmiedia spp.	Cinnamomum	Litsea spp.	Mitchella spp.	Oak spp. (W)	Oak spp. (C)	Oak spp. (E)	Oak spp. (S)	Oth. Broadl. (W)	Oth. Broadl. (C)	Oth. Broadl. (E)	Oth. Broadl. (S)	Persea spp.	Rhododendron spp.	Schinus spp.	
10-49 cm	10-14	0.056	0.030	0.091	0.044	0.050	0.054	0.063	0.050	0.073	0.057	0.037	0.047	0.052	0.054	0.057	0.053	0.058	0.049	0.046	0.043	0.053	0.052	0.045	0.053	
	15-19	0.135	0.080	0.195	0.098	0.122	0.126	0.148	0.114	0.152	0.134	0.094	0.107	0.120	0.132	0.134	0.124	0.137	0.113	0.110	0.102	0.124	0.120	0.104	0.125	
	20-24	0.260	0.167	0.344	0.179	0.238	0.239	0.281	0.211	0.262	0.252	0.191	0.198	0.225	0.256	0.255	0.233	0.260	0.211	0.213	0.197	0.234	0.223	0.193	0.239	
	25-29	0.438	0.299	0.542	0.290	0.406	0.397	0.469	0.345	0.406	0.417	0.382	0.336	0.323	0.369	0.434	0.426	0.387	0.435	0.347	0.361	0.332	0.388	0.367	0.317	0.399
	30-34	0.675	0.485	0.792	0.433	0.633	0.606	0.717	0.520	0.584	0.635	0.585	0.537	0.485	0.559	0.673	0.652	0.590	0.666	0.527	0.559	0.512	0.591	0.555	0.478	0.614
50-99 cm	35-39	0.980	0.734	1.094	0.612	0.926	0.870	1.033	0.739	0.797	0.911	0.843	0.803	0.688	0.796	0.982	0.940	0.846	0.961	0.752	0.814	0.743	0.848	0.791	0.680	0.886
	40-44	1.356	1.055	1.453	0.827	1.292	1.194	1.422	1.005	1.046	1.248	1.161	1.142	0.933	1.086	1.365	1.293	1.160	1.324	1.027	1.131	1.029	1.163	1.079	0.926	1.222
	45-49	1.810	1.456	1.868	1.080	1.737	1.583	1.888	1.321	1.333	1.650	1.542	1.562	1.224	1.431	1.830	1.718	1.537	1.760	1.355	1.515	1.374	1.541	1.421	1.218	1.627
	50-54	2.347	1.947	2.343	1.374	2.267	2.039	2.437	1.690	1.657	2.123	1.992	2.070	1.562	1.833	2.382	2.218	1.978	2.274	1.739	1.970	1.783	1.984	1.821	1.559	2.104
	55-59	2.973	2.534	2.879	1.710	2.888	2.568	3.074	2.113	2.020	2.669	2.513	2.673	1.950	2.297	3.028	2.798	2.489	2.870	2.182	2.501	2.258	2.496	2.281	1.951	2.658
	60-64	3.691	3.228	3.477	2.090	3.606	3.171	3.802	2.594	2.421	3.291	3.110	3.380	2.390	2.824	3.772	3.462	3.072	3.553	2.686	3.113	2.805	3.081	2.805	2.396	3.293
	65-69	4.508	4.035	4.138	2.515	4.425	3.854	4.627	3.134	2.863	3.994	3.787	4.197	2.883	3.418	4.619	4.213	3.731	4.327	3.253	3.811	3.427	3.742	3.393	2.896	4.013
	70-74	5.427	4.964	4.865	2.987	5.352	4.618	5.552	3.735	3.344	4.781	4.545	5.132	3.432	4.080	5.576	5.057	4.468	5.195	3.887	4.597	4.127	4.481	4.050	3.454	4.822
	75-79	6.454	6.023	5.657	3.507	6.391	5.467	6.581	4.401	3.866	5.654	5.390	6.191	4.038	4.813	6.647	5.995	5.287	6.162	4.590	5.477	4.908	5.303	4.778	4.071	5.723
	80-84	7.591	7.220	6.517	4.076	7.548	6.405	7.718	5.132	4.430	6.617	6.324	7.381	4.702	5.620	7.838	7.033	6.191	7.231	5.364	6.454	5.774	6.210	5.578	4.749	6.721
	85-89	8.845	8.564	7.445	4.696	8.827	7.434	8.968	5.930	5.035	7.672	7.350	8.709	5.428	6.502	9.152	8.173	7.182	8.407	6.211	7.532	6.729	7.205	6.453	5.490	7.818
	90-94	10.218	10.061	8.443	5.367	10.234	8.557	10.334	6.798	5.681	8.823	8.471	10.183	6.215	7.463	10.595	9.419	8.264	9.691	7.133	8.715	7.775	8.290	7.405	6.295	9.018
	95-99	11.715	11.720	9.511	6.092	11.773	9.777	11.818	7.737	6.371	10.073	9.691	11.808	7.066	8.503	12.171	10.774	9.438	11.089	8.133	10.007	8.916	9.468	8.437	7.167	10.324
	100-104	13.340	13.550	10.651	6.871	13.449	11.097	13.426	8.749	7.103	11.423	11.013	13.592		9.624	13.885	12.241	10.708	12.603	9.212	11.411	10.154	10.743	9.549		11.739
	105-109	15.096	15.556	11.863	7.705	15.266	12.519	15.160	9.835	7.879	12.877	12.438	15.541		10.830	15.742	13.824	12.076	14.237	10.373	12.930	11.493	12.116	10.745		13.268
110-114	16.988	17.749	13.149	8.595			17.024	10.998	8.698	14.437	13.971			12.122	17.745	15.525	13.544	15.994	11.617	14.570	12.935	13.589	12.025		14.912	
115-119	19.019	20.134	14.508	9.543			19.020	12.239	9.561	16.105	15.613			13.501	19.898	17.348	15.116	17.877	12.947	16.332	14.483	15.166	13.393		16.674	
120-124	21.193		15.943	10.549			21.153	13.559	10.468	17.885	17.368			14.971	22.208	19.296	16.793	19.889	14.363	18.220	16.141	16.849			18.559	
125-129	23.513		17.454	11.615			23.425	14.960	11.420	19.779	19.237			16.531	24.676	21.371	18.577	22.034	15.869	20.238	17.911	18.640			20.568	
130-134	25.983		19.041	12.741			25.840	16.443	12.417	21.788				18.184	27.308	23.576	20.471	24.313	17.465	22.389	19.795	20.541				
135-139	28.607		20.706	13.928			28.400	18.010	13.459	23.916				19.933	30.107	25.915	22.477	26.731	19.154	24.675	21.796	22.555				
140-144	31.388		22.449	15.178			31.108	19.663	14.546	26.164				21.778	33.078	28.389	24.598	29.290	20.936	27.101	23.918	24.684				
145-149	34.329		24.272	16.491			33.968	21.402	15.679	28.535				23.721	36.224	31.002	26.835	31.993	22.815	29.670	26.161	26.929				
150-154	37.433		26.173	17.868			36.982								39.549	33.756	29.191	34.842	24.791	32.384	28.530	29.294				



# Forest and Nature Conservation Code of Best Management Practices of Bhutan

[illegible]

## **7) Generation of Results**

### **Stand and Stock Table Form**

Final results should be given in "Stand and Stock" tables (Format 5, 6 and 7). These are cross-tabular summaries for diameter classes and species groups for our estimates of the 3 main parameters of interest:

- Average number of trees per hectare (Format 5),
- Average basal area per hectare (Format 6) and
- Average volume of trees per hectare (Format 7).

Fill in the stand and stock table form by copying the results of the compilation sheets for the appropriate diameter classes and species group. The above stand and stock results shall be generated automatically in the excel sheet (formulas developed in excel for National Forest Inventory).

[illegible]

[illegible]

### Format 7: Stand & Stock Table: Volume

1. Name of CF:
2. Block name/No.:
3. Number of sample plots:
4. Estimated parameter: Average Volume per Ha (m<sup>3</sup>/ha)

**Dbh class (cm). Write all values in 2 decimals**

[illegible]

## 8) Calculating Annual Allowable Cut (AAC)

Annual allowable cut indicates the harvesting limit of trees including firewood and poles. The Annual Allowable Cut of the Community Forest is calculated using the formula below: Add these together to get the total AAC for each size class from the CF.

$$AAC (m^3) = \frac{Net\ operable\ area * Average\ volume\ per\ hectare}{Rotation\ age} \quad (21)$$

Where:

**Net operable area (ha)** = net area of the CF meant for timber production.

**Average Vol/ha (m<sup>3</sup>/ha)** = Average volume/ha derived from Stand and Stock Table

**Rotation age (year)** = Average rotation age in Broadleaf = 110 year and Conifers = 120 year).

The AAC (m<sup>3</sup>) should be calculated for different forest product categories using dbh class in equivalent number of trees (Table 2.8).

Table 2.8 Annual Allowable Cut

Annual Allowable Cut Table							
Annual Allowable Cut (AAC)	Dangchung m <sup>3</sup>	Tsim m <sup>3</sup>	Cham m <sup>3</sup>	Drashing m <sup>3</sup>	Firewood m <sup>3</sup>	Flag Poles	Fencing Posts
Block I							
Block II							
Block III							
...							
Total AAC							

Notes: for CFMG's understanding, m<sup>3</sup> can be converted into cft. (1 m<sup>3</sup> = 35.32 cft).

## 9) Non-Wood Forest Product Assessment

The NWFPs assessment should be conducted if there is potential for commercial harvesting. Different resource assessment techniques have been developed for various NWFPs because:

- Each species has a different growth pattern (annual, biennial, perennial)
- Distribution is often heterogeneous (patchy)
- Yield during different seasons (they may be absent during some seasons)
- Different types of plants are involved e.g. trees, shrubs, herbs, grasses, fungi, mosses
- Plant parts used are different for each species e.g. roots, stems, leaves, seeds, fruits, bark, resin, etc.
- Use-patterns vary from domestic to commercial.

### How to Prioritize NWFPs

- Discuss and decide with the CFMG members which NWFPs are available in CF area and commercially important to be included in the CFMP.
- Complete the NWFP Priority Assessment Format (Format 3) and rank according to their priority (commercial or domestic consumption).
- If a NWFP is prioritized as commercially important, assessment needs to be conducted and prescribe sustainable management in the CFMP.



- If NWFPs are used only for domestic purposes, then you may not need to carry out resource assessment. However, it shall be useful to develop a set of rules for harvesting that can be included in the CF By-laws.
- When a NWFP becomes commercially important after initiation of the CFMP, you may include in the annual work plan and conduct the assessment or develop harvesting guideline to include in the CFMP.

<b>Format 3. NWFP Priority Assessment Format</b>			
Name of NWFP	Which blocks? (list block names/ numbers)	Priority for commercial (give a ranking between 1-5 where 1 = highest and 5 = lowest)	Priority for domestic consumption (give a ranking between 1-5 where 1 = highest and 5 = lowest)

NWFP resource assessment and harvesting should be done as per the guidelines developed by the Department. If there are no guidelines available for important NWFP species use the table below to carry out the resource assessment or seek assistance from SFED.

*Table 2.9 Recommended Resource Assessment for different NWFPs*

<b>Recommended Resource Assessment for different NWFPs</b>					
Sl. No.	NWFP	Local Name / common name	Resource assessment	Participatory resource mapping	Harvesting & management rules
1	Asparagus recemosa	Nyakhachu (Dz)			✓
2	Bambusa spp.	Baa (Dz)	✓		✓
3	Cane spp.	Patsha (Dz)	✓		✓
4	Mushroom spp.	Shamu (Dz)			✓
5	Aconitum spp.	Bongkar (Dz) Bongnak (Dz)		✓	✓
6	Aconogonon tortusum	Ngalacho (Dz)		✓	✓
7	Acorus calamus	Chudala (Dz)		✓	✓
8	Artemisia spp.	Khempa (Dz)		✓	✓
9	Asphalum punjabinum	Drakzhu (Dz), Shilijit (Lh)			✓
10	Casia fistula	Rajbrikshay (Lh) Donkoshing (Sh)		✓	✓
11	Choerospondia axillaris	Lapsi (Lh)		✓	✓
12	Ophiocordyceps sinensis	Yar-tsha guenbub (Dz)			✓
13	Cymbopogon spp.	Lemon grass (Eng) Sorbhang (Sh)	✓		
14	Daphne spp.	Desho(Dz)	✓		✓
15	Edgeworthia gardneri	Dheykap (Dz) Argaylee (Lh)	✓	✓	
16	Diplazium esculentum	Nakey (Dz)		✓	✓

		Dhawai (Sh)			
17	Diploknema butyracea	Yega shi (Dz) Butter tree (Eng)		✓	✓
18	Elastosteme lineolatum	Dham-boor (Dz) Drimom(Sh)			✓
19	Entada eheedii	Pangri (Lh) Kolokpa (Sh)			✓
20	Fritillaria delavayi	Tseka (Dz)		✓	✓
21	Gaultheria fragrantissima	Chamze Kam (Dz) Machino (Lh)			✓
22	Illicium griffithii	Domleeshing (Dz) Khaila chinang (Sh)	✓		
23	Juglans regia	Tago (Dz), Khesey (Sh) Ohkar (Lh)		✓	✓
24	Litsea cubeba	Siltimbur (Lh), Nenshing (Sh)			
25	Meconopsis paniculata Myricaria rosea	Upel serpo (Dz)		✓	✓
26	Nardostachys jatamansi	Wombu(Dz)		✓	✓
27	Neopicrorhiza scrophulariiflora	Pangpoi (Dz), Jatamansi (Lh)		✓	✓
28	Neopicrorhiza acrophulariiflora/ Picrorhiza kurrooa	Putishing (Dz), Kutki (Lh)		✓	✓
29	Paris polyphylla	Satuwa (Lh)		✓	✓
30	Pedicularis longiflora	lugru serpo (Dz)			
31	Pedicularis megalantha	Lugru marpo (Dz)		✓	✓
32	Persia spp.	Gooli (Dz, Sh)		✓	✓
33	Persia gamblei	Kawla or Kathe Kaulo (Lh)		✓	✓
34	Phyllanthus emblica	Churoo (Dz), Amala (Lh), Chorgnsay (Sh)		✓	✓
35	Piper betleoides	Pani or Paney (Dz) Pan (Lh)			✓
36	Piper hamiltonii	Jungali pan (Lh)			✓
37	Piper longum	Pipla/peepla Lh)			✓
38	Piper pedicellatum	Pipla	✓	✓	
39	Podophyllum Hexandrum	Bamarpoo (Dz)			✓
40	Resin	Thangchu (Dz)			✓
41	Rheum australe	Chutsa (Dz)			✓
42	Rheum nobile	Chhukkha metog (Dz)			
43	Rhododendron anthopogon	Balu (Dz), Dali Metog		✓	✓
44	Rhododendron setosum	Soonpati or sunpatey (Lh) Sulu (Dz)		✓	✓
45	Rubia cordifolia	Tsoy (Dz), Majito (Lh), Lanyi-roo (Sh)		✓	✓
46	Sapindus mukorossi	Soap nut (En), Ritha (Lh), Nakapani (Dz)		✓	✓

47	Swertia chirayita	Chirata (Eng), Chiraito (Lh)	✓	✓	✓
48	Symplocas paniculata	Pangtse (Dz), Zim-shing (Sh), Gunilo (Lh)		✓	✓
49	Taracum eriopodum	Khurmong (Dz)		✓	✓
50	Terminalia bellirica	Baru, Baroo (Dz, Sh)		✓	✓
51	Terminalia chebula	Aru, aroo (Dz, Sh), Har-ra or Ha ro (Lh)		✓	✓
52	Thysanolaena latifolia	Tsakusha (Dz, Sh), Kusho or amlisa (Lh)		✓	✓
53	Zanthoxylum armatum	Thinngay (Dz), Timbur or Timur (Lh), Gi (Sh)		✓	✓
54	Zizyphus mauritiana	Bayer (Lh), Tshoshing (Dz)		✓	✓
55	Viscum nepalensis	Nyashingjormo (Sh)		✓	✓

### Step 5. Forest Produce Prioritization and Species Preference Ranking

These PRA exercises are carried out to identify which product and species are important for the CFMG members through product prioritization and species preference ranking. It is encouraged to be conducted separately in male and female groups.

#### How to conduct forest product prioritization

- List the forest products on the chart as shown in Figure 2.5.
- Pairwise ranking is used to find out which forest products are most important. Figure 2.5 is an example which indicates water (6), as most important followed by timber (4), grazing (4), fodder (4), leaf litter (2) and firewood (1). In this case, the CFMP should contain more emphasis on water.
- When a timber product is ranked as first priority, you should then do a species preferences and availability ranking as shown in Table 2.10.

	Timber	Firewood	Medicines	Fodder	Leaf litter	Water	Grazing
Timber	X						
Firewood		X					
Medicines			X				
Fodder				X			
Leaf litter					X		
Water						X	
Grazing							X

Table 2.10 Species Preference and Availability table

Figure 2.5 Forest Produce Prioritization Matrix

Species Preference and Availability table						
Species/Local name ↓	Uses →	Drashing	Cham	Fencing Posts	Firewood	Flag poles/Dangchung
	Preference					
	Availability					
	Preference					
	Availability					
	Preference					
	Availability					

### **How to conduct species preference and availability exercise**

- If a particular species is not available in the CF, do not include in the prioritization table, even if that species is highly preferred by the CFMG.
- Write the list of species down the left side of the table and products on top of the table. You can also include shrubs and herbs if these are important.
- Ask participants to decide which species are the most important for each product.
- For each species give a value (between 1 and 5 symbols) showing how important the species is for that particular product – this is the species preference. For example if oak is the most highly preferred species for fodder then give a value of 5. Put symbol (X) to show the preference.
- Assign a value to each species to show how scarce or abundant it is in the CF – this is availability e.g. if oak for fodder is scarce then give it a value of 1. Put symbol (\*) to show the availability.
- Some species can be used for more than one product e.g. oak can be used for timber, fodder and fuelwood. In this case record all information but values in preference and availability may differ.
- Mention which species are preferred most and which species are available in the CF. Write them in the CFMP.
- Use both local name and scientific names in the CFMP for the species recorded in this table.

Mark with symbols to show rating e.g. XXXXX = high preference, \*\*\*\*\* = highly available and X = low preference, \* for less available.

**Note:** When preparing the CFMP ensure that all produces with high priority are covered. Where there is a big gap between preference and availability, measures to address these gaps should be included in the management plan.

### **Step 6. Forest Produce Demand Assessment**

Forest Produce Demand Assessment is conducted to quantify the annual forest produce requirement of the CFMG members. The assessment should be done annually during annual work plan preparation to get more accurate information.

#### **How to carry out Forest Produce Demand Assessment**

- Divide participants into small groups. If possible have separate groups for men and women.
- Each group should prepare a list of forest products they use. This should be as detailed as possible and include all forest produce – not just those that come from the proposed CF area. For example, don't just write "timber" but try to have sub-categories such as *Drashing*, *Cham*, *Tsim*, *Dangchung*/flag poles, fencing posts, firewood, etc.
- Ask each group to estimate their annual household requirement for each produce. You may use local measurements e.g. timber should be estimated in terms of numbers of trees, poles, etc. Or if in cft or m<sup>3</sup>. Firewood could be measured in back loads or truck loads, or if possible in cft or m<sup>3</sup>.
- Collect the individual household requirements during annual meetings and compile them in the table below

*Table 2.11 Forest Produce Demand Assessment Format*

Produce	Annual requirement (estimated)		Number of HH that require produce annually (C)	Total requirement of the produce (Annually)		Total requirement of produce in 10 years	
	Number (A)	Volume (in cft or m <sup>3</sup> ) (B)		Number (A*C) = D	Volume (in cft. or m <sup>3</sup> ) (B*C) = E	Number (D*10)	Volume (in cft. or m <sup>3</sup> ) (E*10)
For new Construction							
e.g. Drashing	5	200 cft.	10	50	2000 cft.	500	20,000 cft.
For renovation/extension							
e.g. Drashing	2	150 cft.	15	30	2250 cft	300	22500 cft.
For other construction (toilet, cowshed, etc.).							
e.g. Cham	2	100 cft.	8	16	800 cft	160	8000 cft.
For other produce							
Firewood	2	150 cft.	25	50	3750 cft.	500	37500 cft.
Bamboo	1200	-	10	12000	-	120000	-

- For sustainable management of the CF, encourage CFMG members to write down their actual forest produce requirements.
- When you have covered all the households, estimate the total CFMG annual requirement for different produces.
- If all households are not present, ask participants to estimate how many households in the CFMG shall actually use the produce. For example if out of 60 households, only 55 actually require fodder this should be noted. If all households use the produce, then write “all”.
- Calculate the forest product requirements for the whole CFMG by multiplying household use by the number of households. Record this information in the summary format provided below.

*Table 2.12 Example of Forest Produce Demand Assessment (Summary)*

Example of Forest Produce Demand Assessment (Summary)			
Produce	Annual household requirement (estimated)		Number of households using the produce (if all then write “all”)
	No. of trees	Volume (cft. or m <sup>3</sup> )	
Drashing	80	4250 cft.	25
Cham	16	800 cft.	8
Tsim			
Dangchung			
Firewood	50	3750 cft.	25
Flag Poles			
Fencing Posts			
NWFPs (bamboo)	12000		10

- Mention annual requirement of timber and number of households requiring the timber and calculate total annual in ten-year plan period.
- Facilitate in calculating the requirements of timber and firewood in Cft or cubic meters, except for fencing posts and flag poles.
- Refer Format 5 to calculate number of trees.
- Refer Format 7 to calculate volume in m<sup>3</sup>.

### Comparison of AAC and Demand

The table below compares the AAC (supply) from the CF and demand of the CFMG. In the comment's column, write whether the AAC is sufficient to meet the demand. If not, then mention how and from where the demand shall be met e.g. it may be met from state reserved forests.

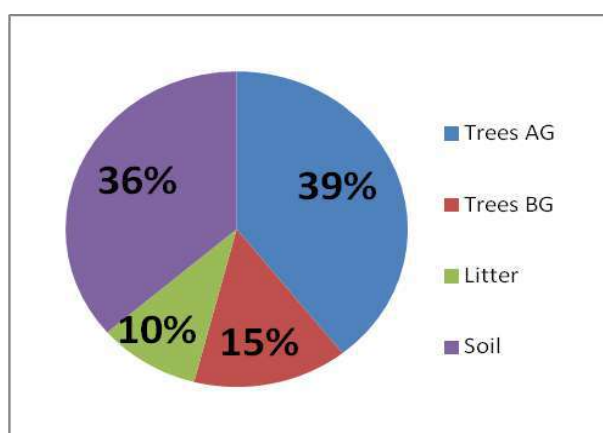
*Table 2.13 Annual Allowable Cut and Demand Format*

Annual Allowable Cut and Demand Format							
Produce	Total AAC		Total Annual Demand		Difference		Comments
	No. of trees	Volume (either in cft or m <sup>3</sup> )	No. of trees	Volume (either in cft or m <sup>3</sup> )	No. of trees	Volume (either in cft or m <sup>3</sup> )	
Drashing							
Cham							
Tsim							
Dangchung							
Firewood							
Fencing Posts							
Flag Poles							
NWFPs ( <i>list all NWFPs</i> )							

### Step 7. Calculating Carbon Stock

An estimate of forest carbon stock is increasingly becoming important. Knowing how much carbon is stored in the forest helps to show how much the forest is contributing to climate change mitigation. If forest biomass is increasing it shall be capturing carbon from the atmosphere. If forest biomass is decreasing (or if the forest is being harvested) it shall lower the carbon sequestration capacity of the forests. It may also release carbon back into the atmosphere and is thus contributing to increased levels of atmospheric CO<sub>2</sub>.

With proper management, CFs have huge potential to enhance the carbon capture and storage. This shall require proper and regular measurement for monitoring of forest carbon stock. It becomes necessary to include it in the CFMP. Based on the forest resource assessment that has already been done it is possible to get an estimate of carbon stock.



*Figure 2.6 : % of total carbon in different forest components*



*Box 2.5 How to measure carbon stock*

1. There is a close relationship between carbon stock and biomass. Therefore, the first step is to calculate forest or tree biomass.
2. On a large scale, forest biomass is estimated by finding out the total area of each forest type and using published figures for biomass (or carbon) per ha for each type.
3. At local level it is possible to calculate the biomass of each individual tree using published biomass tables or equations (usually based on tree diameter and/or height). Volume equations or tables based on dbh are more common. From these it is possible to estimate the stem volume of a tree of given dbh. Knowing this volume and other parameters such as timber density and branch/foilage/root proportions it is possible to estimate the tree biomass. Usually this is expressed in the form of dry weight (kg).
4. From the sample plots from the forest resource assessment you shall know the number of trees per ha in different dbh classes for each block. Using volume or biomass tables you can then calculate the mean biomass of a tree of a particular dbh. Biomass tables show the relationship between dbh and total tree biomass (usually dry biomass). You can use these tables to calculate the biomass for each forest block. This is called above ground biomass (AGB).
5. There is additional biomass in tree roots - this is called below ground biomass (BGB). For a given tree, about 30% of the biomass is BGB. Use this to calculate the total tree biomass.
6. Roughly 50% of tree biomass consists of carbon. Therefore, calculate the total tree carbon as 50% of AGB+BGB.
7. As a rough approximation Bhutanese forests have about 140-150 tC per ha (if well stocked) not including litter and soil carbon and depending on forest type and age.
8. Additional carbon is stored in litter and soil. Figure 13 above shows the % of total carbon in all 4 components of the forest.

This method shall enable you to estimate the approximate carbon stock of a CF. However, to measure it more accurately and to monitor changes in carbon stock is very complex and beyond the scope of this manual. We may have to develop a separate manual for carbon measurement in future.

## **Step 8. Socio-economic Survey**

Socio-economic survey should be carried out after the member registration and the CF management committee election but before writing the by-laws and preparation of the CFMP. This is an important PRA because its outputs form part of the social information in the CFMP and it should trigger discussion on benefit sharing mechanism (equity) when framing the CF By-laws. All information from this PRA tool should be recorded on chart paper for later use. As the exercise deals with socially sensitivity, the information collected should be kept confidential .

The CFMG members should be interviewed and the member household(s) should be earmarked so that during the time of benefit sharing discussion under the By-laws chapter, equity are taken care. The survey ensures first-hand information from the CFMG member households and facilitates a discussion within the CFMG about measures to reduce poverty and address equity.

*Box 2.6 How to conduct Socio-economic Survey*

- Explain the purpose and procedures of the survey to the CFMG.
- Interview the individual CFMG member to gather information
- Compile and analyze the data after completion of the survey. You may have to discuss with your colleagues and group the member households into different well-being category (e.g. rich, medium and poor).
- The CFMG is asked to come up with measures to reduce poverty and address equity; measures are written down on a chart paper and discussed; this part of the exercise can also be combined with the writing of the by-laws, climate vulnerability assessment.

*Form 2.2 Socio-economic survey sheet*

<b>Socio-economic Survey Sheet</b>			
Name and age of the respondent:		House No.:	Thram No.:
NO. OF RESIDENT MEMBERS IN THE HH:		Male:	Female:
No. of civil servants from the HH:		No. of Monks/Nuns from the HH:	
No. of students from the HH:		No. of members in armed forces:	
No. of HH members (others - specify):			
Total No. of HH members:			
Wetland (ac):	DRYLAND (AC):	Orchards:	
Kitchen garden ac/dc:	KHIMSA AC:	No. of HH members using cell phones:	
House type (tick)	Three storeys	Two storeys	One storey
No. of cattle:	No. of horses:	No. of pigs:	No. of poultry:
No. of Goat:	No. of Sheep:	No. of Yak:	
No. of farm machineries:	Tick and list the machineries (e.g. vehicles, Power chainsaw, Power tiller, Rice mill, Flour mill, Paddy trans-planter, sawmills, others)		
Specify availability of any Livestock Farm (Poultry, Piggery, fisheries, etc.)			
Specify availability of any Agricultural Farm (Mushroom, vegetable, etc.)			
Source of income – specify:		Average annual income (Nu.):	

### **Step 9. Climate Hazard and Vulnerability Assessment**

People living in rural areas are increasingly becoming aware of climate change and the effects on their livelihoods. Therefore, the assessment should be conducted to determine the impacts of climate change (and might be in the future) and to identify the vulnerable groups within the community.

This shall enable the vulnerable households to climate change impacts to be more resilient through increased access to resources. Various adaptation options resulting from this assessment should be included in the CF Management Plan. Remember that both forests and people are affected by climate change!

#### **Objectives**

- Assess how local climate is changing
- Identify the most vulnerable households

- Identify vulnerable forest areas within the community
- Recommend activities for coping with and adapting to climate change for inclusion in the CF Management Plan

### Outputs

- A participatory map showing climate hazards
- A ranked list of climate hazards showing which are most serious
- A list of the groups most vulnerable to climate change
- A suggested list of activities for coping with and adapting to climate change

### Equipment

Flip-chart paper, colored pens, participatory map (prepared in the previous PRA exercise), well-being assessment matrix (prepared during the previous PRA exercise)

*Table 2.14 Climate Hazard Matrix (example #1)*

Climate Hazard Matrix (example #1)							
	Landslide	Flood	Drought	Forest fire	Animal disease	Reduced crop yields	
Landslide	x	Flood	Drought	Forest Fire	Landslide	Reduced crop yields	
Flood		x	Flood	Forest Fire	Flood	Flood	
Drought			x	Forest Fire	Drought	Reduced crop yields	
Forest Fire				x	Forest Fire	Forest Fire	
Animal disease					x	Reduced crop yields	
Reduced crop yields						x	
Result: 1 <sup>st</sup> = Forest Fire (5); 2 <sup>nd</sup> = Flood (4); 3 <sup>rd</sup> = Reduced crop yields (2); 4 <sup>th</sup> = Drought (2); 5 <sup>th</sup> = Landslide (1); 6 <sup>th</sup> = Animal Disease (0)							

*Table 2.15 Climate Vulnerability Assessment (example #2)*

Climate Vulnerability Assessment (example #2) (list of climate hazard based on ranking done in earlier exercise)						
Social group /sectors	Forest fire	Flood	Reduced crop yields	Drought	Landslide	Animal diseases
List the social group based on socio-economic survey, e.g. rich medium and poor member.						
e.g. of sector: Forest, Agriculture, livestock, etc.						

*Box 2.7 How to conduct Climate Vulnerability Assessment*

1. Start by explaining the purpose of the exercise. Explain that climate seems to be changing worldwide and that different places are affected in different ways
2. Ask participants to give examples about how they experience climate change and its effects in their village. With some facilitation many examples of these shall arise. Note them down on a piece of chart paper. The table gives some examples.
3. Next show the participants the participatory resource map you prepared with them earlier. Ask them to show on the map where particular climate change effects seem to be taking place (this is called climate hazard mapping). Examples might include places that are liable to flood, drought, fire, land-slides (due to heavy rain), springs that might be drying up etc. Mark these locations on the map (map the hazards)
4. On a different piece of chart paper list all the climate hazards that have been identified and write them across the top and also down the left-hand side (see example #1)
5. Ask participants to consider each pair of hazards in turn and decide which is most critical. Enter the most critical one in the box. After covering all the boxes, count the number of times each hazard was written down. The higher the number, the greater the hazard ranking.
6. On a second piece of chart paper, list the climate hazards identified along the top of the paper in order of ranking (see example #2).
7. Down the left -hand side of the paper list the social groups identified from the socio-economic survey and also list the major sectors in the community such as forest, agriculture, livestock horticulture, health, infrastructure, etc.
8. For each social group and each sector ask participants to rate the vulnerability to each hazard identified along the top of the matrix (e.g. 0 = not vulnerable, 1 = low vulnerability, 2 = medium vulnerability, 3 = high vulnerability, 4 = very high vulnerability)
9. At the end you shall have a matrix that shows which groups and which sectors are most vulnerable to different climate hazards.
10. Selecting those that are most vulnerable – ask participants what activities they think can be carried out to reduce the vulnerability. List these activities.

### **Step 10. Waste Management in CFs**

Waste is a concern in the community forest areas. Waste management particularly the non-degradable waste in the CFs shall be addressed in consultation with the CFMGs. Waste prevention and management provisions of the Waste Prevention and Management Regulation 2012 should be incorporated in the CFMP.

### **Step 11. Forest Management Matrix**

The forest management matrix brings together information and ideas from other steps to identify problems, opportunities and objectives for the block and/or whole CF. CFMG members should identify activities to be included in the CFMP to achieve the CF management objectives (see **Error! Reference source not found.** to differentiate between the objective and activities).

*Box 2.8 Management Objectives*

**Objectives are commonly confused with activities,**

e.g. "thinning" or "planting" are activities not objectives. The real objectives may be "to improve the timber crop in the future" or "to restore degraded forest areas".

If timber shortage is a problem, then the management objective might be "to increase the sustainable production of timber from the block".

Think of management objectives in terms of addressing the causes of any problems rather than their solutions. The solutions tend to relate to activities.

Table 2.16 Block-wise CF Management Procedures

Block-wise CF Management Procedures – e.g. Block I					
1	Produce/services	Drashing	Firewood	NWFPs	
2	Main species	Blue Pine	Oak	Mushroom	Yula
3	Problems	Forest fire	Over lopping for fodder		Over harvest-ing
4	Opportunities	1. Surplus quantity 2. Enterprise dev. 3. Employment genera-tion		Excess re-source	
5	Management ob-jectives (reflecting problems and/or opportunities)	1. Income generation 2. Reduce forest fire	1. Reduce over lopping	Income generation	
6	Activities to achieve the objec-tive (mark as H, M or L)	1. Sale of surplus timber (M) 2. Value addition (H) 3. Awareness (M) 4. Creation of fire line (L)	1. Support pasture dev. (L) 2. Supply fodder seedlings (M) 3. Restrict collec-tion from CF (H)	Sale of mush-rooms	
7	Procedures	1. Follow timber market-ing guidelines 2. Seek support for fund, training on product de-sign and dev. 3. Seek support from rel-evant office for aware-ness before onset of the fire season 4. Members to contribute labour, technical sup-port from forest office	1. Seek support from livestock department. 2. Fodder seedling procurement from forest nurseries 3. Regulate fodder collection from CF area	...	
8	Responsibilities	CFMG, concerned Forest office...			
Definitions					
Problem		An issue which needs to be addressed in the management plan			
Opportunity		A potential benefit which could be utilised in the management plan			
Objective		The aim of carrying out certain management activities			
Activity		The detailed tasks that have to be done to achieve an objective i.e. <b>What?</b>			
Procedure		The way in which the activity shall be carried out i.e. <b>How?</b>			
Responsibilities		The person(s) responsible for carrying out the activity i.e. <b>Who?</b>			

*Box 2.9 How to carry out Forest Management Matrix*

**How to carry out Forest Management Matrix**

1. Prepare a separate forest management matrix for each block. Write the block name clearly at the top of this.
2. Row 1. Write the main forest produce for the block. This information shall come from the Forest Product Prioritization Matrix and the Forest Resource Assessment.
3. Row 2. List the tree, shrub or other plant species which are particularly important for this produce.
4. Row 3. Describe any problems i.e. shortages in availability of different forest produce or mismatch between the supply (AAC) and demand. Refer the Annual Allowable Cut and Demand Format (Step 6). Also write down any biotic problems that were identified in the block during the Forest Resource Assessment and during PRAs such as fire, grazing, erosion, etc.
5. Row 4. Identify any opportunities e.g. if there is a surplus of forest products that can be harvested to meet the demand or if useful NWFP species could be introduced by planting.
6. Row 5. Based on the problems and opportunities, discuss and agree on management objectives (see box). It is helpful to think of management objectives in terms of the causes of problems rather than their solutions.
7. Row 6. List the activities that need to be done to achieve the management objectives. Be as detailed as possible. Different activities shall be needed in different blocks. For each activity decide if it is high (H), medium (M) or low (L) priority and write this down. Check that all the activities are really needed by asking: If we carry out all these activities, then shall the objective be achieved? Several activities shall be needed to achieve each objective. Will all the problems be addressed?
8. Row 7. Write down the detail procedures for each activity on how to carry out the activities.
9. Row 8. Write down responsibilities for carrying out each activity. Responsibilities can be for individual, in group or for an agency.

**Step 12. Participatory Environmental Impact Assessment**

Environmental Impact assessment should be conducted to provide a broad view of environmental impacts and should also include socio-economic impacts. Environmental assessment should be carried out at the end of the CF management planning process but before the plan is finalized for approval so that all activities proposed for the CF can be included and assessed. Participatory Environmental Impact Assessment should be carried out by the CFMG:

- a) As a pre-requisite of the Environmental Assessment Sector Guidelines for Forestry (1999)
- b) To identify and avoid any negative environmental impacts of CF management activities.



Box 2.10 How to carry out participatory environmental impact assessment

### How to carry out participatory environmental impact assessment

1. Prepare a chart as shown in the example below. In the boxes across the top, write down the potential impacts as shown here.
2. List the activities proposed for the CFMP down the left-hand side of the paper. This information on activities should come from the Forest Management Matrix (Step 11).
3. For each activity consider the potential environmental and socio-economic factors listed along the top row. For each of these discuss whether the proposed activity shall have a positive effect, negative effect, or no effect. Show positive impacts by (+), negative impacts by (-), and no impacts by (0). The number of plusses or minuses should show how strong the potential effect is e.g. if timber harvesting is thought to have a strong negative effect on soils (if it might cause erosion), then get the group to put - - - - in the relevant box (see example shown)
4. In a separate table drawn on a large sheet of paper, list each activity which has one or more minus sign in the participatory environmental assessment chart taking particular note of:
  - Areas close to public roads and forest roads
  - Steep slopes
  - Areas lying near streams, rivers and water bodies
  - Blocks with highly critical catchment condition, etc.

For each activity describe in a separate box any procedures that shall be taken to avoid or reduce negative impacts. These procedures must then become part of the CF Management Plan (see examples in Table 2.17).

Table 2.17 Example of a Completed Participatory Environmental Assessment Chart

Example of a Completed Participatory Environmental Assessment Chart								
Activity proposed in CFMP	Potential Environmental Effects				Potential Socio-Economic Effects			
	Soil	Water	Wild animals	Plants	Traditional forest use	Cultural and religious values	Local employment	Local benefits from forest produce
Plantation establishment	+	+++	0	+	--	0	--	0
Fuelwood harvesting	-	-	-	-	0	0	0	++
Flag pole harvesting	0	0	0	-	+	++++	0	++
Timber harvesting	---	---	--	---	+	+	++	++
Grazing control	++	++	+	++	-	0	0	--
Fire control	+	+	++	+++	0	0	0	0
NWFP collection	0	0	0	-	+	++	+	+
Forest protection	0	0	++	+++	++	+	0	--
Soil and water conservation activities	++	++	+	++	0	0	+	0

POSITIVE EFFECT SHOWN BY + + + - NEGATIVE EFFECT SHOWN BY - - - NO EFFECT (OR NOT RELEVANT) SHOWN BY 0

<b>Example of Procedures to address potential negative effects</b>	
<b>Activity</b>	<b>Procedure</b>
Plantation establishment	Local graziers shall be provided with alternative grazing areas. Grass shall be available for cut and carry from plantation areas Native or local species shall be planted
Fuelwood harvesting	Quantities shall be controlled No felling on steep slopes shall be allowed
Timber harvesting	Felling shall be regulated according to sustainable harvest levels. No felling on slopes > 50% No log rolling down slopes No felling within 20 m of water courses Timber shall be distributed within the CFMG according to priority of needs
Grazing control	As for plantation establishment
NWFP collection	The following rare species shall not be collected (list of species)
Forest protection	All CFMG members shall take part in protection Wherever possible, forest products shall be utilised from the CF providing this can be done sustainably.

### **Step 13. Preparation of CFMG By-laws**

CFMG By-Laws should be prepared;

(a) For legal reasons

In accordance with Section 78 (3) of the FNCRR 2017, “CFMG shall adopt by-laws with clear management objective, rights and responsibility, allocation and utilization of forest resources, fund management addressing the issues of sustainability”. That is why we have fund management section in this manual.

In accordance with Section 78 (4), “The management plan shall have separate section for the by-laws prepared by the CFMG in accordance with the relevant policy and laws”.

In accordance with Section 79, “CFMG shall prepare and adopt by-laws observing good governance principles such as participation, transparency, accountability, equity and inclusiveness”.

(b) Promote good governance of the CFMG in order to:

- Identify and target disadvantaged households
- Ensure that CFMG members opinions and views are heard
- Have transparent and fair decisions
- Ensure CFMG committee represents all the interest groups in the village
- Emphasize and encourage women participation in decision making body

### **How to frame CFMG By-laws**

All the members of the CFMG shall be present during framing of the by-laws. The CFMG should not include anything in their by-laws that contravenes the FNCRR 2017. All the topics in the table below can be included – as well as any additional items e.g. covering CFMG governance, equity and benefit sharing, fund management, etc. it is important that everyone in the CFMG should understand the by-laws and agree with it. Refer specific Chapter and Steps of this manual when framing the by-laws. Specific steps are as follows:

1. By the time you reach this step you may already have prepared the CFMP. Bring all the materials you have from this. Ensure that you also have a copy of the FNCRR 2017.
2. Organise a meeting with all members of the CFMG. You might expect this meeting to last for a full day, so plan with this in mind.
3. Start the meeting by explaining what the By-laws are and how these differ from the CFMP.
4. Go through the list of items for the By-laws. As you go through each item first check to see whether anything has already been agreed in earlier planning stages (the forest management matrix shall probably be the useful sources of information). If anything has already been discussed and agreed, then read it out and record it.
5. Ask participants what can be written in the By-laws in addition to what has already been agreed during earlier planning steps. For each of the items in the By-laws, some questions have been provided in the table for you to ask and discuss.
6. It is extremely important to record all the answers (once they have been agreed). Write them down on a large sheet of paper.
7. Finally, read everything that has been written down to the whole group.
8. It may be helpful to divide into sub-groups of different stakeholders e.g. women, youth, etc. and get each subgroup to go through everything that has been written down. At the end let them give their comments or agreement/disagreement to the whole group.
9. This written material can only become the formal by-laws if everyone agrees.
10. Back in the office the by-laws need to be typed out.

<b>Content of By-laws</b>	<b>Checklist for facilitator(s)</b>
CFMG Name	What is the name of the CF and the CFMG? (It can be same)
1. Membership arrangements	<p>How is membership defined?</p> <p>Who is eligible for membership of the CFMG?</p> <p>What are the procedures for becoming a new member?</p> <p>What are the procedures for leaving the CFMG?</p> <p>For both new members joining use Annex 12 and for members leaving the CFMG, use Annex 13 as an application form.</p>

Content of By-laws	Checklist for facilitator(s)
2. CF Management Committee formation	<ul style="list-style-type: none"> <li>• It is recommended to have three posts in the CFMGs to make it standard and uniform. They are Chairperson, Secretary and Treasurer.</li> <li>• These posts are highly recommended to be elected through secret voting procedures and each and every CFMG members should vote.</li> <li>• You should facilitate and ensure that at least one of the CF Management Committee member is women.</li> <li>• Let the CFMG decide the term for the management committee and the procedures for leaving or appointment of the committee</li> <li>• Ensure formal handing/taking between the new and old post holders as per Annex 16.</li> </ul>
3. ToRs for CF Management Committee	There are suggested ToRs for CF Management Committee (Chairperson, Secretary and Treasurer), refer Chapter V Step 1.3) However, you can ask the CFMG members to add on.
4. Roles and Responsibilities of the CFMG	<ul style="list-style-type: none"> <li>• Add general roles and responsibilities of the CFMG.</li> <li>• Refer Section 86 of FNCRR 2017 and see what are they empowered with?</li> </ul>
4. Benefit sharing mechanism	<ul style="list-style-type: none"> <li>• What procedures shall be put in place to ensure equity?</li> <li>• What procedures must be followed for harvesting forest produce (both timber and NWFPs) from the CF e.g. timing, marking, etc.?</li> <li>• What are the rules about collecting different forest produce? E.g. what produce, quantities, collection times, seasons, etc.</li> <li>• What provisions shall be made for particular household e.g. disadvantaged, single woman-headed household, etc.?</li> </ul>
5. Fees (products/ services fees, membership fees, etc.)	<ul style="list-style-type: none"> <li>• Nominal membership fees have to be collected but the amount and frequency shall be decided by the CFMG.</li> <li>• Fees (royalty) for CF produce including NWFPs, sand, boulders and other services shall be decided by the CFMG. However, the royalty rate shall not exceed the existing rural subsidized rates.</li> </ul>
6. Managing CFMG Fund	<ul style="list-style-type: none"> <li>• What are the possible sources of funds for the CFMG? E.g. sale of surplus products, fees, fines, etc.</li> <li>• How CFMG fund should be managed?</li> <li>• Details on fund management is given in Chapter V, Step 8.4 of this manual.</li> </ul>
7. Timber marketing (and marketing of other forest products)	<ul style="list-style-type: none"> <li>• Check whether the CF have potential in marketing of the timber or other forest produce.</li> <li>• What products can be marketed?</li> <li>• How value addition can be done to enhance the income for the CFMGs?</li> <li>• Refer “Marketing Guidelines for Wood-based Products from Community Forest 2017” and for NWFPs, refer the “Framework for Management and Marketing of Non-Wood Forest Products”.</li> </ul>

Content of By-laws	Checklist for facilitator(s)
8. Record Keeping	<ul style="list-style-type: none"> <li>• What records shall the CFMG keep?</li> <li>• Who is responsible for keeping them?</li> <li>• How it shall be shared among the CFMG members and with concerned forestry offices?</li> </ul>
9. Meetings	<ul style="list-style-type: none"> <li>• It is recommended to have at least one CFMG general meeting/assembly in a year.</li> <li>• The frequency of CF Management Committee meetings can be decided by the CFMG, based on need. But ask the following questions to the CFMG.</li> <li>• How often shall the CF Management Committee meet and for what purpose?</li> <li>• How the minutes of the meetings are maintained and shared?</li> </ul>
10. Offences and Penalties	<ul style="list-style-type: none"> <li>• The amount of fines and penalties for both CFMG members and outsiders related to natural resources shall be based on the provisions mentioned in Section 416 of the FNCRR 2017.</li> <li>• The fines and penalties collected from both CFMG members and outsiders can be deposited in the CF account as per the fund management section in this manual.</li> <li>• Fines and penalties collected from other offences related to wildlife, birds, hunting/poaching, forest fire, etc. shall be collected by the concerned forestry offices based on existing systems.</li> <li>• CFMGs can decide on the amount of fines and penalties and impose if their member(s) are absent from CF developmental activities, meetings, etc.</li> <li>• CFMG may also frame fines and penalties if the CF Management Committee members are misusing their powers and not performing their duties as per the ToRs.</li> <li>• The concerned forestry offices shall assist the CFMGs in collecting the fines and penalties with regard to CF and its resources/services.</li> </ul>
11. Conflict management	<ul style="list-style-type: none"> <li>• How shall conflict be resolved/managed?</li> <li>• If not resolved, where it shall be forwarded?</li> </ul>
12. Amendments of the CFMG By-laws	<ul style="list-style-type: none"> <li>• CFMGs can amend their CFMG By-laws with prior approval from the Department.</li> </ul>

#### **Step 14. Writing the CF Management Plan**

The Community Forest Management Plan (CFMP) should be written, in national language. Otherwise, the English version of the Plan should be translated to Dzongkha. The Plan should be prepared as per the standard format/template in Table 2.18 This section refers to this format and explains where the information to complete each section comes from.

Table 2.18 CFMP content/template

<b>CFMP Content/Template</b>	
Cover Page/Title	
Approval Sheet	
Table of Contents	
Acronyms	
Executive Summary	
Part I: Introduction	
Total community forestry area _____ hectare/acre	
Community Forestry Map (2 maps, 1: map with boundary, 2: GIS Land use/land cover map, showing net production area of the CF)	
<b>Community Forest boundaries</b>	
<b>Boundaries</b>	<b>Permanent Features</b>
West	
East	
South	
North	
<b>Social Information</b>	
	<b>Description</b>
Name of the villages	
Ethnic groups with CFMG	
Basic amenities	
Total Household (HH) number of CFMG	
Population of CFMG	
% male and % female	
Main source of income	
Cattle population of the CFMG	
Main crops	
Cropping pattern	
Any other information	
<b>Forest Information (whole forest)</b>	
Annex 1, Format 1 shall be written here! (Format 1 is used for each CF block). Each block with respective AAC	
Forest Management (including objectives)	
Demand assessment	
AAC and demand comparison	
Participatory Environmental assessment including procedures to address negative environmental effects	
Climate hazard assessment	
Forest produce ranking matrix	
Monitoring Plans (Forest Resource Monitoring Plan, social & institutional monitoring plan)	
AWP	
<b>Part II - By-Laws (refer Annex 5 for the contents/template for By-laws)</b>	
<b>Annexes under the CFMP</b>	
1. CF application along with CFMG member list signed	
2. CF boundary GPS coordinates	
3. CF sample plot GPS coordinates	
4. Compilation sheet	



If all the steps 1-13 above have been completed, all the necessary information to complete the CFMP shall already be available. All the PRA tools need not be written in the CFMP. However, the results or the outputs of the PRA tools may be included in the CFMP.

### **Step 15. Monitoring and Evaluation Arrangements**

The arrangements for monitoring and evaluation are extremely important and must be included in the CFMP from the beginning. The different stages of monitoring and evaluation that can be used for these are described fully in **Error! Reference source not found.** of this chapter.

### **2.3.3 Approval Process of the Community Forest**

After preparing the CF Management Plan and By-laws, the CFMG should submit the plan through the CFO to the Social Forestry & Extension Division (SFED) for technical review and approval by the Department. This involves following steps:

#### **Step 1. Submission of the CFMP to the Department**

After final review of the draft CFMP by the CFO, the CFMP should be submitted to the Department through SFED.

#### **Step 2. Review by SFED**

SFED should review the CFMPs in detail. Upon review, SFED shall return the management plan to the Divisions/Parks for any necessary changes. If there are any pertinent issues that warrants a visit, SFED may make a field visit. After incorporating the necessary changes, SFED should seek approval of the plan from the Department and notify the Division/Park.

#### **Step 3. Issuance of the CF Ownership Certificate**

Upon approval of the CFMP by the Department, the CFO of the concerned Division/Park and the Gup of the concerned Gewog shall co-sign the Community Forest Ownership Certificate (Annex VII of the FNCRR 2017) and formally hand over to the concerned CFMG along with a copy of approved plan.

After the Community Forest Ownership Certificate has been awarded, the CFMG can start to implement its CF Management Plan and By-laws with the technical support from forestry staff for:

- Participating in CFMG meetings
- Conflict management
- Skills development and training
- Monitoring, reporting and planning
- Helping to solve specific problems
- Developing linkages with other CFMGs
- Developing commercial linkages for forest product development and marketing
- Others

### **2.3.4 Implementation**

The implementation of the CF shall be guided by Sections 86 to 89 of FNCRR 2017. Forestry staff shall provide technical support for implementation of all activities. CFMG and management committee members often lack basic technical and administrative skills and self-confidence to implement their CFMP from the start. To help them to become more self-reliant and to keep them motivated, capacity building shall be needed. This could be in the form of training events covering different topics or simply on-the-job training and support. The support role of the Forestry staff includes:

- Technical assistance for implementing the CF management plan
- Tree marking e.g. for thinning or harvesting

- Seedling raising, distributing and planting
- Encouraging the committee to meet regularly and facilitating the meetings
- Helping to get good participation including gender during meetings
- Communicating between the CFMG and the CFO
- Training and developing new skills amongst CFMG members
- Helping to resolve conflicts
- Providing information to the CFMG about the FNCRR and other legal matters
- Helping the committee to keep records and accounts
- Monitoring CFMG activities and helping with self-monitoring

**The main implementation responsibilities of CFMGs (according to FNCRR 2017)**

1. Marking of forest produce (90)
2. Issuing permits (90)
3. Harvesting (93-95)
4. Royalties and permits (101)
5. Sale of forest produce (98-100)
6. Transportation of produce (96-97)
7. Formation of CF Networks and Association (108-109)

### **Step 1. CFMG Governance**

Governance is about how the CFMG operates as an institution. It focuses especially on the processes and relationships within the CFMG and the extent to which they follow certain principles of ‘good governance’:

Transparent	Are decisions made in an open and easily understood manner?
Accountable	Are decision makers accountable to the wider group (CFMG members) and can sanctions be effectively imposed in case of infringement or poor decisions?
Responsive	Are decisions and activities responsive to the needs of the wider group – especially poorer and disadvantaged members?
Equitable	Are benefits distributed fairly and in favour of disadvantaged members?
Participatory	Are decisions and all processes made in a way that involves a range of different stakeholders?
Legal	Does the group and its members and representatives operate in compliance with the law?
Efficient (cost effective)	Are decisions and activities those which shall give the best or greatest results at the least possible cost?

Good governance in CFMG is critical for ensuring the effectiveness and sustainability. A number of weaknesses in CFMG governance are identified and support is required to address these. Some of the perceived weakness include transparent decision-making, equity (including pro-poor decision-making and benefit sharing); record keeping; fund management and monitoring.

## **CFMG Meetings and Decision-Making**

CFMGs should function as democratic and accountable institutions. All decisions should be taken during meetings where CFMG members have an opportunity to discuss and share ideas. Usually there should be 2 types of meetings;

- (i) CFMG meetings (sometimes called general assemblies) which are held infrequently (perhaps annually) and
- (ii) (CF Management Committee meetings which are held more often depending on the need.

An important aspect of CFMG governance concerns how such meetings are organised.

*Table 2.19 CFMG Meetings*

<b>Why are CFMG meetings needed?</b>
<ul style="list-style-type: none"> <li>• For information sharing and communicating within the CFMG members.</li> <li>• For decision making and planning by the CFMG.</li> <li>• For building the capacity of CFMG members.</li> <li>• For addressing problems and issues as they arise.</li> <li>• For fund management and transparency.</li> </ul>
<b>How to conduct CFMG meetings</b>
<p>There are 4 steps for conducting an effective CFMG meeting (this applies to both CFMG meetings and to CF Management Committee meetings):</p> <p>(a) Preparing for the meeting; (b) Conducting the meeting; (c) Recording the meeting; (d) Evaluating the meeting</p> <p><b>(a) Preparing for a meeting</b></p> <ol style="list-style-type: none"> <li>1. Plan the meeting and prepare an agenda beforehand listing the topics to be covered. An example of a meeting schedule is given below.</li> <li>2. Ensure that each session of the meeting has a clear objective</li> <li>3. Decide how each session shall be conducted (it is often better if different sessions are facilitated by different people)</li> <li>4. Make sure that a copy of the CFMP and the FNCRR 2017) is available during the meeting.</li> <li>5. Decide who should attend the meeting and issue invitations – especially to anyone from outside the CFMG e.g. the concerned Gewog Forestry Officer, other Local Government officials.</li> <li>6. Issue invitations in good time and mention the purpose of the meeting, the date, time and venue.</li> <li>7. When about two-thirds of the expected participants have assembled you can start the meeting. If not, wait for half an hour for the full or required number of participants to assemble.</li> <li>8. Arrange the seating in such a way that all the participants and facilitators can see each other. Seat them in a circle to ensure full participation.</li> <li>9. Avoid a situation where some people sit on chairs and others on the floor. This is to maintain a feeling of equality and a non-domineering atmosphere. If there aren't enough chairs then everyone should sit on the floor.</li> </ol> <p><b>(b) Conducting a meeting</b></p> <ol style="list-style-type: none"> <li>1. Welcome all the participants to the meeting. Stress that their participation is vital for the meeting's success.</li> <li>2. If some participants are sick or drunk (and therefore unable to fully participate) ask them politely to leave and rest in their houses.</li> <li>3. Tell participants that they should ask questions for clarification during the presentations. Whoever wants to do so should raise their hands first.</li> <li>4. Follow the planned schedule. Present each session clearly, slowly and loud enough for everyone to hear.</li> <li>5. After discussions and when decisions have been reached, summarize the important points for participants. Repeat all-important points several times so that participants shall remember them.</li> <li>6. Control persons who speak for too long. This is to give others a chance to speak.</li> </ol>

7. Encourage shy participants to speak by politely asking them questions about the point being discussed.
8. Use jokes but don't embarrass any of the other participants.
9. Keep the duration of the meetings in mind. As far as possible stick to the schedule. If necessary, you can postpone some points until the next meeting.
10. If some participants sleep or cannot concentrate fully call a short break. You may have to change your style of presentation to make it more interesting.
11. If somebody talks endlessly and is affecting the time allotted politely ask them to allow other participants to give their views.
12. If someone becomes angry or argumentative give the person's points to the whole group to make their suggestions about how to deal with the issues.
13. If everybody starts talking simultaneously raise your hands or clap your hands to get attention. Say that it is difficult to hear anything if everybody speaks at a same time. Those wishing to speak should raise their hands for them to be given the opportunity to speak one at a time.

**(c) Recording the meeting**

1. During every meeting keep notes. After the meeting the Secretary prepares the minutes so that a record of the agenda, issues discussed, actions decided and CFMG member attendance is kept. A format for recording meetings is given in Annex 2 Format 9.
2. The minutes are read out at the start of the next meeting to remind participants what was agreed and discussed.
3. Minutes should be filed in a separate folder and kept in a safe place.

**(d) Evaluating the meeting**

- After the meeting, consider the following questions:
- Were the objectives of the meeting met
- How well was the meeting conducted?
- What lessons can be learnt from this meeting that are useful for conducting future meetings more effectively?

## **Equity and Benefit Sharing**

Equity is an important aspect of CFMG governance because community forestry is expected to benefit poorer people. Equity concerns the distribution of benefits as well as CFMG decision-making and contributions of labour and other resources by CFMG member households. The CFMG should address the issues of poverty. The first step is to identify the poorest and most disadvantaged households and the reasons from the socio-economic survey. This shall indicate which households require most support and the kind of assistance they may need.

The Table 2.20 indicates the types of questions that need to be discussed by the CFMG in order to improve their equity and benefit sharing systems to become more pro-poor. Some of these may already have been discussed during preparation of the CFMG by-laws but they shall need to be reinforced through regular discussion.

*Table 2.20 Type of questions to be discussed*

<b>Area of question</b>	<b>Type of questions</b>
Social capital	About representation of disadvantaged households in the CFMG and their effective participation. Is this sufficient? Are there problems?
Human capital	About trainings that are provided for CFMG members? Who normally benefits? Are the most disadvantaged households involved?
Natural capital	About arrangements for forest product distribution for disadvantaged households. What are the arrangements?
Financial capital	About use of CFMG funds, credit, subsidies and interest rates and how these affect disadvantaged households. Who benefits? Who loses?

Physical capital	About the any infrastructure activities carried out by the CFMG. Do these have any benefits/costs for disadvantaged households?
Rule of law	About provision for disadvantaged groups in the CFMG By-laws and management plan. Are these provisions effective? Are they being followed?
Identification of disadvantaged households	About the well-being assessment. How was it was done? What were the results? Are they being used to target poorer households>?

*Box 2.12 Key aspects of equity in CFMG benefit distribution***Key aspects of equity in CFMG benefit distribution**

- All CFMG members are eligible to use forest products from the CF.
- Produce should be equitably distributed among CFMG members - this means according to their requirements rather than their ability to pay.
- If there is high demand for forest products from both CFMG members and outsiders, CFMG members must have priorities.
- If there is high demand for forest products within CFMG members, those CFMG members who are socio-economically disadvantaged have priority over others.
- Particular attention needs to be given to ensuring that all CFMG members are involved in making decisions - especially those which concern distribution of forest products e.g. rates, quantities, timing etc.
- Contributions of labor e.g. during planting activities, should also be equitable - this means that disadvantaged households should not be expected to contribute more labor than others.

**CF Management Committee**

Committee members should be elected bearing in mind that there is considerable responsibility involved. They are expected to attend meetings and implement tasks on a regular basis. Only individuals who are prepared to take on these responsibilities should be elected. CFMG members elect their own representatives for the CF Management Committee through secret ballot. The CF management committee should genuinely represent all the CFMG members including women.

**Composition of the CF Management Committee**

To maintain uniformity, three posts: Chairperson, Secretary and Treasurer are suggested in all the CFs. Their term shall be decided by the concerned CFMG facilitated by the concerned Forestry Officials. Other members like *Resoop*, Messenger, etc. can also be nominated based on need decided by the CFMG. The CF Management Committee must have good representation of men and women.

Suggested roles and responsibilities for the CFMC are described below. However, additional tasks and responsibilities can also be added.

1. Represents the CFMG in its interactions with other agencies including the forestry staff
2. Represents CFMG members during preparation and implementation of the CFMP.
3. Coordinates and organizes the administration of CF activities and operations and ensures that CFMG members fulfil their management responsibilities.
4. Responsible for the equitable distribution of benefits amongst CFMG members.
5. Responsible for management of forest resources.

6. Responsible for enforcing the by-laws of the CFMG and for collecting fines and penalties.
7. Responsible for ensuring that all the legal requirements for CF are met (including all types of records that need to be kept).
8. Responsible for establishing and maintaining the CFMG fund using monies collected from various sources.
9. Responsible for organizing and conducting CFMG meetings when required.

Add if any other responsibilities are identified by the CFMG.

In addition to the above responsibilities, the three suggested standard post bearers (Chairperson, Secretary and Treasurer) have specific roles and responsibilities.

#### **Suggested ToRs of the Chairperson**

1. Heads the CFMG.
2. Calls meetings whenever necessary and informs concerned persons about date, time and place and the reasons for the meeting.
3. Chairs and facilitates meetings and makes sure each person is allowed to speak, thereby giving everyone a fair chance to speak and raise issues
4. Approves applications for forest products (with Secretary).
5. Countersigns financial transaction and authorization to draw cash from the bank account (with Treasurer).

Add if any other responsibilities are identified by the CFMG members.

#### **Suggested ToRs of the Secretary**

1. Assists the Chairperson and officiate him/her during his/her absence.
2. Manages the correspondence (writing of letters and minutes of meetings) for the CFMG.
3. Maintain the files of the CFMG.
4. Maintains the list of CFMG members.
5. Approves applications for forest products (with Chairperson).
6. Keeps minutes of CFMG meetings.
7. Prepares Annual Progress Report (with other CF Management Committee members).

Add if any other responsibilities are identified by the CFMG members.

#### **Suggested ToRs of the Treasurer**

1. Looks after any financial transactions on behalf of the CFMG.
2. Keeps records of expenditure and labor contribution during CF activities
3. Gives a detailed account of how much money or labor has been contributed, how much has been spent and how much is still left, at every CFMG meeting (or as required)
4. Prepares the Annual Financial Report for the CFO (with the assistance of other CF Management Committee members).
5. Countersigns financial transaction and authorization to draw cash from the bank account (with Chairperson).

Add if any other responsibilities are identified by the CFMG members.



## **Roles and Responsibilities of CFMG**

All individuals and households with traditional claim to forest produce from the CF can seek membership of the CFMG. It is particularly important that disadvantaged households are identified and encouraged to become CFMG members because they can sometimes be missed out. Other eligible member has the choice to join the CFMG.

*Box 2.13 Roles and responsibilities of CFMG as per FNCRR 2017*

The CFMGs are vested with the following roles and responsibilities as per FNCRR 2017:

- (1) The CFMG shall harvest the forest produce from their CF in accordance with the CFMP
- (2) The CFMG shall obtain permit from the Chairperson of the CFMG for harvesting of any forest produce from their CF.
- (3) The CFMG shall be allowed to sell the surplus produce to any buyers within the country provided the timber is not sold in standing form.
- (4) The prices for the sale of surplus forest produce shall be as per the rates decided by the CFMG.
- (5) The CFMG shall be allowed to form CF network and association to strengthen good governance, sustainable utilization of resources, equity and common market access.

Additional suggested roles of CFMG members are to;

1. Follow the procedures and rules of the CFMG as outlined in the CFMP and By-laws.
2. Participate in CFMG planning and decision-making.
3. Elect CF Management Committee members.
4. Participate in drafting of the CF management plan and CFMG by-laws.
5. Participate in CFMG meetings.
6. Co-operate with the CF Management Committee in carrying forest management and other management operations especially by contributing labor if required.
7. Co-operate with the CF Management Committee regulating forest use by other CFMG members and by outsiders
8. Involve in other CFMG activities as planned

## **Conflict Management**

Conflict management is a complex process. Identifying and categorizing types of conflict is essential before attempting to resolve. Some conflicts require different strategies to resolve while some can be resolved by CFMG themselves. The approach to conflict resolution is based on consensus building. This involves identifying common ground and working voluntarily towards finding a mutually acceptable solution to the problem. Conflicts are initially solved by the CF Management Committee. However, when the CFMG calls on the concerned forestry official(s) to resolve the conflict he/she can act as the mediator.

The followings are the suggested procedures to help in resolving the conflicts:

1. The mediator calls the conflicting parties together to discuss the problem.
2. The parties define the problem as they experience it and agree that it needs to be resolved (this is important).
3. The mediator presents the formulated and defined problem on a chart and asks both parties if it is correctly defined.

4. The mediator then asks the parties to work separately and propose solutions to the problem. Chart paper is given and they are asked to note their proposed solutions.
5. The parties present their proposed solutions in turn.
6. After the first solution is presented the mediator asks the other party if the solution proposed is acceptable to them. If yes, then the problem is solved. If no then the mediator asks for amendments to the proposed solution (more discussion may be needed for this). If the second party out rightly rejects the proposed solution then they are asked present their proposed solution.
7. If all the solutions are exhausted and there is no agreement, then the session is adjourned for further reflection by both parties.
8. A time is fixed for another meeting and they are asked to return with ideas for further discussion.
9. This process may take several meetings to resolve. The mediator must stay neutral at all times and cannot propose a solution – this must come from the 2 parties involved.

## **Step 2. CFMG Capacity Building**

Capacity building for CFMGs shall be a continuous process from the initiation of CF till monitoring and evaluation of CF. The capacity building programs are aimed at enhancing the knowledge and skills of the CFMG to manage the CF independently, efficiently and equitably, making it self-sustaining local institution in the long run.

Before initiating any capacity building plans, it is necessary to identify the capacity gaps hindering the implementation of CFMG activities and existing skills and capacity of the CFMG. Job and Jobholder Analysis shall be conducted to identify the capacity gaps, which should be included in the capacity building plan.

### **Job and Jobholder Analysis**

Job and Jobholder Analysis is used to identify which activities CFMG members are required to undertake and whether they can actually carry them out. These should be done through the following steps;

1. Discuss with CF Management Committee members about their jobs and prepare a list of tasks (things they are expected to do). Lists the responsibilities of the CF Management Committee.
2. Discuss with the CF Management Committee about this list of tasks. For each task let them first decide whether it is a high (H), medium (M) or low (L) priority for them. Fill the Job Analysis column indicating the agreed priority.
3. Next, categorise each task according to whether CFMG Management Committee members are already able to do it. Put an X in the appropriate column for “can do”, “partly do” or “can’t do” according to the CFMG Management Committee’s own assessment and that of the concerned Forestry staff.
4. The completed table is the basis for a capacity building plan. You could prepare a similar table for other aspects e.g. forest management, or monitoring

*Table 2.21 Example of Job and Jobholder Analysis*

<b>Example of Job and Jobholder Analysis</b>					
	Tasks	Can do	Partly do	Can’t do	Priority
<b>GENERAL ADMINISTRATION</b>					
1	Write letters		X		M
2	Dispatch letters (send)	X			L
3	Record letters (receive)	X			L
2	File correspondence			X	H
3	Prepare work plans		X		M
4	Prepare Progress Reports			X	H
5	Conduct meetings		X		M
6	Draft meeting minutes		X		M

Example of Job and Jobholder Analysis					
7	Record penalties and compensation	X			L
8	Use the CFMG seal	x			H
9	Keep inventory of CFMG property			x	H
10	Enforce Bylaws	x			H

### Preparing a Capacity Building Plan

A capacity building plan should be prepared to guide the concerned Forestry staff in organizing technical support to CFMGs.

### How to Prepare the Capacity Building Plan

1. Using the Job and Job Analysis table, list all the tasks which are ‘high priority’ but which are also categorised as ‘can’t do’. These are the most important tasks for capacity building.
2. Next, look for high priority tasks which are categorised as ‘partly do’ and also medium priority tasks which are categorised ‘can’t do’. These are the next most important for the capacity building plan.
3. Finally list all the other tasks and complete the table (example below)
4. For each activity decide on the objectives i.e. what the CFMG would like to achieve after the capacity building activities have been done.
5. Next, set the dates or months during which you plan to carry out capacity building activities. Record this in the period column but remember that some capacity building activities shall be continuous.
6. Under the Inputs column identify any inputs (financial, physical, administrative, and technical) that shall be required to carry out capacity building. An example is shown below
7. Finally, include all the planned capacity building activities into the Annual Work Plan for the year.

Table 2.22 Example of a capacity building plan

Example of a capacity building plan				
Task	Objective	Activity	Period	Input
Operate a bank account	CF Management Committee members are able to deposit and withdraw money, issue cheques, use the passbook and keep records of transactions.	Prepare materials.	April 2020	Funds for purchase of material. Assistance of staff in material preparation
		Make arrangements with financial institution		Letter of CFO to Bank
		Conduct a Banking & Book keeping Training for three CFMGs.		Venue at Dzongkhag. Funds for refreshments for CFMG members. Concerned Forestry staff facilitation inputs
Manage forest product utilisation	CF Management Committee members are able to select, measure, and mark trees for thinning and harvesting.	Silviculture training	January 2020	Funds Forest site for practical exercise Technical resource person
		Hands on training in the forest	February 2021	Concerned Forestry staff to spend time with CF management committee during tree marking
		Post-harvesting inspection	May 2021	CF management committee and concerned Forestry staff inspect site after harvesting and discuss any problems

### **Step 3. Silviculture and Forest Management**

A major role for the CFMG is to implement the forest management activities specified in the CFMP. These aspects are covered by a separate forestry field manual for Bhutan “Silviculture and Other Forestry Operations” Second Edition 2016.

### **Step 4. Community Development**

Besides CF management, the CFMG should also focus on community development in order to bring immediate benefit to CFMG members in the short term – especially disadvantaged members. The level of these activities that can be carried out depends on local needs and on the resources available within the CFMG.

Suggested community development activities can include:

- Activities for creating local employment
- Water supply and sanitation activities
- Agriculture and irrigation development
- Health related activities e.g. support for health facilities, awareness and capacities
- Education including infrastructure, resources and awareness
- Infrastructure such as village roads, footpaths, culverts, footbridges and community buildings etc.
- Soil conservation

### **Step 5. Addressing Poverty and Disadvantaged Members**

One of the aims of community forestry is to contribute in reducing poverty amongst CFMG members. During the preparation of the CFMG by-laws, a discussion should take place about what activities or special provisions can be included for addressing poverty. The best ideas for tackling poverty shall come from the target households themselves and this should be considered

Managing CFMG Fund specifies that not more than 50% of their CF fund should be allocated for loan and CFMG enhancement which includes targeted actions for poverty reduction. Suggested poverty activities can include the following:

1. Subsidized rates for forest produce.
2. Special provisions for collecting certain forest produce e.g. NWFPs.
3. Support for disadvantaged households to set up small scale income generation activities
4. Lower interest rates or interest free loans for disadvantaged households.
5. Creation of employment opportunities for disadvantaged households in CF management and other CFMG activities.
6. Encourage to include disadvantaged households in the CF Management Committee.
7. Establishment of emergency funds to help disadvantaged households in times of need.
8. Provision of support for disadvantaged households for medical treatment, education, agricultural inputs and other social services.

Those components, wherever applicable should be given importance and considered as crucial part of CF management. The success of the enterprise development shall have direct impacts on addressing poverty.

### **Step 6. Adapting to Climate Change**

Climate change adaptation supports the individuals, communities and natural systems to deal with the adverse effects of climate change that cannot be avoided. It involves taking practical actions to manage risks, protect communities and enhance resilience. However, the ability to cope and adapt differs among individuals and households. To enhance and build resilience of households and communities against the negative

impact of climate change identified through Vulnerability Assessment, the following suggested possible coping and adaptation options should be included in the CMFP;

1. Provision of water storage facilities (household level and community level)
2. Spring protection
3. Soil conservation and land management activities
4. Agricultural support activities such as new horticulture and crop varieties, irrigation facilities, and pest control measures
5. Forest fire control measures
6. Crop and livestock produce storage facilities

### **Step 7. Enterprise Development and Employment**

Community Forestry program can lead to sustainable management of forest resources and provide avenues for livelihood improvement through enterprise development. Some potential community-based enterprise development within CF are listed below:

- Ecotourism (*Menchu*/hot stone bath, home stay, trekking, recreational centres, picnic spots, bird watching, handicrafts production, camping sites, horse riding, safari, rafting, etc.)
- Payment for Environmental Services
- Marketing of surplus sand and stones
- Potential NWFPs (production, product diversification, value addition, marketing, etc.)
- Marketing of surplus timber (value addition, product diversification, wood-based industries)
- Firewood/Wood chips
- Bottling plants for mineral water/package from *Drupchus*, *Menchus*, etc. available within the CF area.

### **Step 8. CFMG Administration**

For efficient and effective administration of CFMGs, the following administrative processes should be followed;

#### **Filing Systems**

Correspondence e.g. letters and other documents should be properly maintained. Correspondence, letters and documents are first sorted according to specified subjects and dates and kept in labelled files for easy identification and retrieval.

#### **The CF Hammers**

The CF hammers (Marking and Passing hammer) (Figure 2.7) shall be issued by the Department through office order or notification. The hammers contain Dzongkhag Code (DC) and Serial Number (SL.NO.). The registered hammers shall *be under the custody of CFO/Forest Officer for proper safety and the Forest Officer shall use the marking hammer.*

Figure 2.7 shows the 2 hammers. ‘CF’ indicates that the hammer is for Community Forests. ‘DC’ is for Dzongkhag Code and then serial number for the CF. ‘M’ indicates that the hammer is used for marking timber for felling while on the other hammer the ‘P’ for passing refers to timber marked for sale. Note that hammers may change from time to time as regulations for community forestry evolve. Ensure that you are fully updated with the current system for timber marking.

M	P
DC/SL.NO	DC/SL.NO.
CF	CF

*Figure 2.7 CF hammers*

The CF marking hammer is used to mark trees that have been approved for felling by the CF Management Committee and for felled and cut logs on the ground. The passing hammer is used to mark timber that are sold and for transportation.

### **CFMG Record Keeping**

A set of standard formats has been developed to simplify record keeping. The concerned Forestry Office shall provide these formats to the CFMG after approval of the CF for the initial plan period. The CFMG is obliged to maintain these records, which should be made available to the CFMG members and to the forestry staff on demand.

- Format 1. Annual Work Plan and Progress Report
- Format 2. Seedling and Plantation Record
- Format 3. Attendance Register (Annual Labour Register)
- Format 4. Record of Penalty and Compensation
- Format 5. Collection Permit
- Format 6. Records of Forest Produce Utilisation
- Format 7. Money Receipt
- Format 8. Cash Book
- Format 9: Meeting Minutes
- Format 10: Loan Record
- Format 11: Stock Register
- Format 12: Calculation of payables to group members from forest sales
- Format 13: Calculation of payables to individual group members from the forest sales based on collection
- Format 14: Calculation of payables to individual group members from the sale based on labour contribution
- Format 15: Payable Form
- Format 16: Receivable Form



[illegible]

[illegible]

ཁྲིའཕྱོན། (Chairperson)

འཕྲིན་པུ་ (Secretary)

### Format 3. Attendance Register (Annual Labor and Meeting)

**འཛིན་སྐྱོང་གི་ལྷན་ཁག་**

ལུ་ཚབ་གྲི་མིང་། Name of CFMG/NWFP Group:

[illegible]

[illegible]

ཁྱིམ་འཛིན་ (Chairperson)

འཕྲིན་པ་ (Secretary)

Format 5: Collection Permit						
བསྐྱུ་ལེན་ཆོག་ཐམས། Collection Permit						
ཡང་། No.		སྟོན་ཆས། Date:				
ཆོག་ཐམས་འཆང་མི་གི་མི། Name of permit holder:						
གཡུས། Village:		གོང་ལོག། Gewog:				
Dzongkhag:		Permit No:				
རྒྱུ་ཡུན། Duration	འཛོན་ཁྱུངས་ཁ་གསལ། Details of products	ས་གནས་ཡང་ན་ས་སྒོ། Location or Block	ཆོད་གཞི། Quantity	རིང་གོང་། རྒྱུ་ཡུན། Rate (Nu)	རྒྱུ་ཡུན་ཡོངས་བསྟོན། Total amount	འཛོན་ཆེད། Remarks

འཛིན་པོ། (Chairperson)

རྒྱུ་ཆོད་པོ། (Secretary)

Format 6: Record of Forest Utilization															
ནགས་ཚལ་པའི་སྤྱོད་ཀྱི་ཐོ་གཞི་ལྡན་པའི་རེག་དོན་གྱི་ཐོ་གཞི་ལྡན་པའི་རེག་དོན་ (Number of Trees)															
མྱོངས་སྤྱེ་ནགས་ཚལ་གྱི་མིང། Name of CF:															
རྫོང་ལག   Dzongkhag:															
ལོ། Year:															
ཨང། Sl. No.	སྤྱི་ཚེས། Date	མྱོངས་སྤྱེ་ནགས་ ཚལ་སྤྱེ་ཚད་གྱི་ འབྲས་མི་མིང། Name of CFMG member	གྲང་ཡང། House No.	ཚོགས་ཐམས་ ཡང། Per- mit No.	དཀིང། Drashing	ལུས། Cham	གཙོས། Tsim	དངས་ཅུང། Dangchung	གཙོ་ཐུག། གཞི་རྒྱལ་གས། Posts (No. trees)	ཐབས་ཤིང་ གཞི་རྒྱལ་གས། Firewood (No. trees)	གཞན། Others	འབྲས་ རྫོང་པ་ཡོངས་ བསྡུས། Total Fee			
													ཚད་གཞི། Quantity	མེ་ རྫོང་པ་ Fee Paid	ཚད་གཞི། Quantity
ཡོངས་བསྡུས། Total															

ཁྲི་འཛིན། (Chairperson)

ཁྲི་འཛིན། (Secretary)



Format 7. Money Receipt

འབྲུང་རྒྱུ་ལྟ་སྟངས་ Money Receipt

ཡུང་པ་No. \_\_\_\_\_ ས་ཁོངས་དང་དུམ་ཚུལ་ Place, date: \_\_\_\_\_

སྒྲིལ་བའི་མིའི་འོག་ཀྱི་སྤྱོད་པ་ Name of CF/NWFP Group: \_\_\_\_\_

སྒྲིལ་བའི་མིའི་འོག་ཀྱི་སྤྱོད་པ་ Received from (name) \_\_\_\_\_ དང་ཡུང་པ་ Nu. \_\_\_\_\_  
 ཡུང་པ་ Nu.

དང་ཡུང་པ་ལྟ་སྟངས་ལྟ་སྟངས་ལྟ་སྟངས་ By cash/cheque/cash warrant/demand draft No.

དང་ཡུང་པ་ལྟ་སྟངས་ལྟ་སྟངས་ As a payment for

1/1 \_\_\_\_\_

2/2 \_\_\_\_\_

3/3 \_\_\_\_\_

དང་ཡུང་པ་ལྟ་སྟངས་ལྟ་སྟངས་ Total Nu. \_\_\_\_\_

མིའི་དང་གོ་གནས་ Name & designation: \_\_\_\_\_

མཚན་རྒྱུ་ལྟ་སྟངས་ Signature:

[illegible]

Format 9: Meeting Minutes		འཛེམས་འདུ་ གྲོས་ཚད། Meeting Minutes	
ཕྱི་ཚེན་གྱི་མིང། Name of CFMG/NWFP Group: _____			
འཛེམས་འདུ་ སྤྱི་ཚེས། Date of meeting:		འཛེམས་འདུ་ གྲོས་ཚད་འབྲི་མི། Minutes taker (name):	
འཛེམས་འདུ་ ལྷན་མཆན། Purpose of meeting:			
འོང་ཡོད་པ་པོའི་འཕུས་མི། Total number of members (Member House-		མོ་ཡོངས་པ་སྟོན་པ། Number of Female participants:	
holds) present:		མོ་ཡོངས་པ་སྟོན་པ། Number of Male participants:	
མཚོན་མཁ་ཡང་ན་ འགོ་དཔོན་གྱི་མིང་དང་གོ་གནས། Names and designation of guests/officials present:			
ཨང། Sl. No	གོ་བསྐྱེད་འབད་ནི་གི་གནད་དོན་དང་དཀའ་ངལ། Issues/points of discussion	འཛེམས་འདུ་གྲོས་ཚད། འགན་ཁུར་འབག་མི་ག་མོ། བཟའ་འཛེམས་འདུ་རྒྱུ་བཅི? གཏེ་ལུ་འབད་རྒྱུ་བཅི? Meeting resolutions (De- scribe actions: By whom? When? Where?)	

## Format 10. Loan Record

[illegible]

[illegible]

Format 12. Calculation of payables to group members from forest sales					
འགས་ཚལ་ཐོན་སྐྱོད་ཀྱི་ཚོང་སྤྱོད་ལས་ཚགས་པ་ལུ་སྤྱོད་དགོ་པའི་རེ་ཕྱིས།					
Calculation of payables to group members from forest product sales					
ཨང་ Sl. No	གནད་དོན་ Particulars	ཇུ་ཕྱུག་ Unit	ཁ་ཕྱུངས། Quantity	གོང་ཚད་ Rate (Nu)	དངུལ་ཀྲམ་ཡོངས་པ་སྤྱོད་པས་ Total Amount (Nu)
	ཐོན་སྐྱོད་པ་ཚོང་ལས་འོང་འབབ། Revenues from selling products				
ཀ A	འོང་འབབ་ཡོངས་པ་སྤྱོད་པས། Total revenues				
	ཚོང་འབྲེལ་གྱི་འགྲོ་སྤྱོད་ Expenses for marketing products				
ཁ B	འགྲོ་སྤྱོད་ཡོངས་པ་སྤྱོད་པས། Total expenses				
	ཁེབ་ས་དཔེ་སྤྱོད། Net Income (A-B)				

**Note:** གསོག་འཛོག་པ་ཞེས་པའི་འབྲུས་མི་ལུ་གཞི་བཞག་ཞིན་ན་ ཚོགས་པའི་འབྲུས་མི་དེ་དེ་བཞིན་དུ་ལུ་སྤྱོད་དགོ་པའི་ཕྱིས། Calculation of rate to be paid to individual group members based on collection. ཚོགས་པའི་འབྲུས་མི་ལུ་སྤྱོད་དགོ་པའི་ཡོངས་པ་སྤྱོད་པས་ ཚོགས་པ་གིས་གསོག་འཛོག་འབད་མིའི་ཁ་ཕྱུངས། Total payables to group members/ total quantity collected by the group. ཚོགས་པའི་འབྲུས་མི་ལུ་ ཉིན་གྲངས་ལས་མི་ལུ་གཞི་བཞག་ཞིན་ན་ སྤྱོད་དགོ་པའི་ཕྱིས། Calculation of rate to be paid to individual group members based on labour days. ཚོགས་པའི་འབྲུས་མི་ལུ་སྤྱོད་དགོ་པའི་ཡོངས་པ་སྤྱོད་པས་ ཚོགས་པ་གིས་ལུ་འབད་ཡོད་པའི་ཉིན་གྲངས། Total payables to group members/ total labour days invested by the group.



**Format 13. Calculation of payables to individual group members from the forest sales based on collection**

ནགས་ཚལ་ཐོན་སྐྱོད་ཀྱི་ཚད་སྡུར་ལས་ཚོགས་པའི་འཕུས་མི་དེ་དེ་བཞིན་ཁུ་ལུ་སྡོད་དགོ་པའི་ཨྱིས།

Calculation of payables to individual group members from forest product sales based on collection

[illegible]

\* ཚོགས་པའི་འཇུག་མི་རེ་འབེལ་གྱི་ལུ་སྒྲིང་དགོ་པའི་གོང་ཚད་ཡིན། བར་ཚད་པ་གིས་སྒྲིང་མི་གོང་ཚད་འདི་མེད། རེ་ཚོགས་པའི་འཇུག་མི་རེ་འབེལ་གྱི་ལུ་སྒྲིང་དགོ་པའི་གོང་ཚད་ཡིན། བར་ཚད་པ་གིས་སྒྲིང་མི་གོང་ཚད་འདི་མེད།

**Format 14. Calculation of pavables to individual group members from the forest sales based on labor contribution**

[illegible]

### Calculation of payables to individual group members from forest product sales based on labour contribution

[illegible]

\* གོང་ཚད་འདི་འབུམ་མིའི་གྲས་ཀྱི་ཕྱིན་དཔོན་གྱི་ Rate per Labour Day as calculated to be paid to the individual group members; not the same as government labour day rates.

[illegible]

Format 16. Receivables Form							
ལེན་མིའི་དྲི་ཐོག་། Receivables form							
ཨང་ Sl. No	ལེན་མིའི་མིང་དང་ཁ་ཕྱད་ Receivable from (name & address)	ཁ་ཕྱད་ཁ་ཕྱད་ Description	འཛིན་ཐོག་གི་ ཚེས་ཁྱེད་། Date (of invoice)	འཛིན་ཐོག་གི་སྤྱི་ལོ་ རྩིས་ཚད་། Due date (of invoice)	འཛིན་ཐོག་ ཨང་ In- voice no.	བསྐྱེལ་པ། Amount (Nu)	དྲན་གསུང་། Remarks

## **Managing CFMG Fund**

CFMG by-laws should address the fund management. Based on the provisions in their respective by-laws, CF fund can be utilized either in group or by the individuals who are the member of CFMG. Management of CFMG fund is mainly the responsibility of the CF Management Committee. The Treasurer shall maintain all transaction records and should provide an update of the fund status during CFMG and Committee meetings.

The fund sources are included in the CFMG's by-laws. The probable sources of CF fund are:

- Membership fees
- Contributions from CFMG members and outsiders
- Fines paid by CFMG members and outsiders
- Forest product fees
- Sale of forest products (timber, NWFPs, sand and boulders)
- Sale of services (ecotourism and ecosystem services)
- Donations
- Interest returns.

## **How to Manage the CF Fund**

CF fund should support in fulfilling the activities for CF development as reflected in respective CFMP (i.e. CF development activities like plantation, thinning, cleaning, fire line creation, etc.).

CFMG should emphasize on poverty targeted activities: Support to poorer/disadvantaged households based on need rather than the ability to pay. It is important that the CFMG integrates the principles of sustainability (i.e. long-term benefits), Equity in benefit sharing (fair rather than equal) and pro-poor provisions.

### *Box 2.14 Equity vs Equality*

Equity often means that all members receive an equal share of benefits. A better way to think of equity is in terms of fairness - what is fair under the prevailing circumstances? Regarding income generation and fund management an important aspect is equity in benefit sharing which should ensure that the poor or disadvantaged people are not made absolutely or relatively worse off.

Example: a poor household is waived off with membership fees and labor contribution. A single and elderly woman headed household is waived off the loan interests, etc.

It is the responsibility of the CFMG to decide how much fees should be contributed by each member. It is important to make certain consideration for those members who cannot pay (i.e. disadvantaged members). Fixing fee rates should therefore take into account equity (rather than equality).

### *Box 2.15 Some examples for pro-poor provisions*

- Provide support for disadvantaged households for medical expenses, education, agricultural inputs, food and others.
- Emergency fund to poor households in times of dire need, e.g. in case of death, sickness, natural disasters.
- Give loans for poorer households (at interest-free or lower interest rates).
- Give incentives to committee members of poorer background in order to reduce their transaction costs.

The concerned Forestry Officer shall attend the CFMG meetings/assemblies, whenever possible. He/she shall provide guidance on fund management.

*Box 2.16 Transaction Costs*

Transaction costs refers to the costs (financial and others) involved in transacting the business associated with CF. this include things such as the time spent in meetings and in negotiations, as well as direct costs such as contributing labor in tree planting and other CF developmental activities. There are economic consequences associated with transaction costs that are often quite severe, particularly for poor people who might have to forego livelihood or income generating activities in order to participate in CF related activities.

All CFMG members have the right to know about the status of their fund. All documents related to CF fund should be available for inspection by CFMG members to ensure transparency and accountability.

The CFMG shall produce all documents for review, inspection, auditing, monitoring by concerned Forestry Officer at any time. All documents related to CF fund shall be maintained properly by the CF Management Committee.

*Box 2.17 Pro-poor Loan Scheme*

Smaller loans first: the CFMG shall decide to distribute first the smaller amounts and then the bigger amounts.

Interests Rates: the CFMG may decide to give loans to disadvantaged members at lower interest rates or even interest-free loans).

Purpose: the CFMG may decide and prioritize loan disbursement based on the purpose (e.g. activities to reduce poverty, education, health, emergency cases).

### **Procedures in CF Fund Management**

- All CFs should open a bank account within one month from the day of award of CF Ownership Certificate
- The account shall be operated under the joint signatory of the CF Chairperson and the Treasurer or as reflected in the respective By-laws
- Money receipts should be issued for all payments received
- Contingency fund of Nu. 5,000 may be kept with the Treasurer.
- Amount over Nu. 5,000 (five thousand only) should be deposited within 10 days. Failure to deposit on time, the Treasurer shall be liable to pay the interest rate and deposit in the CF account.
- All money received should be recorded in the Cash Book by the Treasurer
- The Treasurer collects all contributions, fees, fines, donations and maintain records
- The Treasurer shall present the schedule of collections to the CFMG at least annually.
- There should not be any over-writing, use of correction of fluid, tearing of pages, etc. in the record keeping books and money receipts including permit books.
- All financial records should be made available to authorized auditing team/inspection team anytime.

### **Suggested CF Fund Utilization Areas**

The followings are some of the areas where CFMG can utilize their CF fund. Based on the table below, the CFMG shall allocate the CF fund on different priority areas. The CFMG shall discuss and decide on fund utilization during the preparation of the CF Management Plan and shall be reflected in the by-laws.



*Table 2.23 Allocation of CF Fund*

<b>Areas of fund Use</b>	<b>Limit (%)</b>
CF development activities (CF review, nursery creation, plantation, thinning, cleaning, salvage operation, sanitation, boundary demarcation, fire line creation, etc.)	Not less than 25
CFMG enhancement (Loan, capacity building, study visits, meeting, workshops, networking, visitors in CF, income generation and enterprises development, etc.).	Not more than 50
Reserve fund in the Bank (security)	Not less than 5
Others (to be decided by the CFMG members on e.g. incentives to victims of natural calamities, incentives to disadvantaged members/households, contribution to community <i>Lhakhangs</i> , water supply, farm road, etc.)	Not more than 20

### **Disbursement Procedures**

- Any expenditure up to Nu. 10,000 shall be decided by the CF Management Committee and beyond that amount the decision shall be made by the 2/3<sup>rd</sup> majority of the CFMG members.
- The Treasurer shall maintain all detail expenditure records (receipts, vouchers, bills, including minutes of meetings, etc.). All such expenses shall be immediately recorded in the cash book.
- The Treasurer shall present the details of expenditure to the CFMG members and concerned inspection team(s).
- The concerned Forestry Officer shall ensure the compliance of above provisions.

### **CFMG Fund for Loans and its Procedures**

Once the particular CF generates income, they can allocate not more than 50% of the total fund for loan. The CF by-laws should have provisions to facilitate CFMG fund for loan. The borrower shall submit an application as per Form 2.3.

Form 2.3 Loan application form

<b>Annex 9: Loans Application for CFMG members</b>							
Loan Application Form རྒྱུན་འགྲུལ་ཁྱུ་ཡིག་བྲིས་ཤོག	Date ཟུང་ཚེས་:.....						
Name མིང་: .....							
Village གཡུས་: .....							
Gung No. དགུང་ཨང་: .....							
Thram No. ཁྲམ་ཨང་: .....							
CID No. རྩ་སྒྲིང་ལག་ཁྱུར་ཨང་: .....							
Mobile No. འགྲུལ་འབྲིན་ཨང་: .....							
Amount Applied Nu: མ་དངུལ་བསྐྱུར་གྱི་ (in words རྟོག་ཐོག་ ཁ་རེ).....							
Purpose གནས་དོན་: .....							
Mortgage གཏང་མེད་ (optional)							
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;">a)གླ</td> <td style="width: 50%; padding: 5px;">Total value of mortgage (s)</td> </tr> <tr> <td style="padding: 5px;">b)ལེ</td> <td style="padding: 5px;">གཏང་མའི་བརྩི་མཐོང་བསྐྱུར་</td> </tr> <tr> <td style="padding: 5px;">c)གླ</td> <td style="height: 40px;"></td> </tr> </table>	a)གླ	Total value of mortgage (s)	b)ལེ	གཏང་མའི་བརྩི་མཐོང་བསྐྱུར་	c)གླ		
a)གླ	Total value of mortgage (s)						
b)ལེ	གཏང་མའི་བརྩི་མཐོང་བསྐྱུར་						
c)གླ							
Third Party Guaranty (if any): ཁས་ལེན་ཁག་འགན་འབག་མི་ཡོད་པ་ཅིན་ཀྱི།							
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;">Name, CID No. M. No. Thram No. Gung No.</td> <td style="width: 50%; padding: 5px;">Signature and Date</td> </tr> <tr> <td style="padding: 5px;">མིང་/ རྩ་སྒྲིང་ལག་ཁྱུར་ཨང་ / འགྲུལ་འབྲིན་ཨང་/ཁྲམ་ཨང་/དགུང་ཨང་</td> <td style="padding: 5px;">མིང་རྟགས་དང་དབྱིན་ཚེས་</td> </tr> <tr> <td style="height: 100px;"></td> <td></td> </tr> </table>	Name, CID No. M. No. Thram No. Gung No.	Signature and Date	མིང་/ རྩ་སྒྲིང་ལག་ཁྱུར་ཨང་ / འགྲུལ་འབྲིན་ཨང་/ཁྲམ་ཨང་/དགུང་ཨང་	མིང་རྟགས་དང་དབྱིན་ཚེས་			
Name, CID No. M. No. Thram No. Gung No.	Signature and Date						
མིང་/ རྩ་སྒྲིང་ལག་ཁྱུར་ཨང་ / འགྲུལ་འབྲིན་ཨང་/ཁྲམ་ཨང་/དགུང་ཨང་	མིང་རྟགས་དང་དབྱིན་ཚེས་						
Signature and Date of Applicant with legal stamp: ཁྱིམ་སྐོར་ནས་འགྲུལ་ཁྱུ་ཡིག་བྲིས་པའི་རྟགས་དང་དབྱིན་ཚེས་							
Sanctioned by: གནང་བ་སྤྱོད་མི							
Treasurer བརྩིས་བྱུང་ ལྷན་ཆེན་ ཁྱིམ་འཛིན་	Secretary						
Chairperson							

### **Eligibility Criteria for Loan**

Every CFMG member shall be given opportunity to avail loan from their respective CFMG fund.

- Loan from CFMG fund shall not be given to non CFMG members.
- The borrower must be of 18 years and above.
- Only one member from the household is eligible for loan at a time.
- Should not have any outstanding loan in the CFMG.
- The borrower should have his/her census in a household who is member of the CF.
- Need of mortgage or guarantor shall be decided by the CFMG.

### **Interest Rates**

CFMG members shall decide on the interest rate during general meeting/assemblies with 2/3<sup>rd</sup> majority following the provisions mentioned in the CF by-laws. The interest rate shall be on annual basis. However, the interest rate should not exceed 15 % per annum in accordance with Section 17 (1) of the Movable and Immovable Property Act of Bhutan 1999.

CFMG may apply different interest rate e.g. lower interest or interest-free loan for members of disadvantaged and single woman headed households.

### **Loan Term**

The loan term shall be decided by the CFMG depending on the repayment capability of the borrower. However, all loans and other dues must be cleared before the expiry of the CFMP.

### **Repayment Schedule and Process**

The borrower shall pay the principal amount including the interest on instalment basis annually or upon completion of the loan term. It is the duty of the CF Management Committee (Treasurer) to maintain proper records of all financial transactions. Fresh loan can be availed only after repayment of the previous loan.

### **Penalties**

The CFMG shall decide penalties in case of non-repayment of the loan and it should be reflected in the loan agreement and the respective CF by-laws. Refer Annex 10 for loan agreement. However, the penalties charge shall not exceed 24% per annum as per financial rules.

If the borrower has serious financial trouble but assures the CF Management Committee that the loan shall be repaid, the CF Management Committee can exceptionally decide to reschedule the loan after an evaluation of the repayment problems. However, the CF Management Committee shall ensure that the borrower repays loan and other dues before the expiry of the CFMP period.

### **Mortgage and Guarantor**

Requirement of mortgage and guarantor shall be decided by the CFMG. In case they decide to have mortgage, the minimum mortgage value shall be 150% of the loan amount. Mortgage value shall be assessed by the CF Management Committee prior to loan approval as follows:

- Detailed description of the collateralized goods.
- Valuation of the goods on the basis of their market value.
- Collateral agreement signed during the loan request.
- The applicant shall produce “No Objection Certificate” from household members in the event of mortgaging the collateral.

### **Allowable collateral:**

- House, buildings and land with legal property documents.
- Cars, vehicles with the official government certificate of the property.

- Livestock (Cattle/horses/pigs).
- Poultry/dairy farms.
- Agriculture machineries (power tiller, rice mill, etc., decided by the CFMG).

### **Loan Approval and Disbursement Process**

Upon fulfilling the eligibility criteria, the CFMG shall approve the loan based on general consensus or with 2/3<sup>rd</sup> majority. The borrower and the lender shall sign the loan agreement before the loan disbursement. The loan agreement is prepared in two copies, one for CF Management Committee and one for the borrower. The CF Management Committee shall withdraw/transfer the amount from their respective bank account and disburse to the borrower.

### **Loan Review**

At the end of each year, the CF Management Committee shall review all the loans and repayments. The information shall be shared during the CFMG general meetings/assemblies.

## **Step 9. Annual Work Plan Preparation**

An annual work plan (AWP) should be prepared every year during the Community Forest Management Group general meeting based on the Forest Management Matrix (Step 11) prepared and approved in the Community Forest Management Plan (CFMP). It may be helpful to start this process (during the first year) by doing a seasonal calendar (PRA tool).

### **2.3.5 Monitoring, Evaluation and Reporting**

Monitoring and evaluation are parts of the action learning cycle (Figure 2.8). Actions are implemented and information about their effects is collected and discussed. The reflection on what has happened leads to improvement and revision of future actions. Monitoring and evaluation are important to ensure the achievement of objectives, implementation of actions and the accountability of stakeholders. The action learning cycle happens on many levels in community forestry. Different stakeholders are involved at different stages.

**Monitoring** means collection of information as indication for the achievement of objectives.

**Evaluation** means assessment of information in order to review the achievement of objectives and to decide about how to go on.

**Indicators** are things that can be measured to monitor an objective.

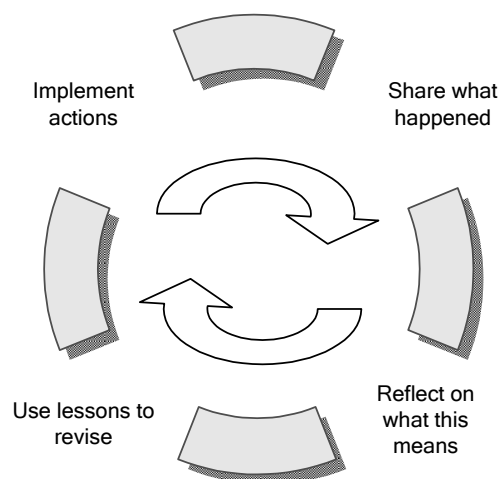
**Activities** are actions like harvesting, thinning or patrolling taken to produce specific outputs.

**Outputs** are products and services like timber or income which directly result from activities.

**Outcomes and impacts** are the bigger medium-and long-term effects like sustainable forest management or poverty reduction which result from the combination of different outputs and which are influenced by multiple other factors.

The objectives, the responsibilities and the processes (including their timing) need to be clearly defined to facilitate monitoring and evaluation. Answering the following questions can help to do so:

- What do we want to monitor and evaluate?



*Figure 2.8 Action learning cycle*

- Who does the monitoring and evaluation?
- How is the monitoring and evaluation carried out?

### **Step 1. Self-Monitoring and Evaluation by the CFMG**

CFMG shall conduct self-monitoring to check its own progress against the CF management objectives by using various indicators. The CFMG shall monitor the followings:

- Achievement of the overall CF management objectives.
- Achievement of block-wise management objectives.
- Implementation of planned activities (in the CF management plan and AWP).
- Implementation of the CFMG By-laws.

### **Step 2. Participatory Monitoring**

Participatory monitoring by the CFMG needs to cover all 3 aspects i.e. (i) participatory forest resource monitoring, (ii) social and institutional monitoring and (iii) environmental impact monitoring.

Monitoring of all these should be carried out in a participatory way so that all CFMG members understand the system, take responsibility for monitoring and for ensuring that as a group they are achieving their planned and agreed objectives.

#### **Step 2.1 Participatory Forest Resource Monitoring**

*Box 2.18 Indicators to monitor forest resources*

During implementation of the CFMP the CFMG needs to continuously check that the management objectives for each block are being achieved. This is done by monitoring against a set of agreed indicators for each activity.

1. Make a list of all the management activities that have been included in the CF management plan (from the Forest Management Matrices in Step 11).
2. Discuss each activity with the CFMG and try to identify 2 or 3 indicators that could be used to monitor the achievement of the activity. For example: If the activity is “establish plantation in degraded forest”, then possible indicators might include survival rate/percentage; etc. in the block. If the activity is “patrolling, to stop illegal activities”, then indicators might include the numbers of culprits apprehended, fines and penalties levied.
3. Out of this list, discuss with the CFMG whether it shall be possible for them to measure them. Remember that the measuring system needs to be simple, practical and understandable.
4. Finalise a short-list of indicators which shall be monitored by the CFMG over the period of the CF management plan (3 or 4 key indicators shall be sufficient).
5. For each indicator, discuss with the CFMG about the procedure for measuring and recording it e.g. How? Who? How often? How shall it be recorded etc.?
6. Various possible monitoring indicators are described here and an example of a completed participatory forest resource assessment table is also shown in Table 2.24.

- Regeneration
- Numbers and diameters of trees of different species
- Canopy density
- Grass cover
- Vegetation cover
- Soil cover
- Level of soil erosion
- Quantity of leaf litter
- Water quantity e.g. from a source
- Level of grazing pressure
- Frequency of fires
- Evidence of illicit cutting of trees
- Availability of various forest products e.g. fuel wood, fodder, NWFPs
- Survival and growth of planted seedlings

*Table 2.24 Example of a Participatory Forest Resource Impact Monitoring Table*

<b>A. Example of a Participatory Forest Resource Impact Monitoring Table</b>				
Activity	Indicator	How it shall be monitored	Responsibility	Comments
Establishment of plantation in degraded areas	Survival percentage, numbers of seedlings growing	Survival of planted seedlings measured in the plantation area	CF Management Committee to organise	TD/PO staff shall support
Patrolling within CF to stop illegal activities	No. of patrolling conducted and culprits apprehended	Regular patrolling and monitoring of the CF area	CF Secretary shall record the information	Resoop may submit patrolling report to the CF Chairperson/ Secretary
Construction of fire lines	Length of fire line constructed	Labour contribution made for fire line construction and physical verification	CF Management Committee and all other members	TD/PO staff shall give support for fire line width and length

## **Step 2.2 Participatory Social and Institutional Monitoring**

Other activities carried out by the CFMG aim to achieve socio-economic and institutional objectives such as contributing to poverty reduction amongst CFMG members or improving CFMG governance. These aspects also need to be monitored by the CFMG by monitoring against agreed indicators. Discuss these poverty and good governance activities with the CFMG members to identify possible indicators (examples are given in the table below). Indicators can also be developed to cover Climate Hazard and Vulnerability Assessment (

Step 9. Climate Hazard and Vulnerability Assessment).

*Table 2.25 B. Example of a Participatory Social and Institutional Impact Monitoring Table*

<b>B. Example of a Participatory Social and Institutional Impact Monitoring Table</b>				
Activity	Indicator	How it shall be monitored	Responsibility	Comments
Providing loan for CFMG member HH income generation	Number of households provided with loan	Records in Fund Management	CFMG with TD/PO staff facilitation	Carried out during loan repayment
Resource allocation based on equity	No. of single woman headed household, no. of disadvantaged households, etc.	Record books	CF Management committee	
Review of socio-economic survey	No. of single woman headed household, no. of disadvantaged households, etc.	Participatory review	CF management committee with TD/PO staff facilitation	
CFMG General meeting	No. of participation of CFMG members in meetings	Meeting records	CF management committee	Collect names of participants during every meeting
CF Management Committee meeting	No. of women attended the committee meetings	CFMG records	CFMG	Overall aim is 1 woman out of three committee



### Step 2.3 Participatory Environmental Impact Monitoring

The indicators identified from the environmental impact assessment need to be monitored to minimise negative environmental impacts.

1. A participatory environmental impact assessment is carried out during CF management plan preparation. This identifies a number of potential negative environmental and social impacts.
2. List the areas where major potential environmental risks are identified. For each of these develop one or more indicators (see Table 2.26).
3. Complete the participatory environmental impact monitoring table showing monitoring methods (how) and responsibility.
4. Finally, having completed table for forest resource, social and institutional and environmental monitoring, combine and include under monitoring section of the CFMP.

*Table 2.26 Example of a Participatory Environmental Impact Monitoring Table*

<b>Example of a Participatory Environmental Impact Monitoring Table</b>				
Possible negative impact	Indicator	How it shall be monitored	Responsibility	Comments
Reduced water flow in springs	Quantity of discharge during driest month	Time to fill a bucket of known volume	CF management committee	Records to be kept by CFMG
Damage to natural regeneration	No. of seedlings damaged	Counting in a sample plot	CF management committee and forestry staff	Participatory assessment
Loss native species	Occurrence of invasive species sighted.	Anecdotal evidence. Growing sites of invasive species	All CFMG members to report	Will give qualitative data only

### Step 3. Monitoring of CF and CFMG

Annual monitoring should be carried out by the concerned forestry office jointly with the CF Management Committee. Regular information should be updated in the database.

### Step 4. Mid-term and Final Evaluation

The CFMP is prepared for a 10-year period. Mid-term evaluation of CFMP shall be carried out at the **last quarter of the 5<sup>th</sup> year** of the plan period. Final evaluation and revision of the CFMP shall be done at the **last quarter of the 9<sup>th</sup> year** of the plan period. The mid-term evaluation shall enable to identify issues which can be incorporated in the AWP. The final evaluation shall be an important input for preparation of the next 10-year CFMP.

Key questions for the mid-term and final evaluations include:

- What was planned and how much was actually carried out?
- What were the main impacts (on the forest, on the socio-economic status of households and on the wider environment)?
- What problems occurred? How were they addressed?
- What are the main outstanding issues?

Although mid-term or final evaluations may not be extensive, there is a minimum data set that should be included (Table 2.27).

Table 2.27 Reporting template for Mid-term and Final Evaluation

<b>Format 2: Reporting Template for Mid-term and Final Evaluation</b>
Name of the CF:
Gewog:
Dzongkhag:
Division/Park:
Executive Summary
Acronym
Table of Contents
Introduction
Key achievement highlights
<i>Mid-term and final evaluation of CFMP/CFMG based on the indicators/criterion set for evaluation in the CF manual (Annex 6, Format 2). Key achievement highlights contributed by the activities.</i>
Constraints
<i>Problems or constraints faced during the implementation of CFMP (difficulties faced, etc.).</i>
Feedback
<i>Feedbacks received (from the implementer) and sought (reporting agency).</i>
Lessons learned
<i>Lessons learned from the implementation of CFMP (experiences, shortcoming and opportunities etc.).</i>
Recommendation
<i>Way forward follow-up actions for improvement (mid-term monitoring and evaluation) and for revision (final evaluation) of the CFMP.</i>
Conclusion
References
Annexure

## Step 5. Reporting

### 5.1 Annual Reporting by the CFMG

The CFMG shall prepare and submit a financial report of its activities to the Beat/Range Office with a copy to the CFO within one month of the end of the fiscal year. The report shall contain the following information:

- Activities completed as prescribed under the Management Plan;
- Quantity of each type of forest produce harvested;
- Quantity of forest produce sold to persons and entities other than the CFMG and its members, and the amount of proceeds of those transactions;
- Summary of financial accounts for the year (income, expenditure, and the disbursement of profits);
- Other information concerning the operations, activities and management of the CF as the Department or the Royal Government may require.

Since the CFMG shall have already collected all information in the regular CFMG record keeping books, the CFMG report can simply be a photocopy of the following formats:

Format 1: Annual Work Plan and Progress Report

Format 1: Annual Work Plan and Progress Report								
ཕྱི་ལོ། Year:		གྲོང་ཁྱེན་གྱི་ཚེས་ཀྱི་མིང། Community Forest Name:				རྫོང་ཁག། Dzongkhag:		
མི་རྒྱུ་འཆར་གཞི། Annual Work Plan					མི་རྒྱུ་འབྲུལ་འབྲས་ལྡན་གྱི། Annual Progress Report			
དམིགས་ཕུལ། Ob- jective	མང། Sl. No	ལྟ་རིག་ལ། Ac- tivity	ས་གནས་ཡང་ན་ས་ཁྱོ། Block or lo- cation	ལ་གྲུང་ལ། Quantity	ཇེ་ཕན་ Unit	རྩིས་ལ། Month	འབྲུལ་འབྲས་ཚད་གཞི། Quantity achieved	དྲན་གས། Re- marks
Add more rows if required								

ཁྲི་འཛིན། (Chairperson)

ཁྲི་ཚན། (Secretary)

Format 2: Seedling Plantation Record

Format 2. Seedling and Plantation Record										
ཤིང་ཕྱངས་དང་འཛུགས་སྐྱོང་གི་ཐོ། Seedling and Plantation Record										
Name of CF:						རྫོང་ལག། Dzongkhag:				
Gewog:						ལོ། Year:				
ཟླ་མ། Month	ས་གནས་ཡང་ས་ཁོངས། Location or Block	འཛུགས་སྐྱོང་གི་དབྱེ་ལག། Category of plantation	ཤིང་རིགས། Species	ཤིང་བཙུགས་པའི་ས་ཁོངས་རྒྱ་ཚད། Area planted (ha)	ཕྱངས་གྱི་གྲངས་ལ། Number of seedlings	འཛིན་སྐྱོང་གི་རིང་གོང་། རྒྱུ་ལྷན་གྱི་ Plantation Costs (cash only, not in-kind)				རྒྱུ་གསལ། Remarks
						ཕྱངས་གྱི་རིན་གོང་། Seedling cost	བསྐྱེལ་འབྲེན་གྱི་རིན་གོང་། Transport cost	རིན་གོང་གཞན། Other Costs	རིན་གོང་ལྷངས་བསྐྱེལ་གྱི་ Total cost	
Add more rows if required										

ཁྱེད་ཀྱི་འཛིན་པ། (Chairperson)

ཁྱེད་ཀྱི་མཛུགས་པ། (Secretary)

Format 5: Collection Permit

Format 5: Collection Permit						
བཟུ་ལེན་ཆོག་ཐམ། Collection Permit						
ཡང་། No.				ལྷན་ཆེན། Date:		
ཆོག་ཐམས་འཆང་མིག་མེ། Name of permit holder:						
གཡུས། Village:			གོང་ལོག། Gewog:			
Dzongkhag:			Permit No:			
རུས་ཡུན། Du-ration	འབྲུག་ཁྱེད་ལ་ཐོབ་པའི་སྐོར་གྱི་གསུང་ལཱ། Details of products	ས་གནས་ཡང་ན་ས་ཁྱོ། Loca-tion or Block	ཆོད་གཞི། Quantity	རིང་གོང་ རྒྱུ་ལ་གྲུ་མེ། Rate (Nu)	རྒྱུ་ལ་གྲུ་མ་ཡོངས་བསྟོན། To-tal amount	བྲན་གསོ། Re-marks

ཁྲི་འཛིན། (Chairperson)

ཁྲིའཛིན། (Secretary)

### Format 6: Records of Forest Produce Utilisation

### Format 6: Record of Forest Utilization

[illegible]

ಪ್ರಿವಿಟ್ (Chairperson)

सुदक्ष (Secretary)



Format 8: Cash Book

Format 8. Cash Book									
Cash book									
ཕྱི་ཚམས་བྱི་མིང་། Name of CFMG/NWFP Group: _____									
ཚུན་ཡུང་ལ། Date	ཐོང་ལ། RECEIPT			སྤྲོད་ལ། PAYMENT			ཕྱི་ལོ་བཟོ། BALANCE		དྲིལ་གསལ། REMARKS
	གནད་དོན་། Particulars	རྩི་ཁུངས་ཡུང་། Ref No	དུས་ཡུམ་། Amount (Nu)	གནད་དོན་། Particulars	རྩི་ཁུངས་ཡུང་། Ref No	དུས་ཡུམ་། Amount (Nu)	དུས་ཡུམ་། Amount (Nu)	དུས་ཡུམ་། Amount (Nu)	

## **5.2 Annual Reporting by the Forestry Offices**

The Field Office staff must submit an annual status report as per the “Guidelines for Monitoring & Evaluation of community Forestry, 2016”. The TD/PO staff should provide information on CFs in their respective jurisdiction for the national CF database that is maintained by FRMD. This needs to be based on reports prepared for each CF and on the CFMG annual financial reports.

### **2.3.6 Revision of Community Forest Management Plan and By-laws**

The Community Forest Management Plan follows a 10-year cycle plan. Upon completion of the 10 years plan period, the plan shall have to be revised. Revision of the CFMP shall be done at the last quarter of the 9<sup>th</sup> year of the plan period. It is likely that the CFMG shall require some help in preparing a new management plan, but the same (or similar) methodology can be used as for the initial plan with the following considerations:

- The renewal and approval of the revised CF plan shall be subject to findings of the final evaluation of the CF implementation for the past 10 years.
- The revised CFMP should be built on experiences from the previous plan.
- Summary of key findings of the previous plan should be mentioned in the introduction part of the revised plan.





### **3. Local Forest Management Area**

**Authors:**

1. Tashi Norbu Waiba, Dy. Chief Forestry Officer, FRMD
2. Arun Rai, Principle Forestry Officer, FRMD
3. Dawa Zangpo, Dy. Chief Forestry Officer, FRMD
4. Lhab Tshering, Sr. Forestry Officer, FRMD

**Contributors:**

1. Norbu Wangdi, Chief Forestry Officer, FRMD
2. Dorji Wangdi, Dy. Chief Forestry Officer, FRMD
3. Kinley Dem, Dy. Chief Forestry Officer, FRMD
4. Saran Pradhan, Dy. Chief Forestry Officer, FRMD
5. Jamyang Choden, Forestry Officer, FRMD
6. Ugyen Tshering, Sr. Forest Ranger II, FRMD
7. Tsheddar, Senior Forest Ranger, FRMD
8. Norbu Wangchuk, Senior Forester, FRMD
9. Choney Wangmo, Forest Ranger II, FRMD
9. Namgay Bidha, Forest Ranger II, FRMD



### 3. Local Forest Management Area

### 3.1 Management Context

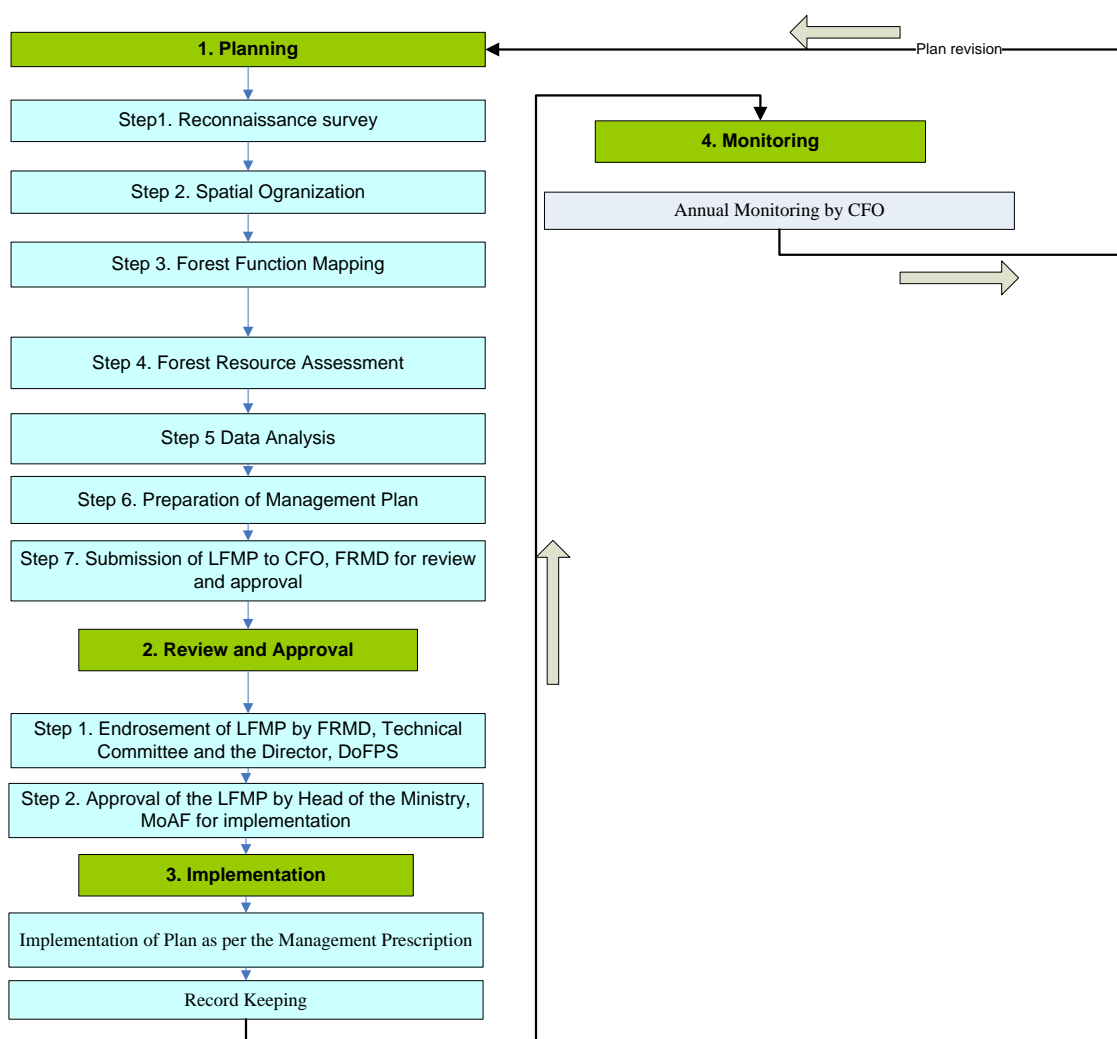
The Local Forest Management Plan (LFMP) is designed to bring all State Reserves Forest land (SRFL) under management regimes for sustained supply of forest products and ecosystem services. This focuses on sustainable management of all forest resources which are not covered by other management regimes. The effective implementation of this guideline shall ensure sustainable management of forest resources and achieving the goal of bringing all of country's forest resources under sustainable management.

### 3.2 Roles and Responsibilities

The Divisional Forest Offices (DFO) is entrusted with the responsibility of preparing the LFMP of a Gewog. Forest Resources Management Division (FRMD) shall provide technical support in the preparation and implementation of the management plan.

### 3.3 Planning

Figure 3.1 shows the steps in preparation and implementation of a LFMP, which is further discussed in Table 3.1.



*Figure 3.1 Management Planning Process*

Table 3.1: Planning Steps

1. Reconnaissance Survey					
Steps	Activity	Objective	Output	Lead agency	Collaborators
1	Identification of LFMA Boundary	To verify the LFMA Boundary	The administrative boundary of the Gewog verified.	CFO, Divisional Forest Office	Local Government/Public
2. Spatial Organization					
Steps	Activity	Objective	Output	Lead agency	Collaborators
1	Exclusion of Areas Managed under other Management Regimes	To exclude the Gewog area which are already managed within existing management regimes	Areas under existing management regime excluded	CFO, Divisional Forest Office	Local Government/Public
2	Demarcation of future Management area	To exclude areas from which extraction of rural timbers is practically not feasible during this plan period <i>due to reasons of inaccessibility, remoteness from the settlements or other factors</i>	Future Management area determined and mapped	CFO, Divisional Forest Office	Local Government/Public
3	Demarcation of current Management area	To determine the current management area.	Current Management Area demarcated and mapped	CFO, Divisional Forest Office	Local Government/Public
4	Determination of Local Forest Management Area	To determine Local Forest Management Area	Local Forest Management Area determined and mapped	CFO, Divisional Forest Office	Local Government/Public
5	Compartmentalization	To divide the Local Forest Management Area into Blocks and Compartments.	Local forest management area divided into Blocks and compartments	CFO, Divisional Forest Office	FRMD



	a. Establishment of Blocks	To divide the Local Forest Management Area into Blocks	Local Forest Management Area divided into Blocks of approximate size of 1500-2500 ha.	CFO, Divisional Forest Office	FRMD	Block boundaries must follow ridges separating individual watershed-catchments or other prominent topographical features such as large streams or rivers.
2	b. Establishment of Compartments	To sub-divide the Blocks into Compartments	Blocks divided into Compartment of approximate size of 100-500 ha.	CFO, Divisional Forest Office	FRMD	Generally, compartment boundaries could follow major forest type lines. However, identifiable topographic or plan metric features such as roads, streams, rivers, main ridges, etc. can also form the compartment boundaries.
3. Forest Function Mapping						
Steps	Activity	Objective	Output	Lead agency	Collaborators	Comments
1	Mapping Protection Management Function in LFMA	To map Protection Management function in LFMA	Protection Management Circle mapped	CFO, Divisional Forest Office	FRMD	Refer function mapping protocol and function mapping chapter in the code
2	Mapping Non-Production function in LFMA	To map Non-Production function in LFMA	Non-Production Management Circle mapped	CFO, Divisional Forest Office	FRMD	
3	Mapping Production function in LFMA	To map Production function in LFMA	Production Management Circle mapped	CFO, Divisional Forest Office	FRMD	
4. Forest Resource Assessment						
Steps	Activity	Objective	Output	Lead agency	Collaborators	Comments
1	Forest Stratification	To stratify the LFMA by Landuse and forest types	LFMA stratified by Land use and Forest types.	CFO, Divisional Forest Office	FRMD	Forest stratification to be carried out using LULC data/maps
2	Determining no of sample plots (Inventory Plots)	To calculate the no of sampling plots (Inventory Plots)	Total number of sample plots determined and calculated.	CFO, Divisional Forest Office	FRMD	No of sample plots to be calculated based on forest strata and CV for each forest type

3	Determination of Inventory Grid	To determine the inventory grid (Plot to Plot spacing)	Inventory grid determined and calculated	CFO, Divisional Forest Office	FRMD	
4	Preparing Inventory Design	To prepare Inventory Design.	Inventory designed	CFO, Divisional Forest Office	FRMD	To be done in GIS, refer Function mapping protocol.
5	Formation of Inventory Crew	To form inventory crews	Inventory Crew formed	CFO, Divisional Forest Office	FRMD	Inventory crew to be formed by pooling staffs of the division
6	Forest Inventory & Data Collection	To collect forest inventory data	Forest Inventory conducted and data collected in tally sheet	CFO, Divisional Forest Office	FRMD	Data collection to be done using appropriate tally sheets.
<b>5. Data Analysis</b>						
<b>Steps</b>	<b>Activity</b>	<b>Objective</b>	<b>Output</b>	<b>Lead agency</b>	<b>Collaborators</b>	<b>Comments</b>
1	Transfer of data from tally sheet to Compartment sheet and analysis	To analyse the inventory data at individual compartment level	Compartment results generated	CFO, Divisional Forest Office	FRMD	The compartment inventory data collected in the tally sheet must be transferred to Compartment sheet/register
2	Transfer of data from Compartment sheet to summary sheet and analysis	To compile and analyse the Inventory data of all the compartments within the LFMA	AAC of LFMA other stand information generated	CFO, Divisional Forest Office	FRMD	The compartment results generated must be transferred to summary sheet.
<b>6. Preparation of Management Plan</b>						
<b>Steps</b>	<b>Activity</b>	<b>Objective</b>	<b>Output</b>	<b>Lead agency</b>	<b>Collaborators</b>	<b>Comments</b>
1	Preparation of Management Plan as per the plan layout	To prepare management plan	Management Plan prepared	CFO, Divisional Forest Office	FRMD	The management plan must be prepared as per the plan layout.
2	Review and recommendation by CFO	To technically review and verify the Management plan prepared	Management Plan technically reviewed and recommended for approval to CFO FRMD	CFO, Divisional Forest Office	FRMD	The Plan prepared must be technically reviewed by CFO before submission to FRMD
<b>7. Approval</b>						
<b>Steps</b>	<b>Activity</b>	<b>Objective</b>	<b>Output</b>	<b>Lead agency</b>	<b>Collaborators</b>	<b>Comments</b>

1	Endorsement of LFMP by FRMD, Technical Committee and the Director, DoFPS	To ensure that the plan is consistent with the technical standards and other legal provisions as enshrined in Acts, Policies and Rules.	LFMP technically reviewed and endorsed by FRMD, Technical committee and the Director, DoFPS	FRMD	CFO, Forest Division	
2	Approval of LFMP by the Head of the Ministry	Approve the Forest Management Plan for Implementation	The LFMP approved for implementation	FRMD	CFO, Forest Division	
<b>8. Implementation</b>						
<b>Steps</b>	<b>Activity</b>	<b>Objective</b>	<b>Output</b>	<b>Lead agency</b>	<b>Collaborators</b>	<b>Comments</b>
1	Implementation of Plan as per the Management Prescription.	Management Plan implemented as per the Management Objectives	Management Plan implemented as per the Management Objectives	CFO, Divisional Forest Office	Concerned Range Officer	
2	Record Keeping	To maintain adequate records of resource allocation from LFMA	1. Tree Marking book maintained 2. Gewog Register Maintained	Concerned Range Officer	CFO, Divisional Forest Office	The tree marking book and Gewog register must be maintained as per the excel sheet prescribed
<b>9. Monitoring</b>						
<b>Steps</b>	<b>Activity</b>	<b>Objective</b>	<b>Output</b>	<b>Lead agency</b>	<b>Collaborators</b>	<b>Comments</b>
1	Annual Monitoring of LFMP by CFO	To annually monitor the implementation of LFMP activities	LFMP annually monitored and monitoring report prepared as per the format prescribed for submission to FRMD	CFO, Divisional Forest Office	Concerned Range Officer	The annual monitoring report must be submitted to FRMD as per the format and timeline prescribed

### **3.3.1 Reconnaissance survey**

Reconnaissance survey is the preliminary survey that is carried out within the area of interest to examine the area with respect to Forest Types, Wildlife, NWFPs, general topography, road connectivity and accessibility, cultural significance, past and current management history, socio-economic status of the people living within the area, climate, weather, etc.

#### **3.3.1.1 Objective**

To provide preliminary information on social, environmental, topographic and economic information that is required in order to prepare a sustainable Forest Management Plan for Local Forest Management area within a Gewog. The information collected must guide the planner at the later phase of planning in determining the Management area, Forest Types, accessibility for resource extraction, delineating barren and degraded forests, important water catchment areas, areas of cultural significance and important wildlife habitats.

#### **3.3.1.2 Preparation of Survey**

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

1. Topographic map with 40 m contour lines at a scale of 1:50,000 (including Gewog boundary);
2. LULC (latest available Land Use Land Cover map) at a scale of 1:50,000;
3. Others (Satellite image, Aerial photos etc. (if available)).

#### **3.3.1.3 General Description and Current Situation**

Basic information with respect to the location, forest types, forest composition, accessibility, past and current Management history and socio-economic status of the people living within the Gewog. In order to collect more accurate information, public consultation with the people living within the Management area is highly recommended

#### **3.3.1.4 Identification of LFMA boundary**

The LFMA boundaries should be based on Gewog boundary. One Gewog is one LFMA. The planner must validate the boundaries by carrying out field visits and consulting the Local leaders preferably Gups in order to confirm the Gewog boundary. Field validation of the boundaries can be done by using topographic maps with a scale of 1:50000.

### **3.3.2 Spatial Organization of the area**

The objective of the spatial organization of the LFMA is to sub-divide the LFMA in order to aid in the preparation and implementation of annual activities.

#### **3.3.2.1 Exclusion of Areas Managed under other Management Regimes**

Local Forest Management Plans are prepared for areas which fall outside other existing Management regimes to bring all forest under management. Thus, all the areas falling within any of the managed regimes or those planned to be brought under any management shall be excluded from the Local Forest Management area.

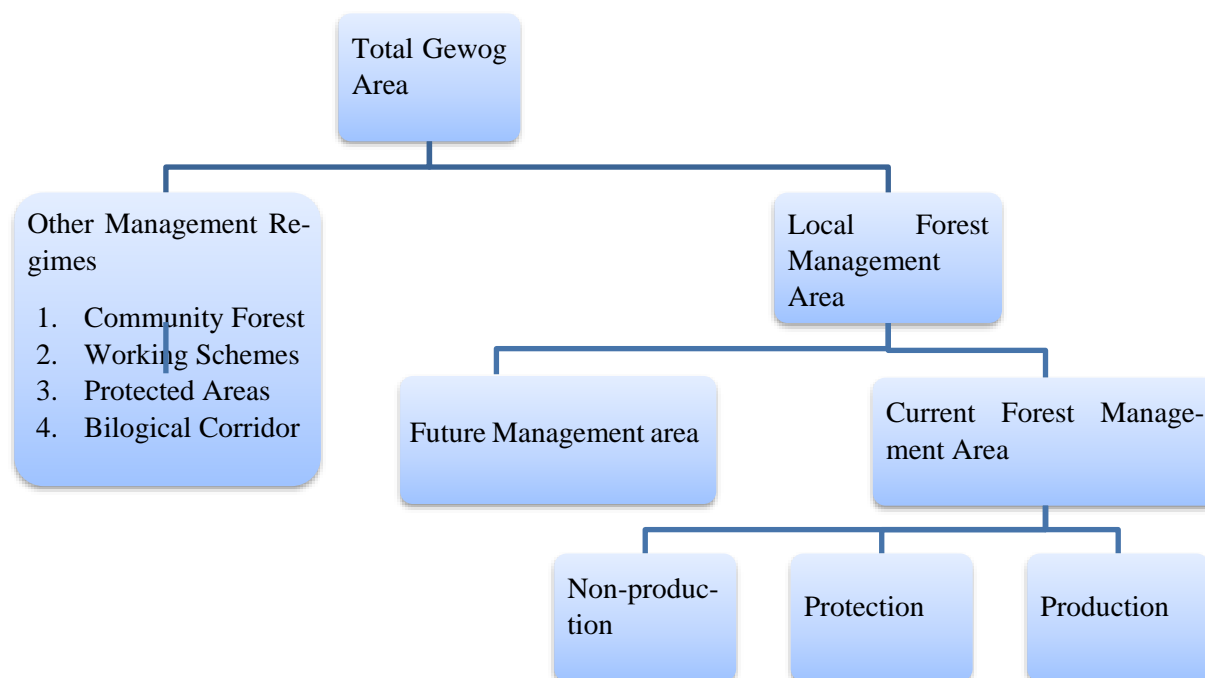


Figure 3.2 Local Forest Management Area

### 3.3.2.2 Demarcation of Future Management area

Any other areas from which extraction of rural timbers is practically not feasible during this plan period *due to reasons of inaccessibility, remoteness from the settlements or other factors must be demarcated and mapped as **Future Management area***. Although, these areas cannot be operated during the current plan period, it may be brought under or production management in the future. The areas thus demarcated must be clearly mapped in the Management Map as “**Future Management Area**”. A detailed explanation with regards to the “*Future Management Areas*” must be included in the plan with probable future management options.

However, if all the areas within the Gewog outside managed regimes are accessible for rural timber extraction during the current plan period, there may not be the need for demarcation of *Future Management Area*. In such instances the *Future Management Area* shall be zero.

Note: The Future Management Area shall be identified as a separate Block with no compartments and shall be mapped under Non-Production circle.

### 3.3.2.3 Demarcation of Current Management Area.

The Management Area for the current plan period, hereafter referred to as the **Current Forest Management Area** shall be the area left after exclusion of areas as described under 3.3.2.1 & 3.3.2.2. However, for protected areas (National Park, Wildlife Sanctuary and Biological Corridor) the identification of resource allocation area and area exclusion should be based on park zonation.

### 3.3.2.4 Local Forest Management Area

The “*Local Forest Management Area*” for the plan period shall be the sum total of “*Future Management Area*” and “*Current Forest Management Area*” as determined under section 3.3.2.2 and 3.3.2.3 respectively.

### **3.3.2.5 Compartmentalization**

Compartmentalization is the process of sub-dividing Forest Management area into Blocks and Compartments. Compartmentalization is done in order to identify the production forest area for rural use and to subdivide this area into more uniform units for the purpose of management and monitoring.

*Note: Compartmentalization is done within the Local Forest Management Areas as determined under section 3.3.2.4.*

#### **Objectives**

The overall objectives of compartmentalization are to:

1. divide the entire forest management area into more uniform units for management.
2. focus on specific management interventions and prescriptions in a smaller area.

#### **Blocks and Compartments**

##### **Blocks**

The blocks are the basic orientation and administrative units within the LFMA. They are essentially major water-catchments separating easily recognizable major parts of the Forest Management Areas. Therefore, the block boundaries shall in most cases follow ridges separating individual water-catchments. Other prominent topographical features such as large streams or rivers can also be used to identify block boundaries. For all practical purposes, the number of Blocks must be kept as minimum as possible to a maximum of 5-10 Blocks with an average area of a block of about 1500 to 2500 hectares (if determined by topography it can be much smaller, or larger). It should be kept in mind that eventually, with increased management intensity, the block could become an administrative unit within the LFMA, such as a beat.

The name of a block must be an easily recognizable, commonly used name for that particular area. In name selection, care has to be taken to avoid using unfamiliar or confusing names.

##### **Compartments**

The compartments are basically orientation units created to facilitate easy orientation within each unit and to provide for easy administration, recording and monitoring of operations within the LFMA. Compartments are created in order to identify more or less uniform forest areas, which requires the same silvicultural treatment and management prescription. Furthermore, it serves for the spatial organization of forest use and for the purpose of monitoring.

*The Compartment is the unit for forest resource assessment and planning in Current Forest Management Areas.* The boundaries of the compartments follow easily identifiable topographic or planimetric features such as roads, streams, rivers, main ridges, etc. In some cases, boundaries could follow major forest type lines. The size of the compartment would depend on the intensity of management, intensity of road network and a topographic makeup of the area. Typically, it would be anywhere between 100 and 500 hectares.

Dividing the areas into compartments should be based on the forest types and natural features, the size of which shall vary accordingly. Furthermore, it serves for the spatial organization of forest use and for the purpose of monitoring.

##### **Process**

Compartmentalization (preparation of blocks and compartments) should be done within Local Forest Management Area as determined under section 3.3.2.4. The entire process of compartmentalization is carried out using Google Earth in combination with Geographical Information System (GIS). The final outcome of compartmentalization shall be a spatial organization map which reflects blocks and compartments within the forest management area. The steps for compartmentalization is as given below.

#### **Determination of areas of Blocks and Compartments**



The areas of each block and compartment can be calculated in GIS or Google Earth. Along with the spatial organization map, the area statement of each block and compartment should be calculated and recorded as well.

### **Naming of Block and Compartment**

Blocks are named with the name of the village or with any local name of a place falling within the Block (eg; Kawang Block, Chang Block, etc.,). If the area where the block is located is known by some local name it is very important that this name is used/ entered on the maps. By doing this the block shall become associated with the name with which local people are familiar with. This shall again facilitate easy orientation.

Compartments are named by Roman Numerals (I, II, III). The compartment naming is usually carried out clock-wise starting from north.

### **GIS Steps**

#### ***GIS Steps***

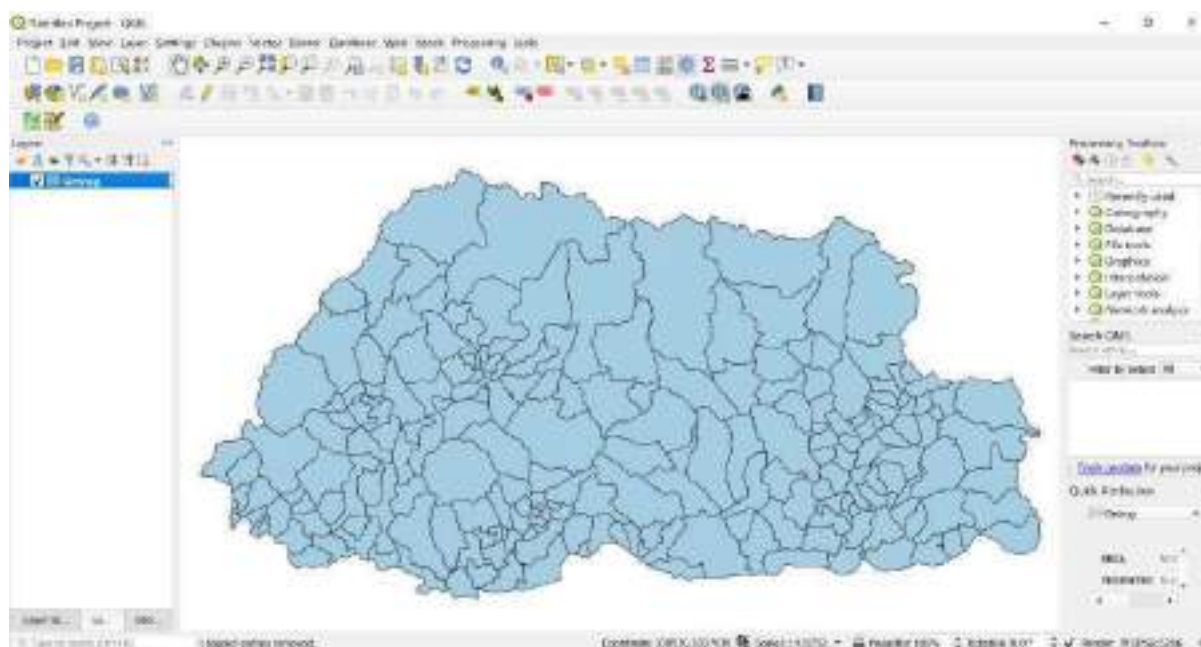
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

#### **Defining the Boundary of LFMA**

Gewog boundary is considered as LFMA boundary

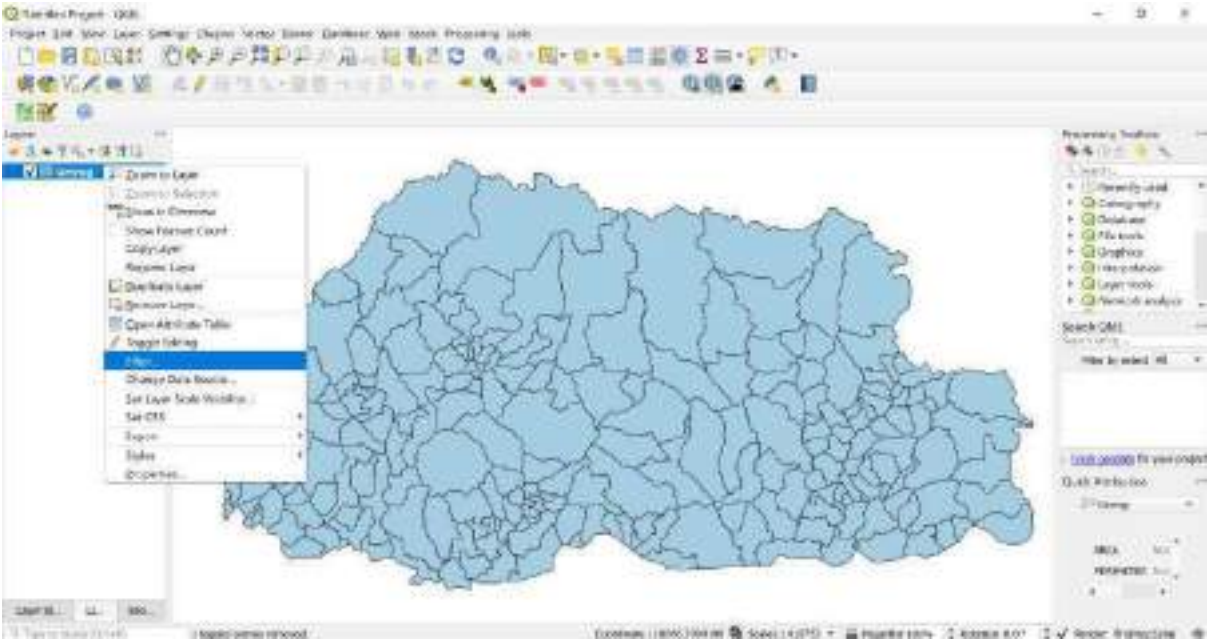
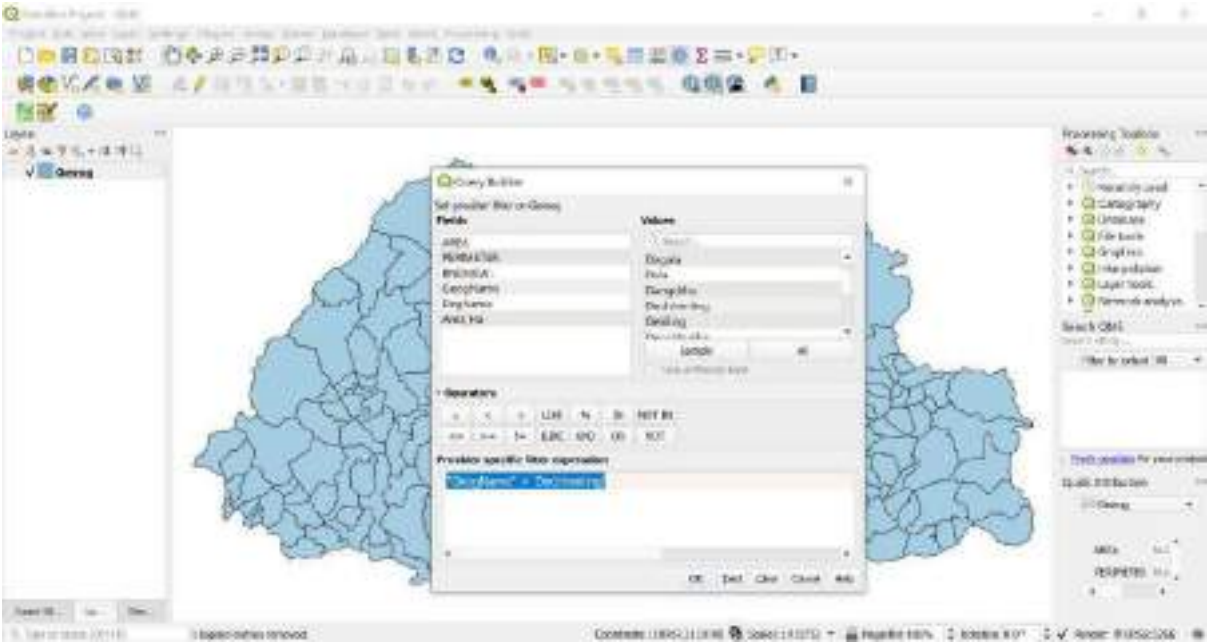
Open QGIS

- *Add Gewog of Bhutan file*

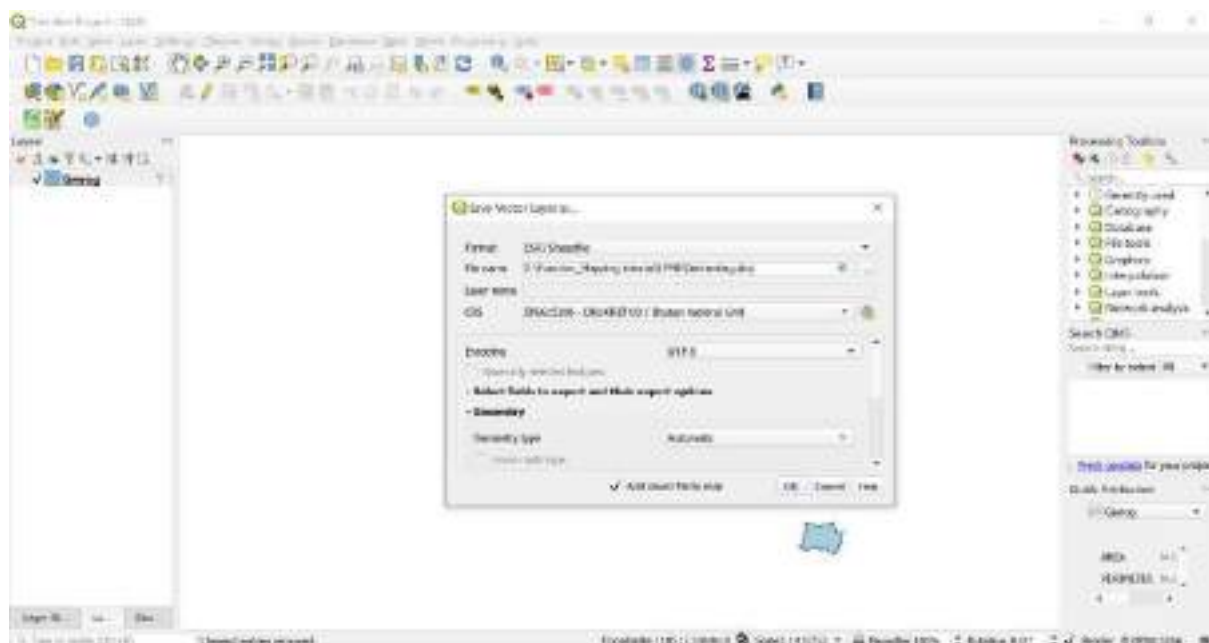


Select the gewog of interest for LFMA boundary

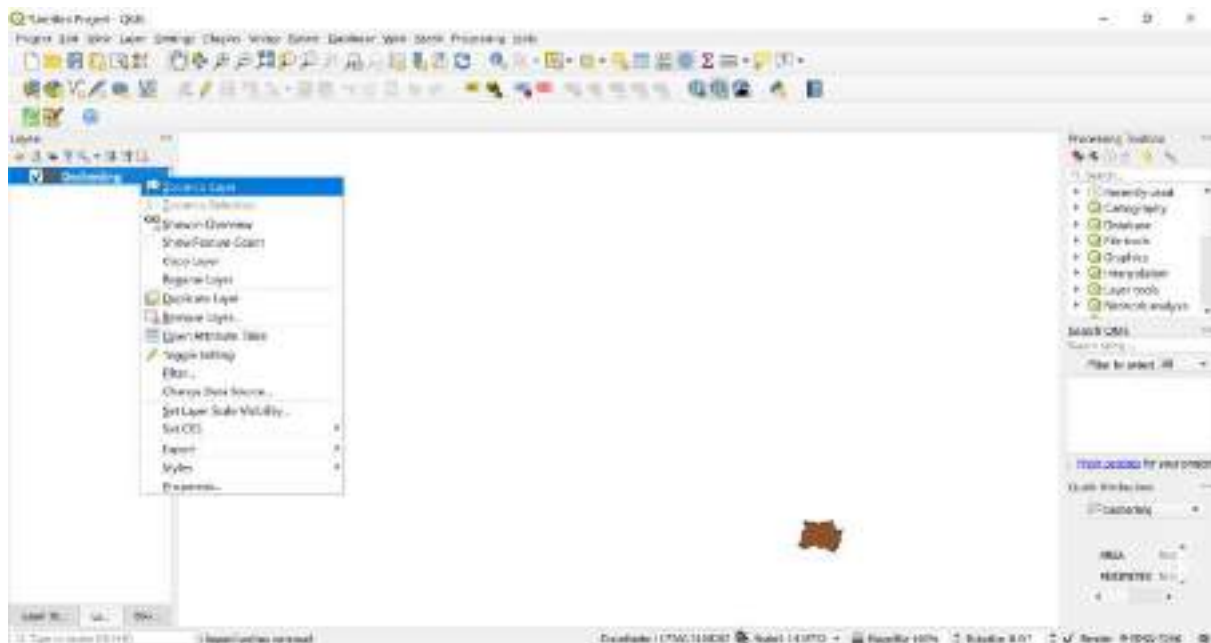
- *Right click gewog file > Click Filter*
- *Enter the following expression:*  
*"GeogName" = 'Dechhenling'*
- *Click Ok*



- *Right click on filtered layer > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *Save the file with appropriate name in working directory*
- *Click OK*



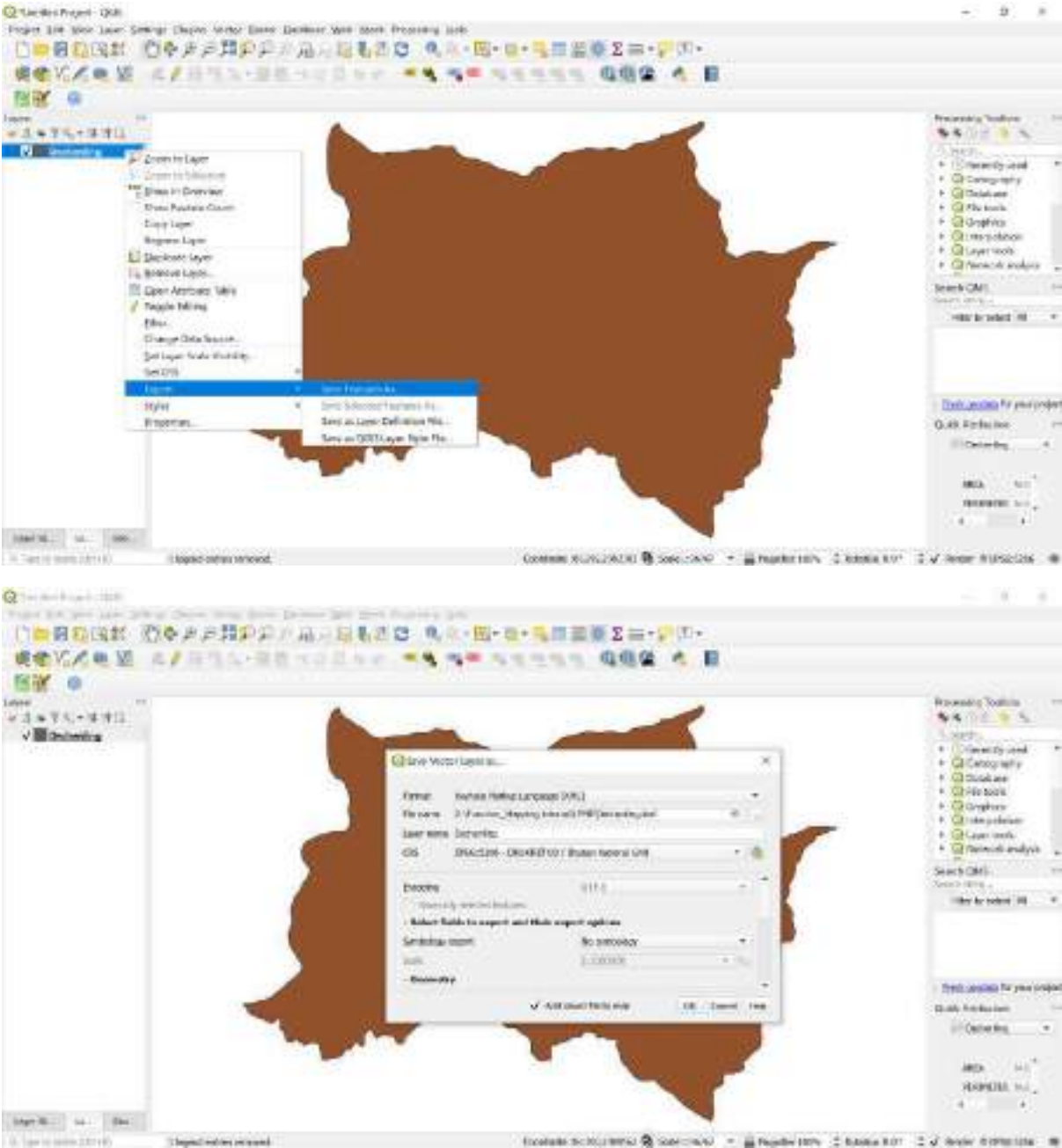
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This is gewog is going to be the boundary of LFMA. Now within this boundary, Blocks and Compartments needs to be delineated. We shall Google Earth Pro to delineate the boundary of Blocks and Compartments.

### Convert the shapefile into Keyhole Markup Language (KML) file

- *Right click on layer > Export > Save Features As*
- *Format: Select Keyhole Markup Language (KML)*
- *Save the file with appropriate name in working directory*
- *Click OK*



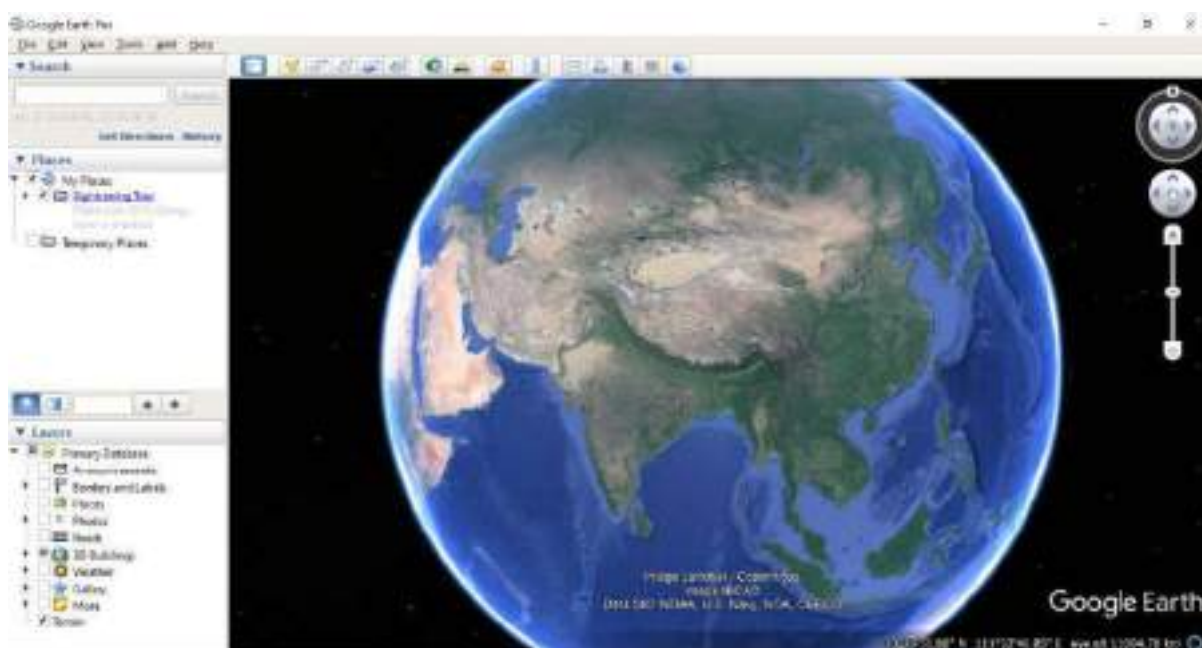


Open Google Earth Pro



Add the LFMA boundary (KML) file

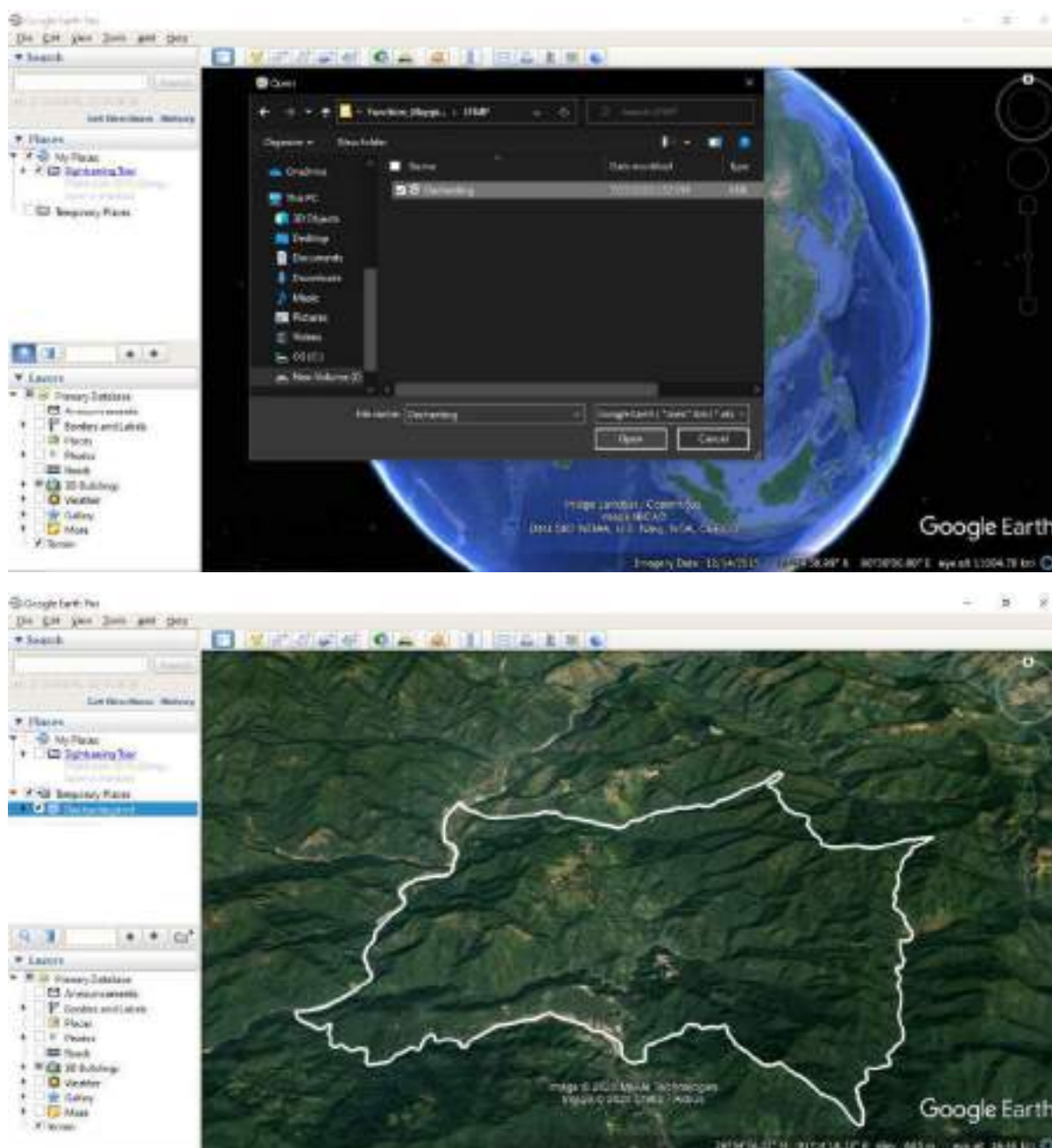
Click File > Open



Navigate to the folder where kml file was saved

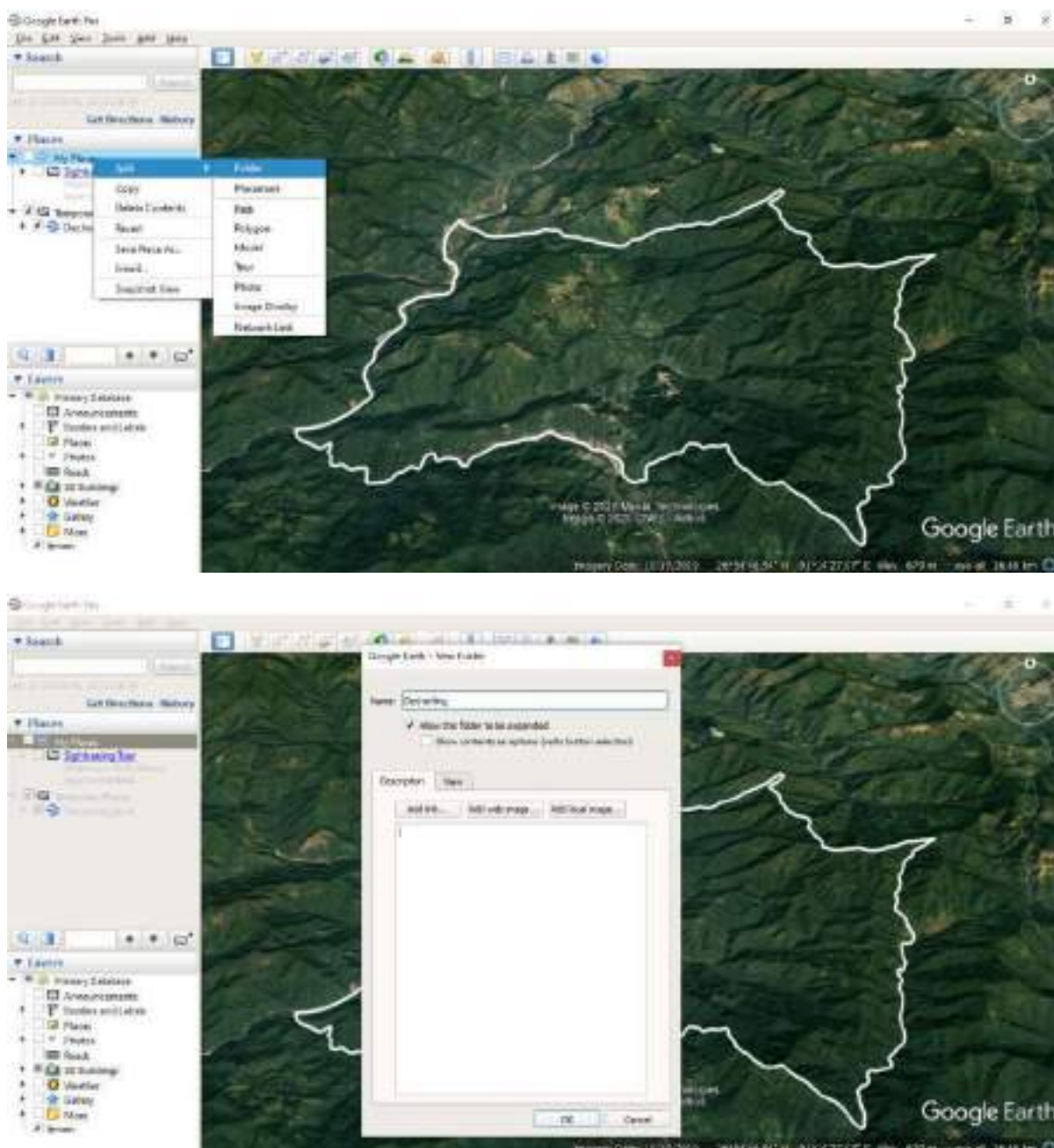
Select the LFMA boundary kml file > Click Open





Now based on this LFMA, delineate Blocks and Compartment Boundary as line features

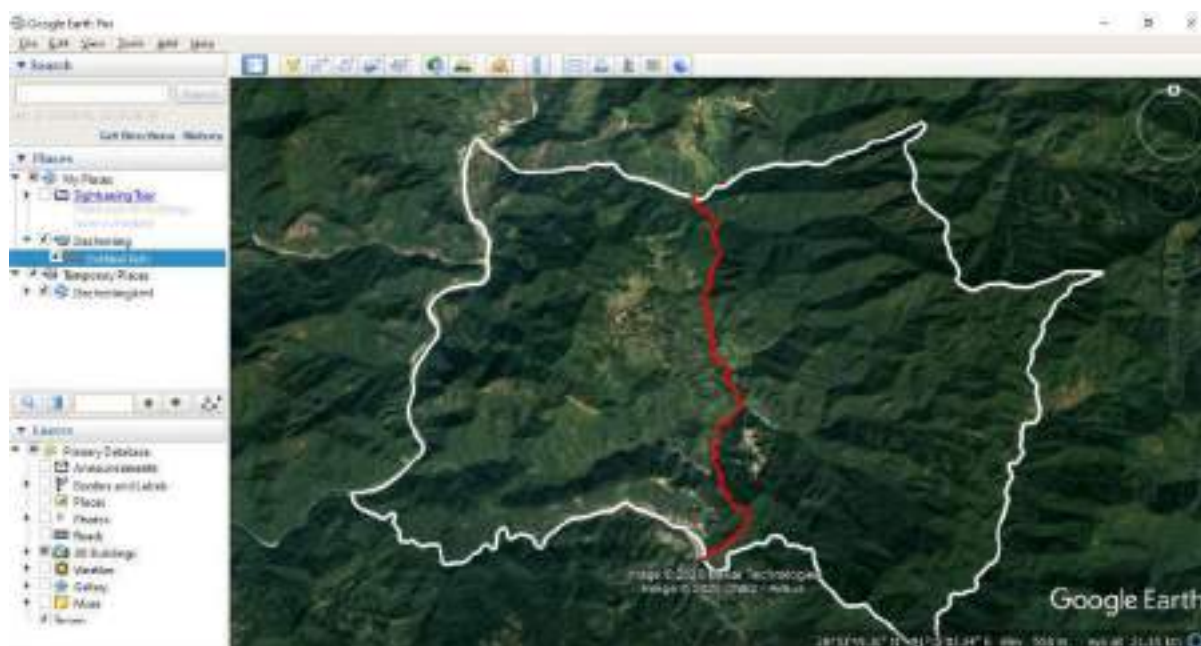
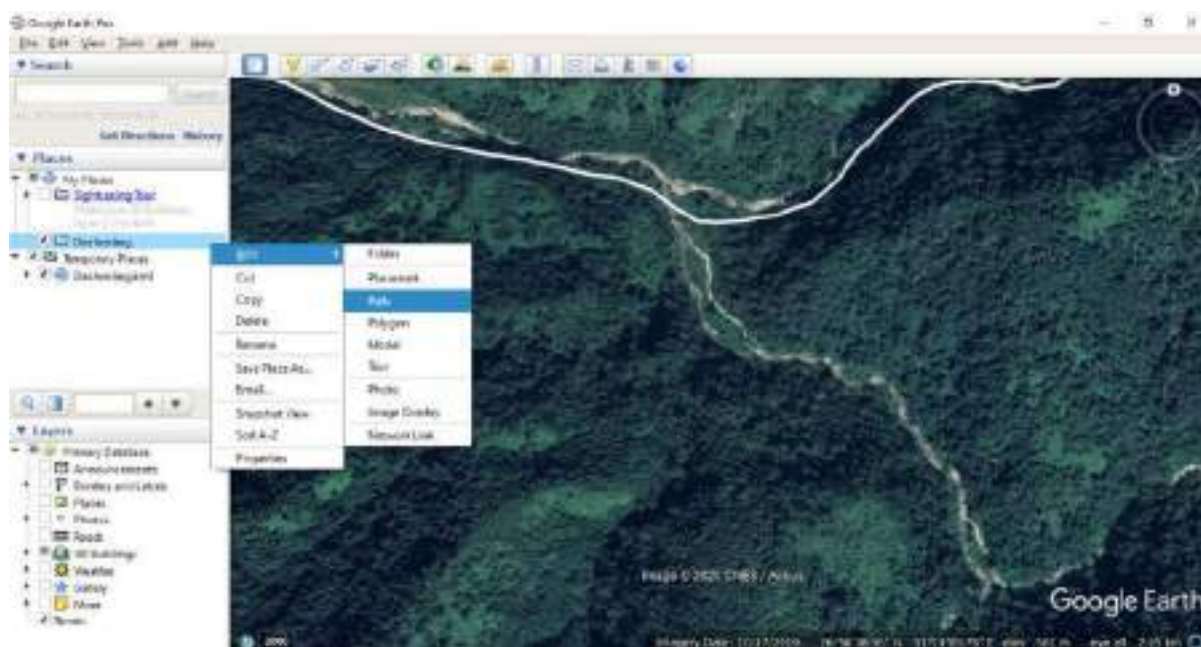
- *Right click on My Place > Add > Folder*
- *Give appropriate name to the folder and save it*



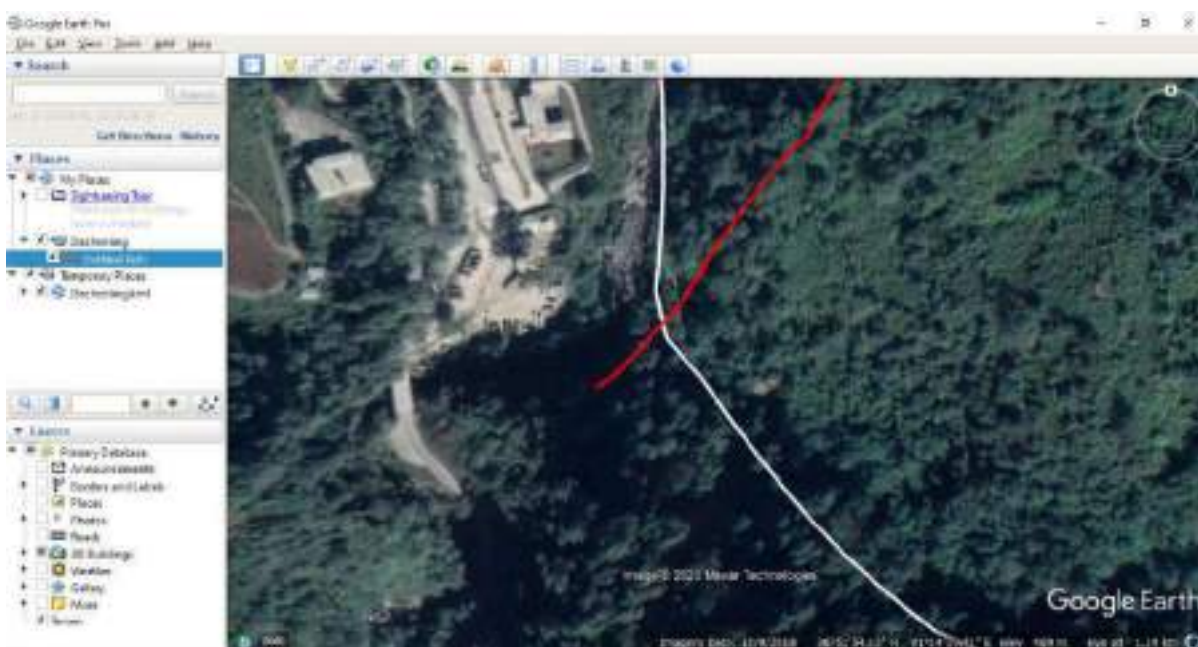
Draw boundary for Blocks using line features

- Right click on newly created folder (Dechenling) > Add > Path
- Draw the line taking natural features which can be served as boundary of Blocks (Note: it need not be one single line to cover the boundary of Blocks. Multiple segments of lines can be used to make the boundary by joining them, however, **make sure end on one segment of line is over lapped with starting point of another segment of line** as shown in the figure below)



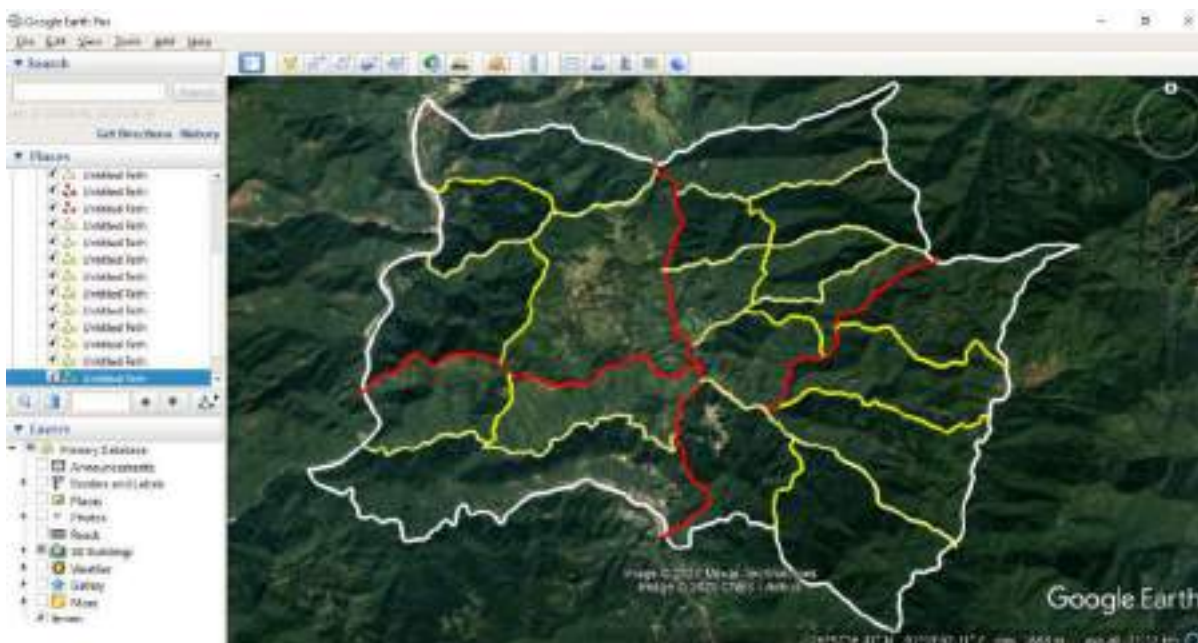


Similarly draw boundary using line features (Path) for all Block boundary



Draw boundary for Compartments using line features.

- Right click on newly created folder (Dechencling) > Add > Path
- Draw the line taking natural features which can be served as boundary of Compartments (Note: it need not be one single line to cover the boundary of Compartments. Multiple segments of lines can be used to make the boundary by joining them, however, **make sure end on one segment of line is over lapped with starting point of another segment of line, overlap with boundary of LFMA, Blocks and Compartments**).



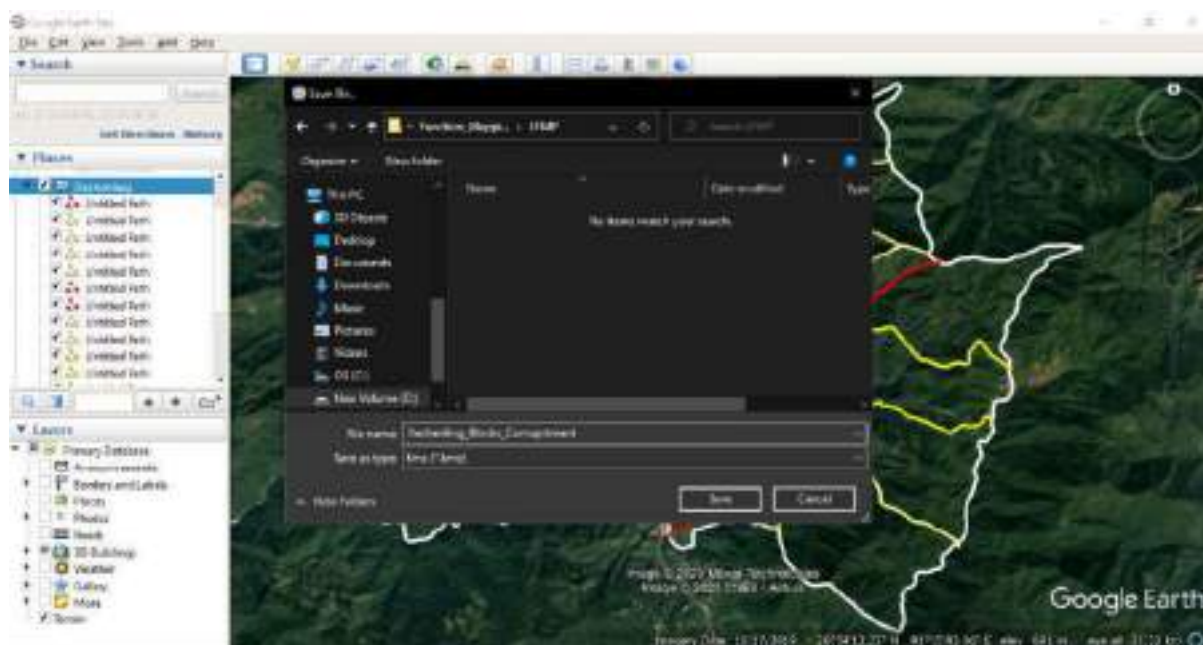
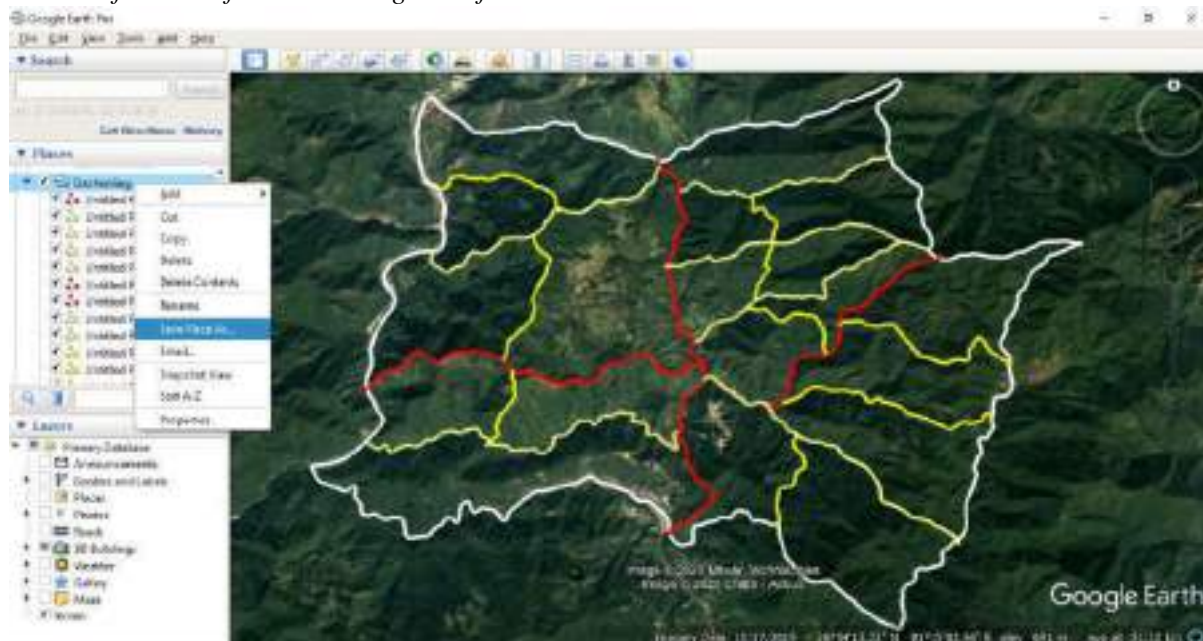
Repeat the process to draw the boundary of Sub-compartment if required.



## Forest and Nature Conservation Code of Best Management Practices of Bhutan

Once the delineation of all boundaries of Blocks, Compartments and Sub-compartments as line features is completed, import the Keyhole Markup Language (KML) file to QGIS.

- Right click on newly created folder (Dechenling) > Save Place As
- Save the file KML file in the designated folder.

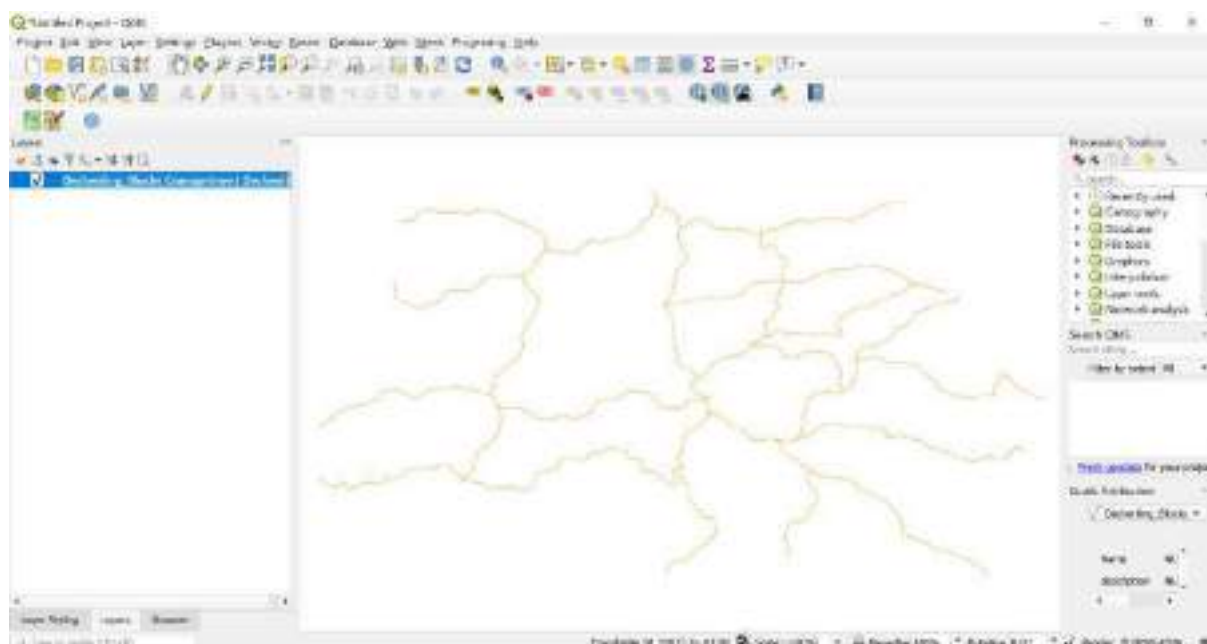


Once all the line features of Blocks, Compartments and Sub-compartments are saved as KML file, next step should be carried out in QGIS

- Open QGIS
- Navigate to Layer < click Add Layer > Click Add Vector Layer...

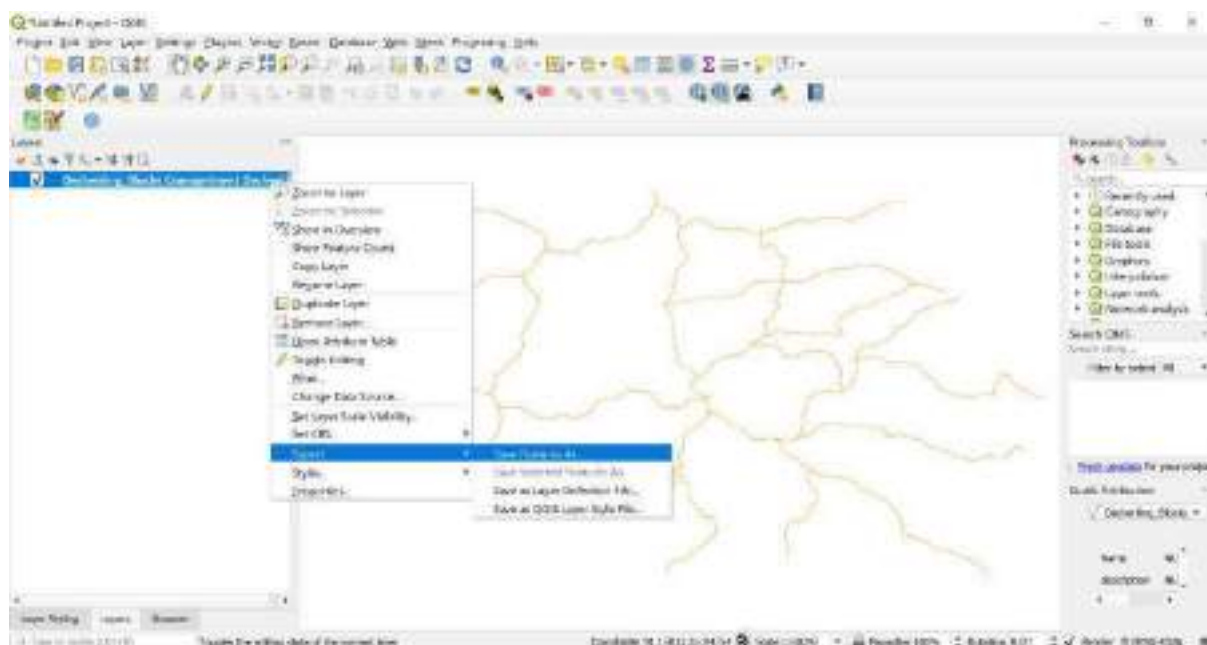


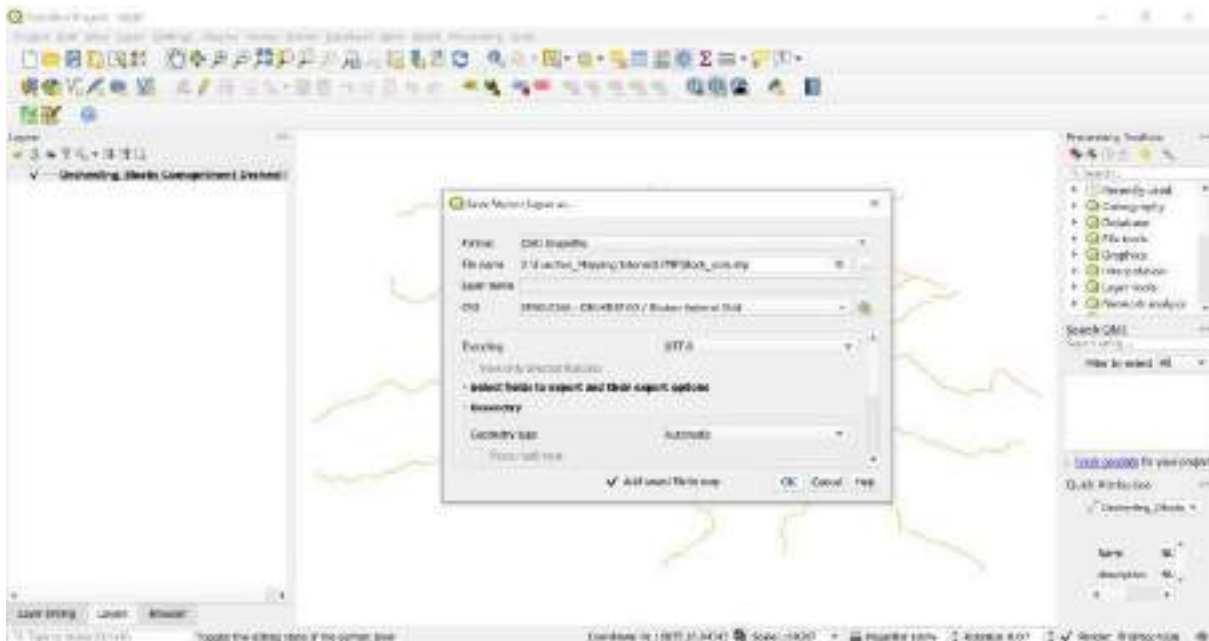




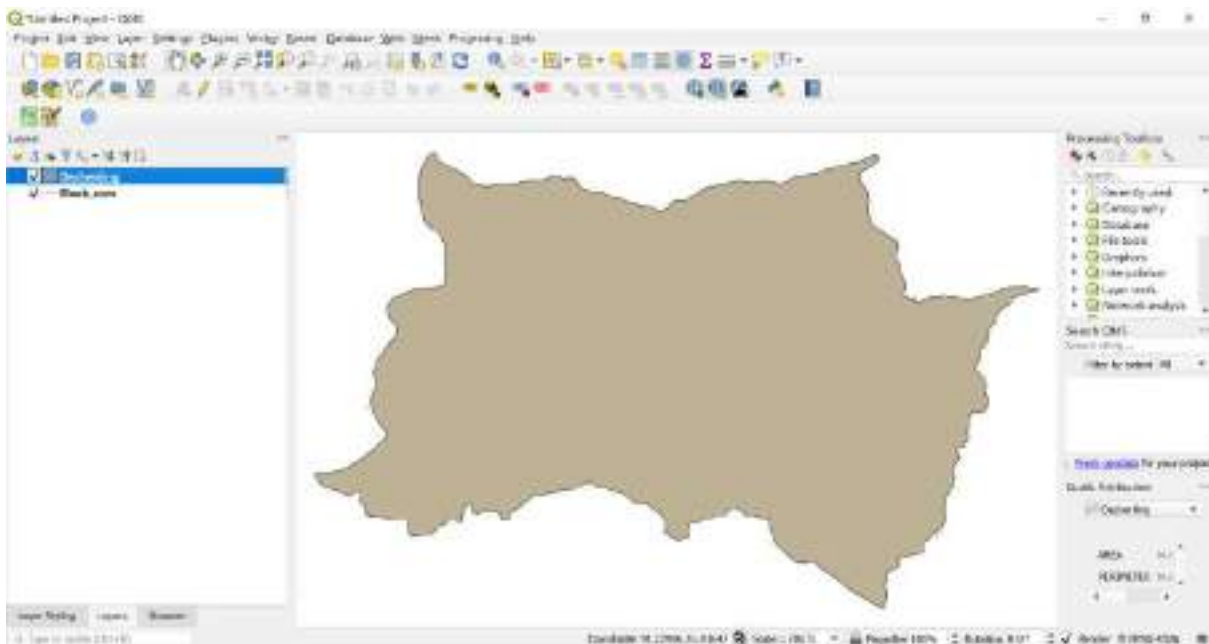
KML file need to be converted into ESRI Shapefile format for further analysis.

- *Right click on file > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *CRS: DRUKREF 03/ Bhutan National Grid*
- *Save the file with appropriate name in working directory*



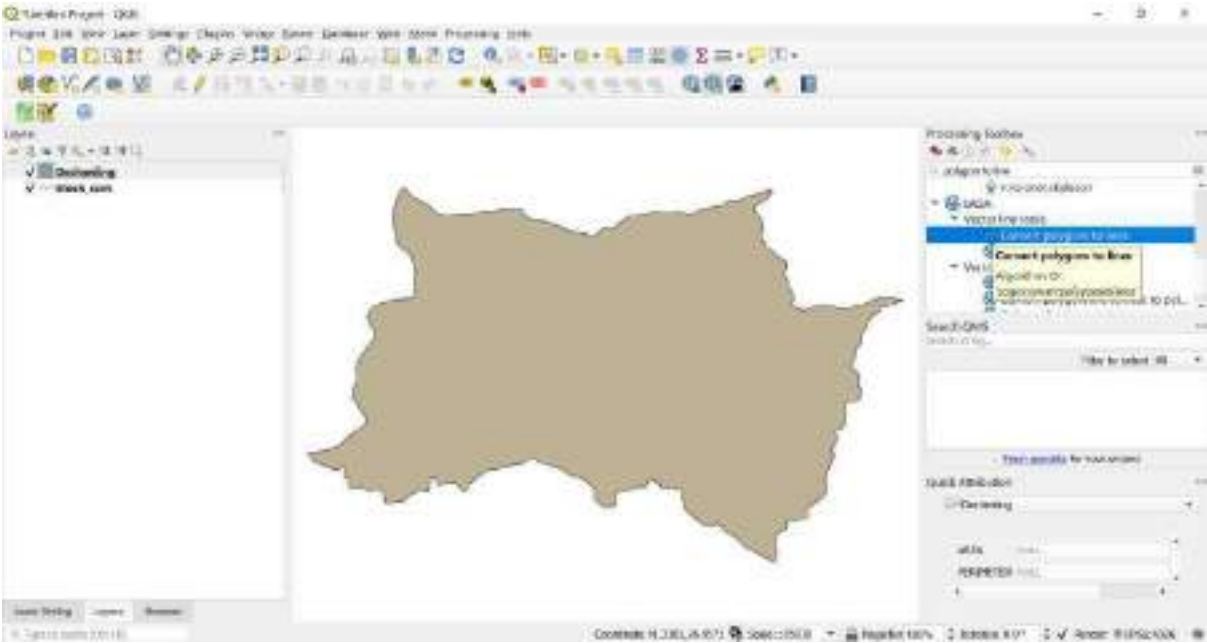
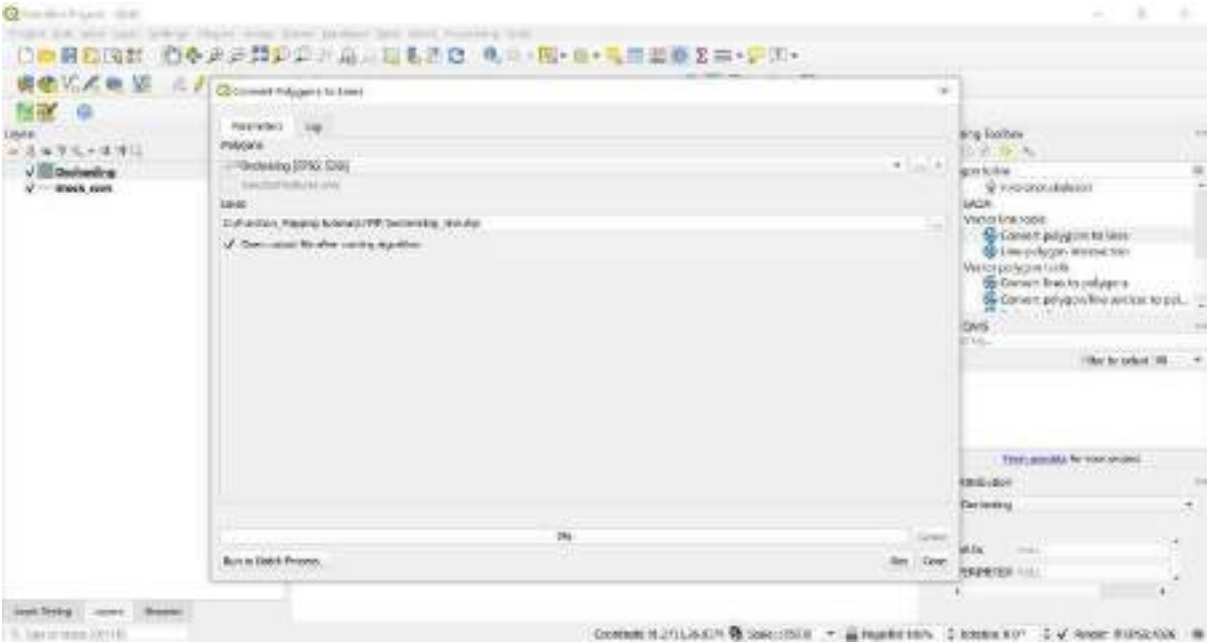


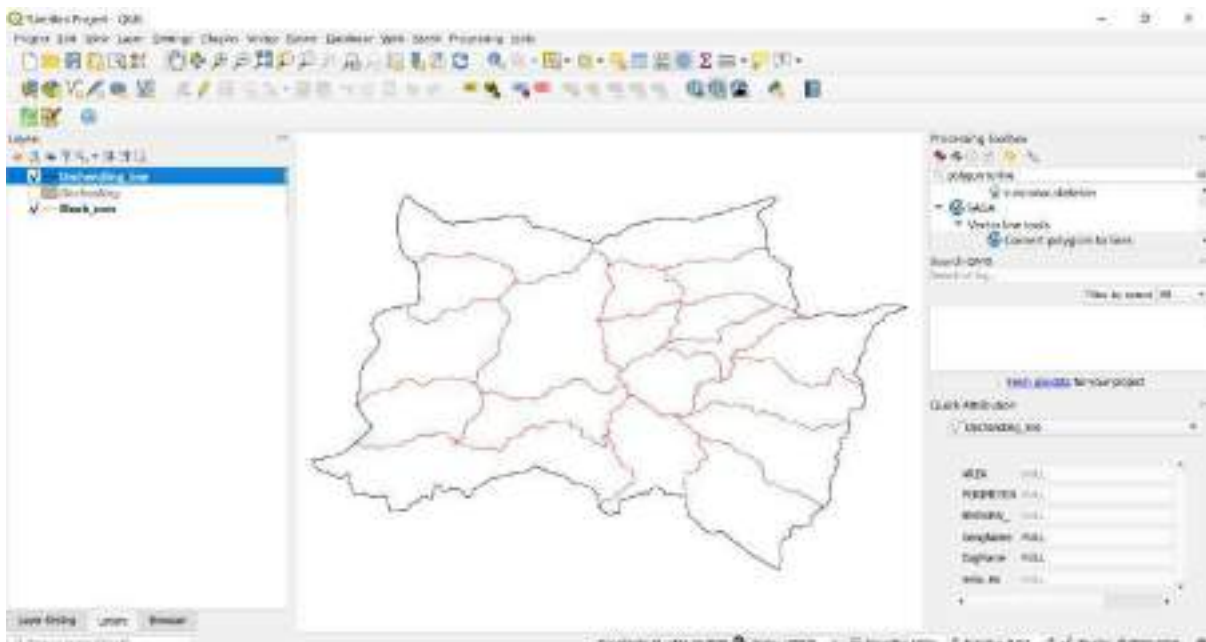
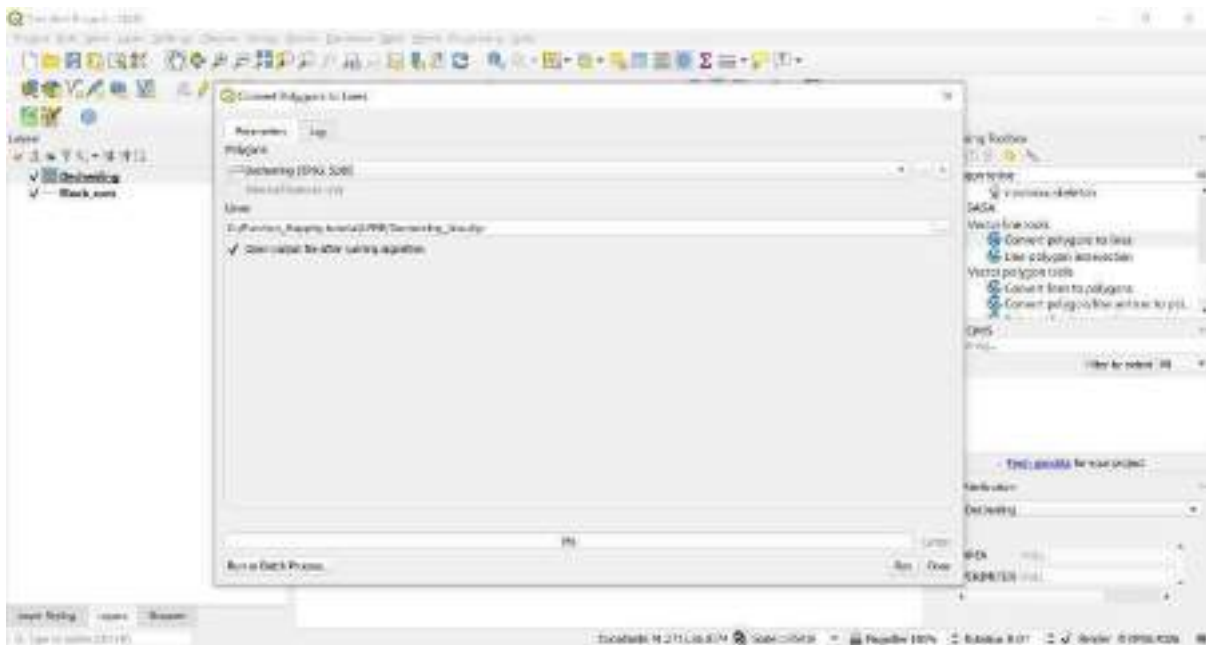
- Add LFMA boundary



Convert the LFMA from polygon feature to line feature

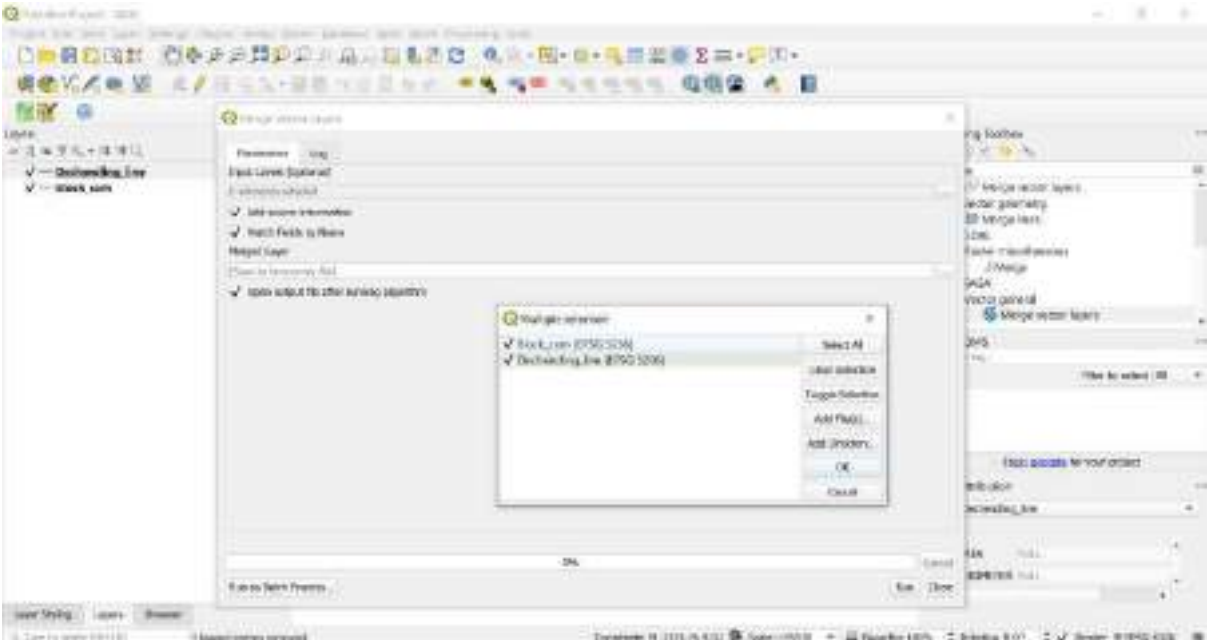
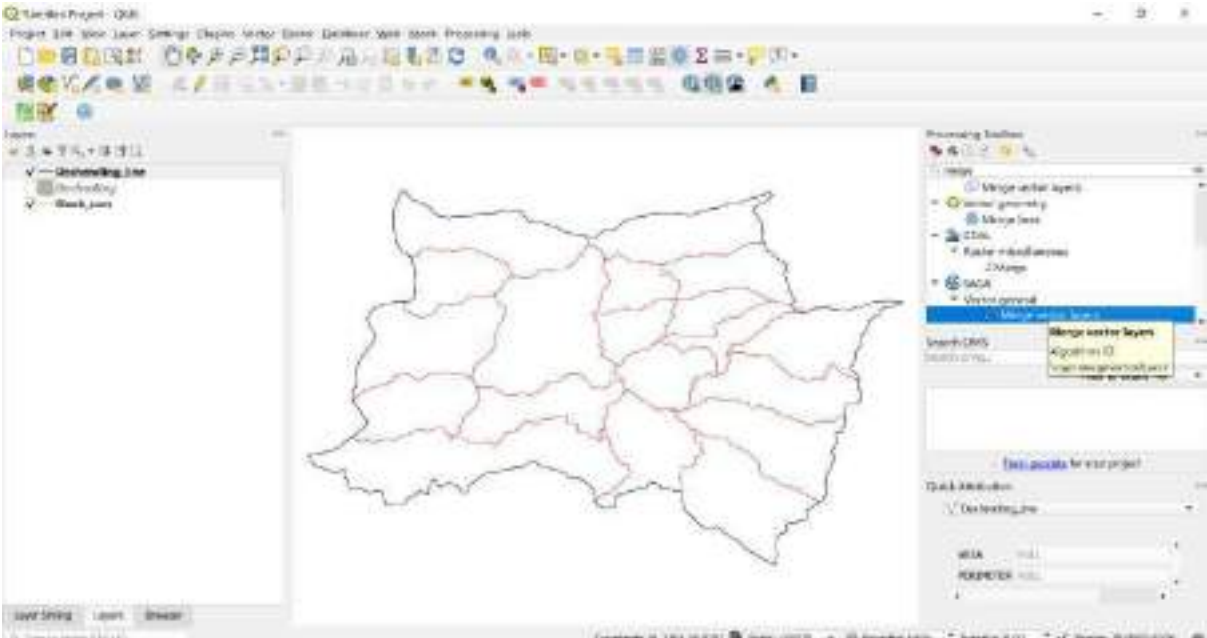
- *type **polygon to line** in processing toolbox Navigate to SAGA > Vector line tools > select Convert polygons to lines*
- *In Input Layers: Select the polygon feature (LFMA boundary) you want to convert to line feature*
- *Save the file with appropriate name in working directory*
- *Click run*

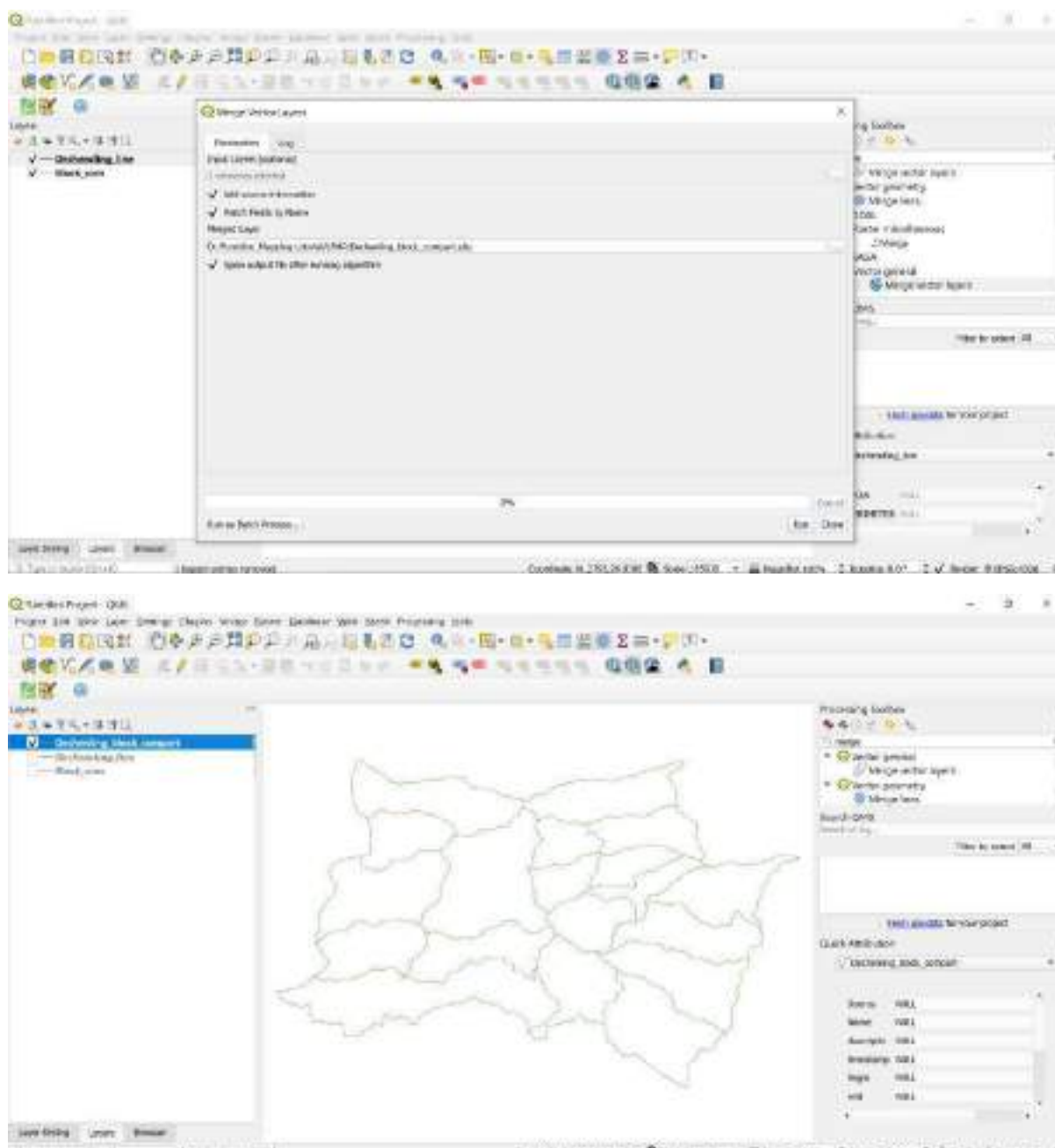




Now there are two line features (LFMA boundary and Blocks and Compartments). We need to merge these two files as one single shapefile.

- *Type Merge in the processing toolbox*
- *Navigate to SAGA and select Merge vector layers*
- *In Input Layers: Check all line features (LFMA boundary and Block and compartments) that needs to be merged*
- *Save the file with appropriate name in working directory*
- *Click run*

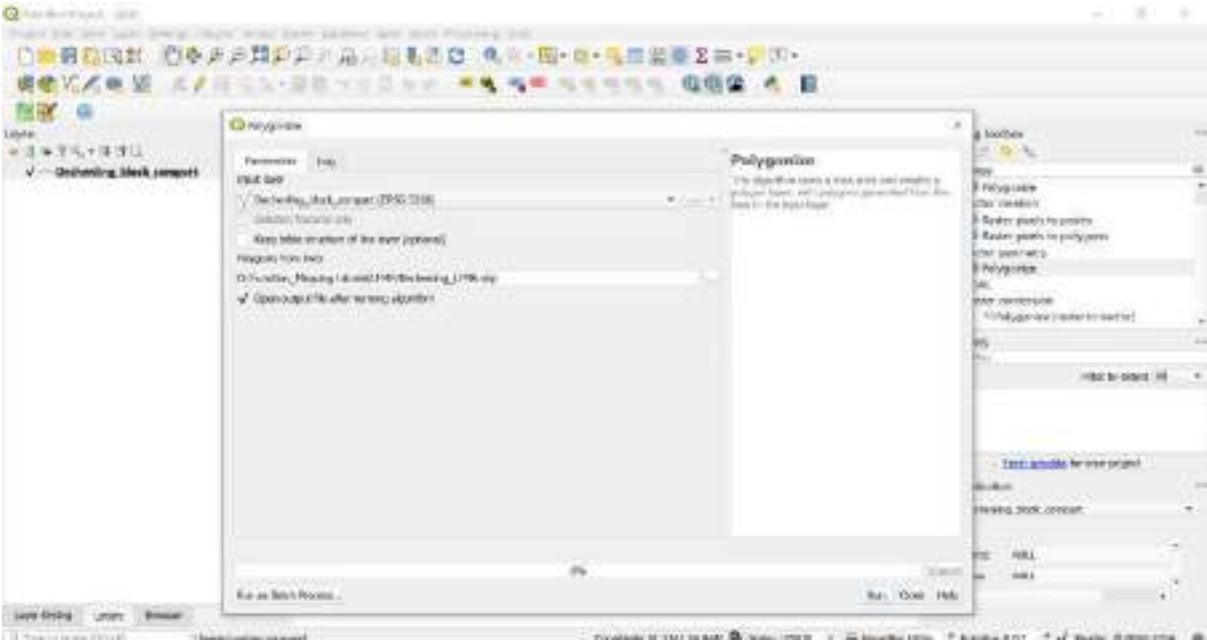
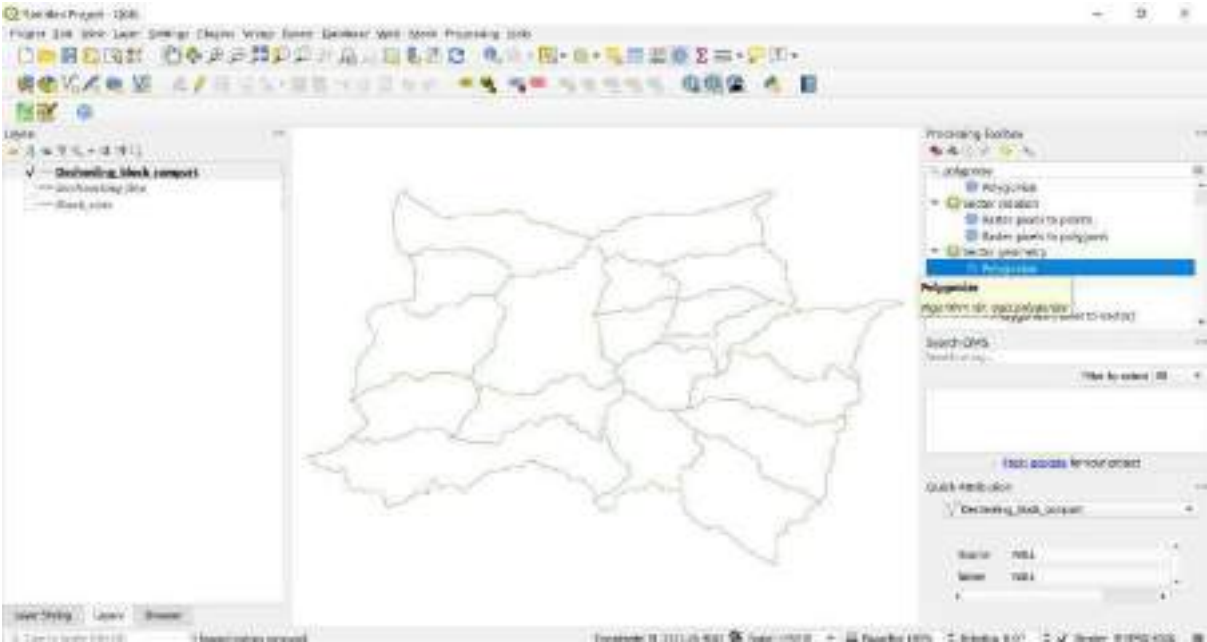


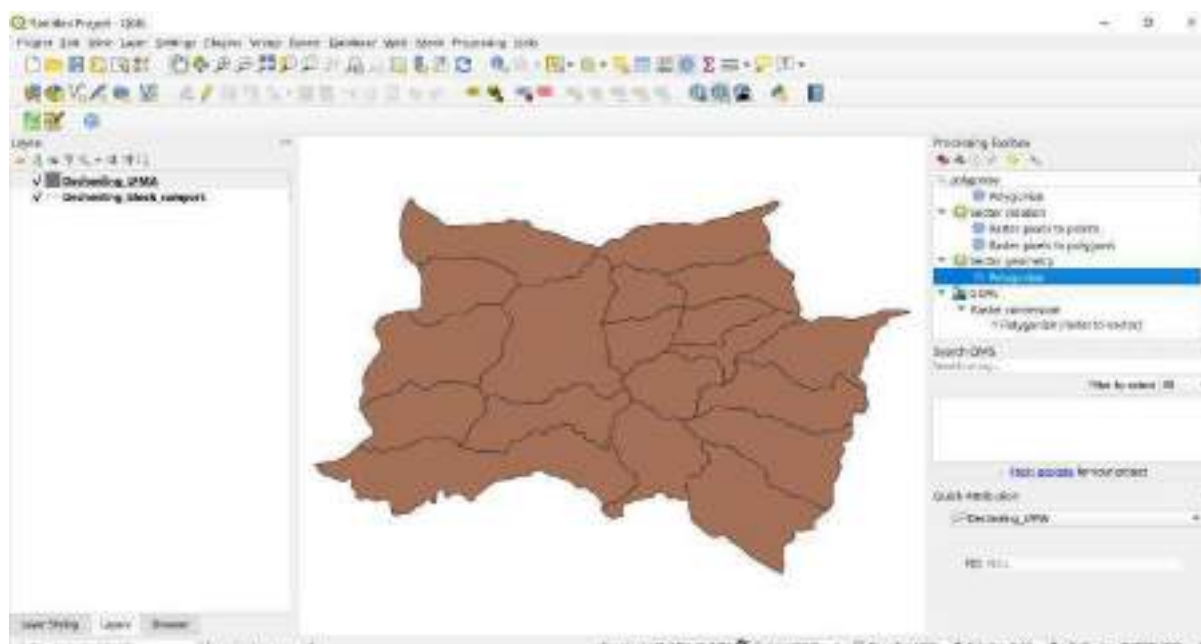


Merged shapefile is still in line features. Now we need to convert the line features into polygon features.

- Type **Polygonize** in processing toolbox
- Navigate to Vector geometry and select Polygonize tool
- In Input Layers: Select the file you want line feature file
- Save the file with appropriate name in working directory
- Click run

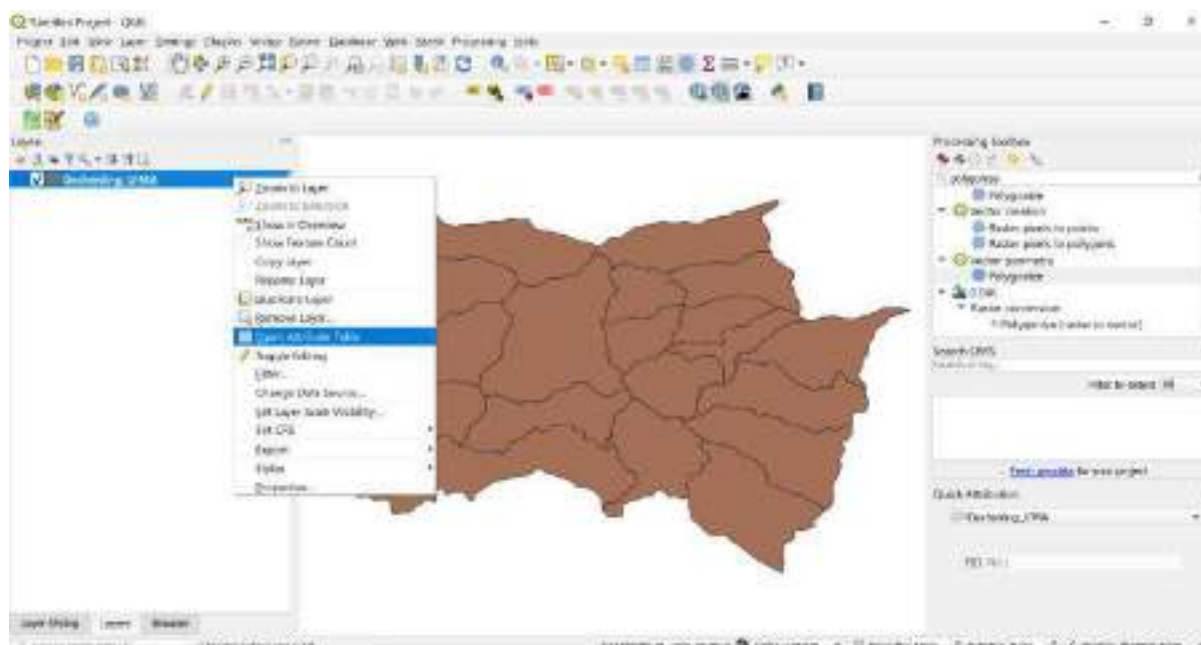


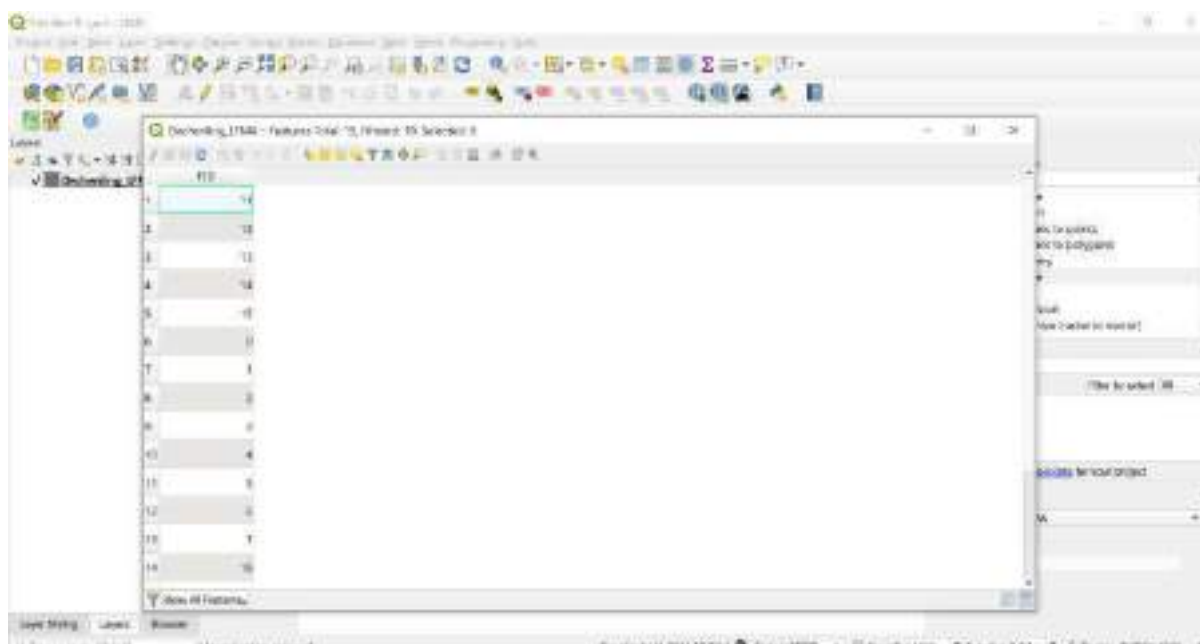




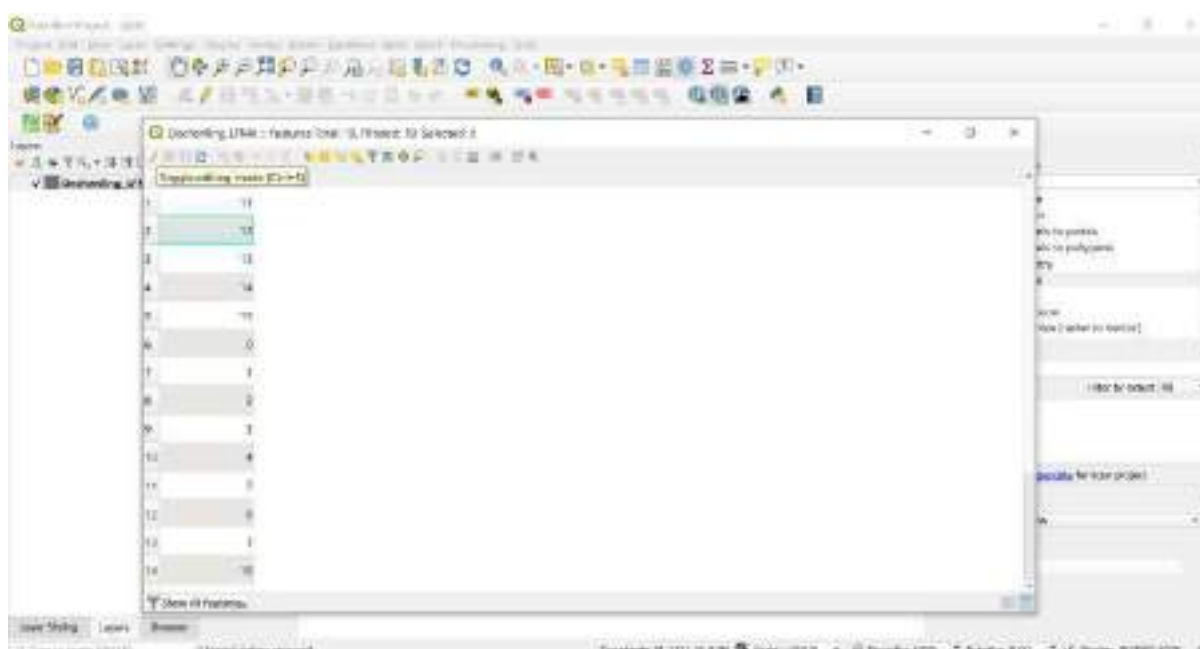
Now the line features have been converted into polygon features. We need to give the appropriate name of LFMA, Blocks, Compartments and Sub-compartments.

- *Right click on polygon layer > Click Open Attribute Table*

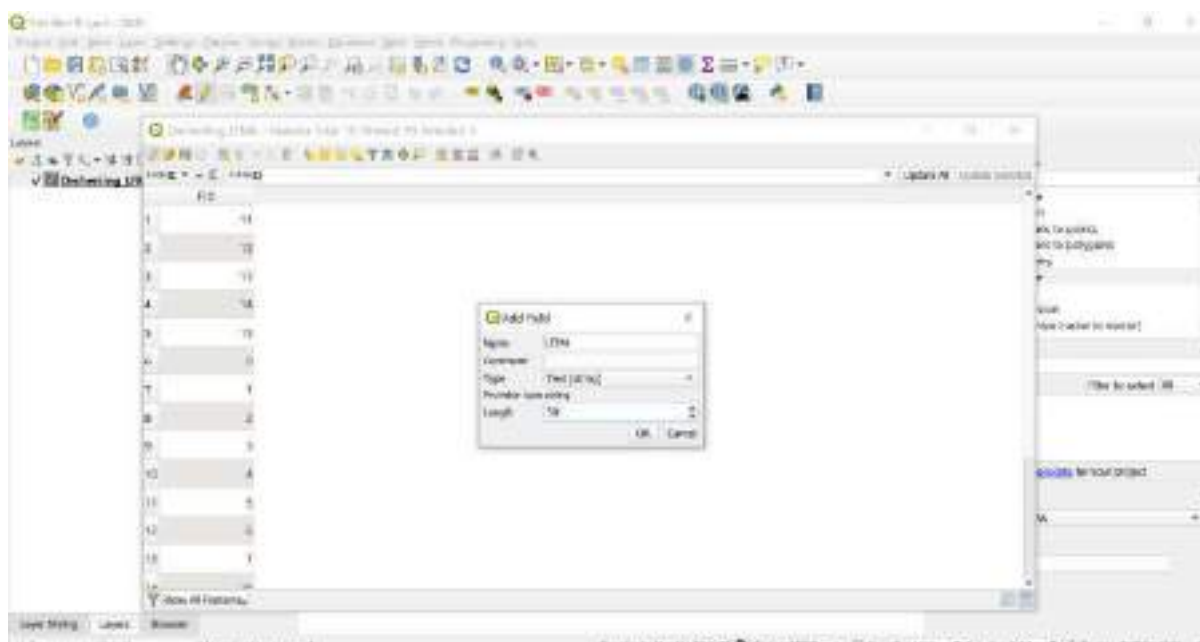




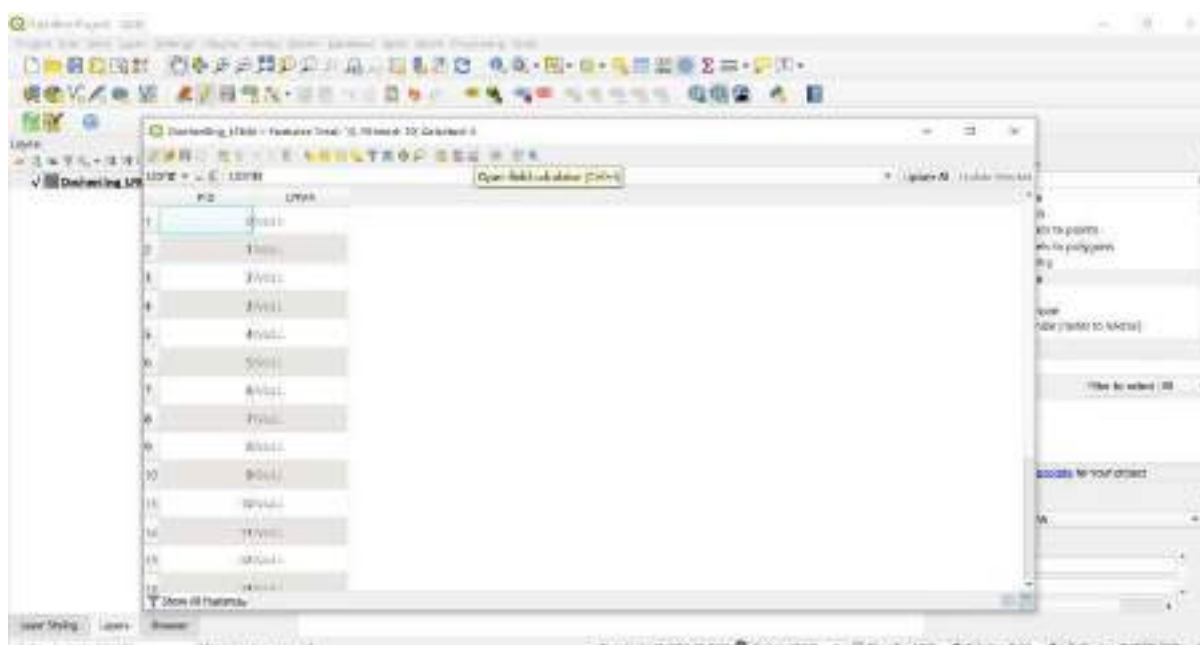
- *Click Toggle Editing Mode*

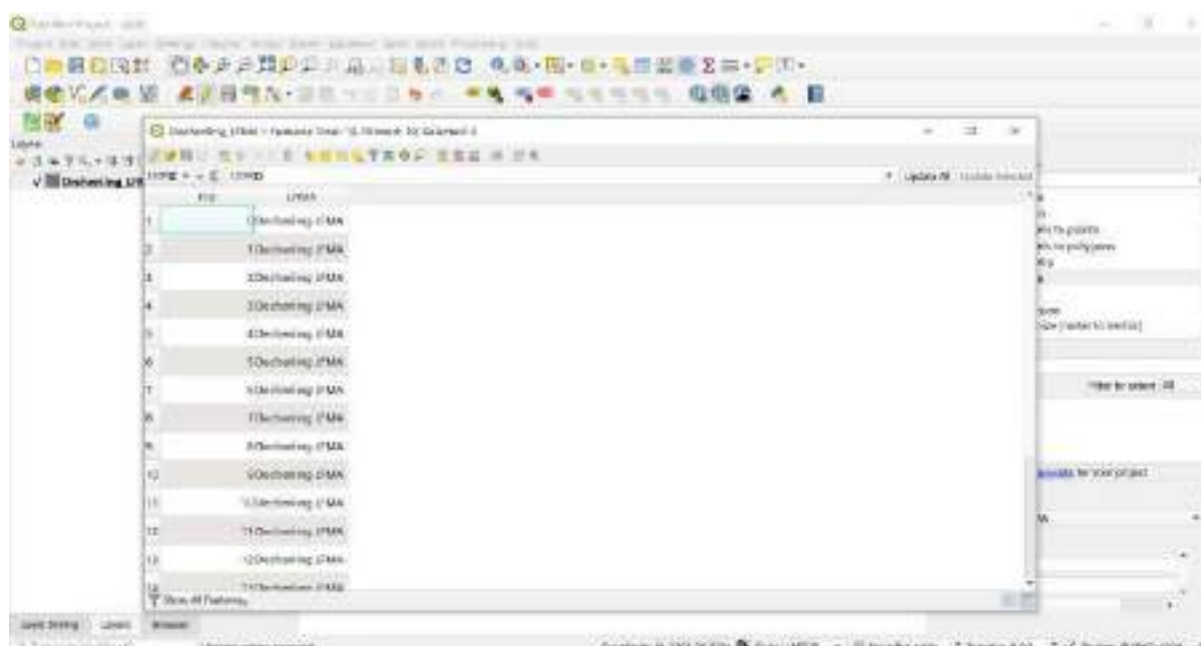
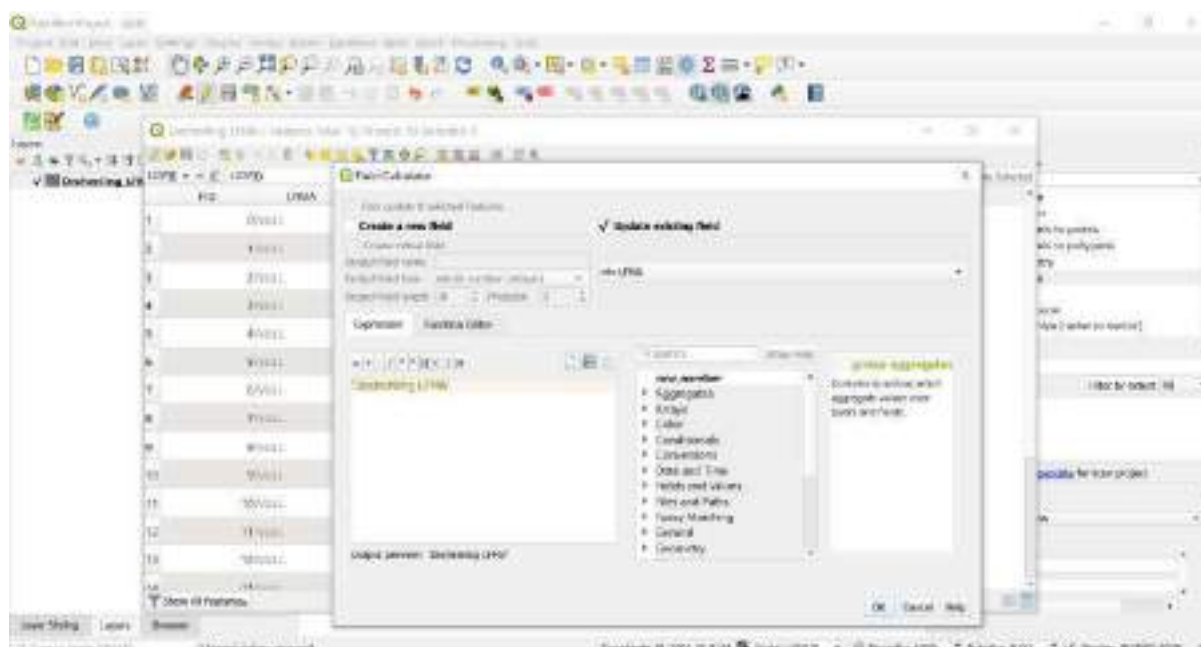


- *Click on New field*
- *Name: Type FMU*
- *Type: Select Text(String)*
- *Length : 50*
- *Click Ok*

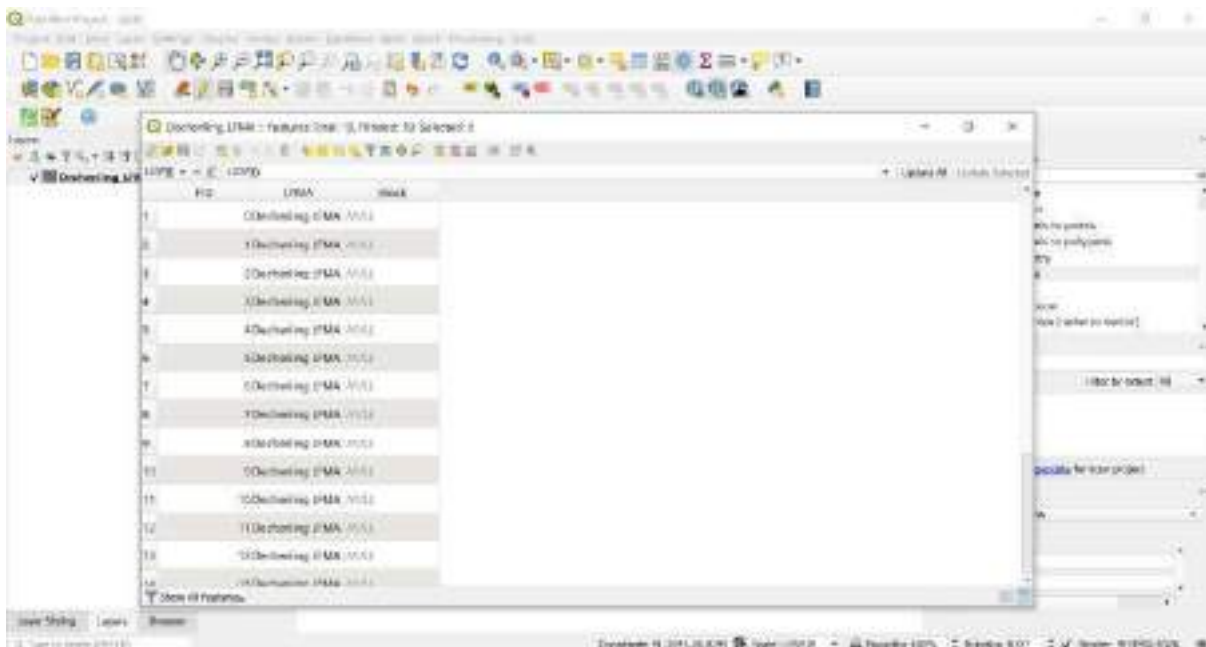


- Click Open Field Calculator
- Check Update existing field
- Select LFMA
- In the expression box; type Name of LFMA within inverted coma e.g. ('Dechenling LFMA')
- Click ok





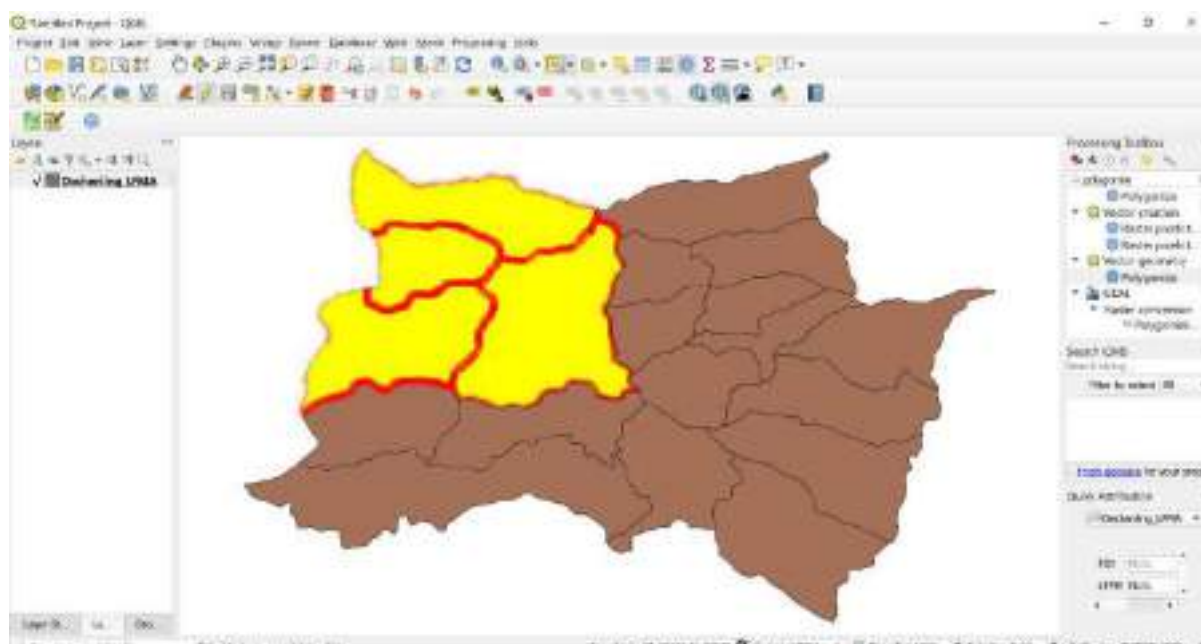
- Click on New field
- Name: Type Block
- Type: Select Text(String)
- Length : 50
- Click Ok



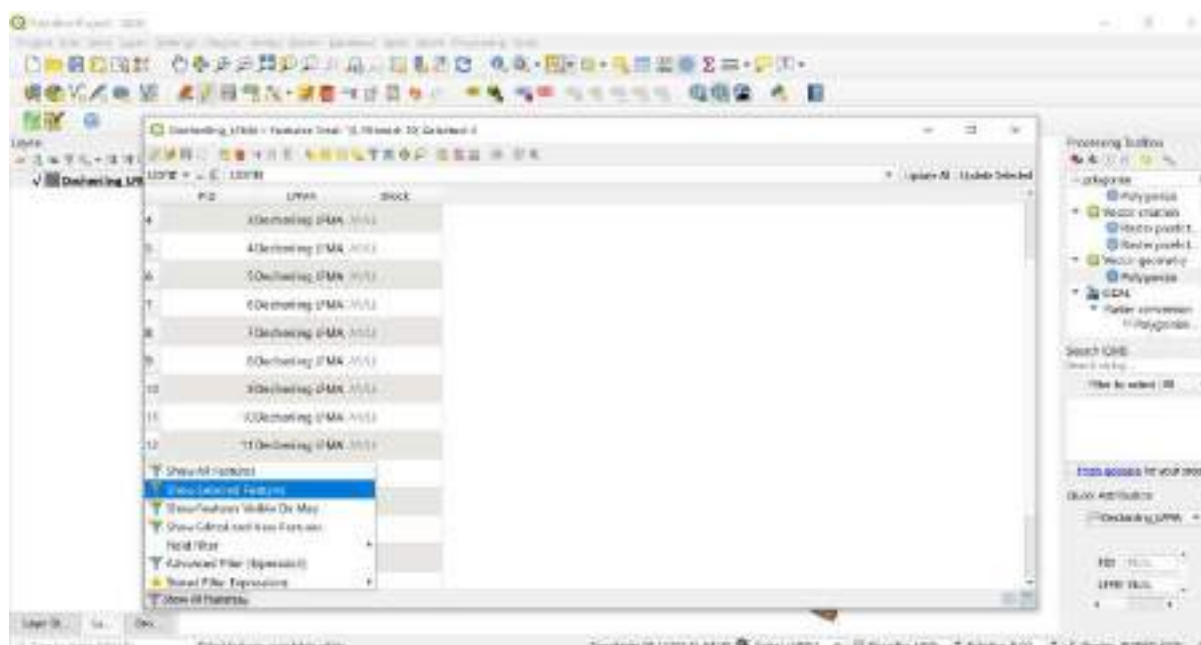
- *Minimize attribute table*
- *Click Select Feature*
- *Identify each different Blocks, we need to name the block one at a time*
- *Move your mouse and click one polygon (it shall be highlighted yellow). We can also select multiple polygons by pressing control on keyboard and clicking on multiple polygons to be selected. Select all the polygons that falls under one Block*







- *Open/maximize attribute table*
- *Select Show Selected Features (this shall show only polygons that are selected)*



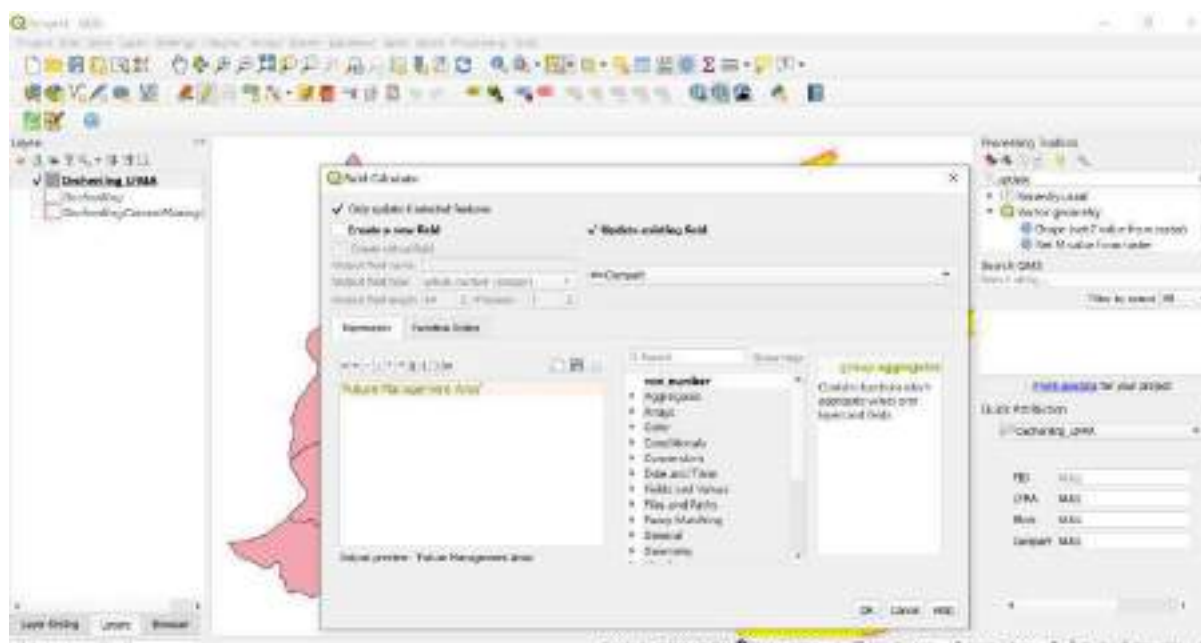
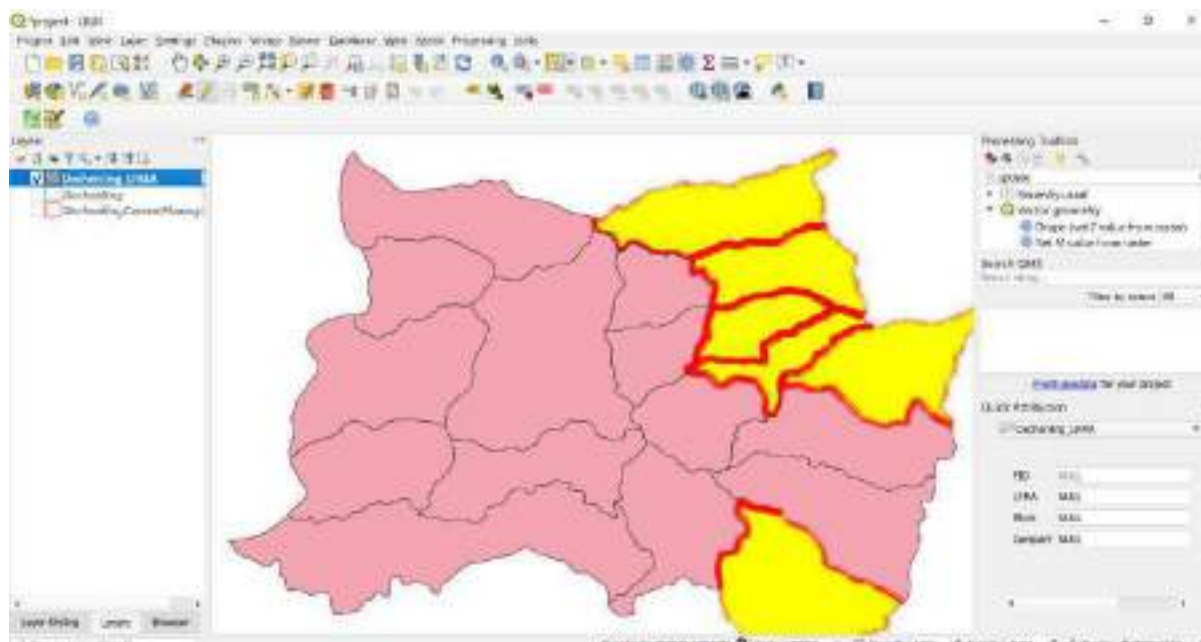
- *Click Open Field Calculator*
- *check Update existing field*
- *Select Block*
- *In the expression box; type Name of Block within inverted coma e.g. ('Dechenling')*
- *Click ok*



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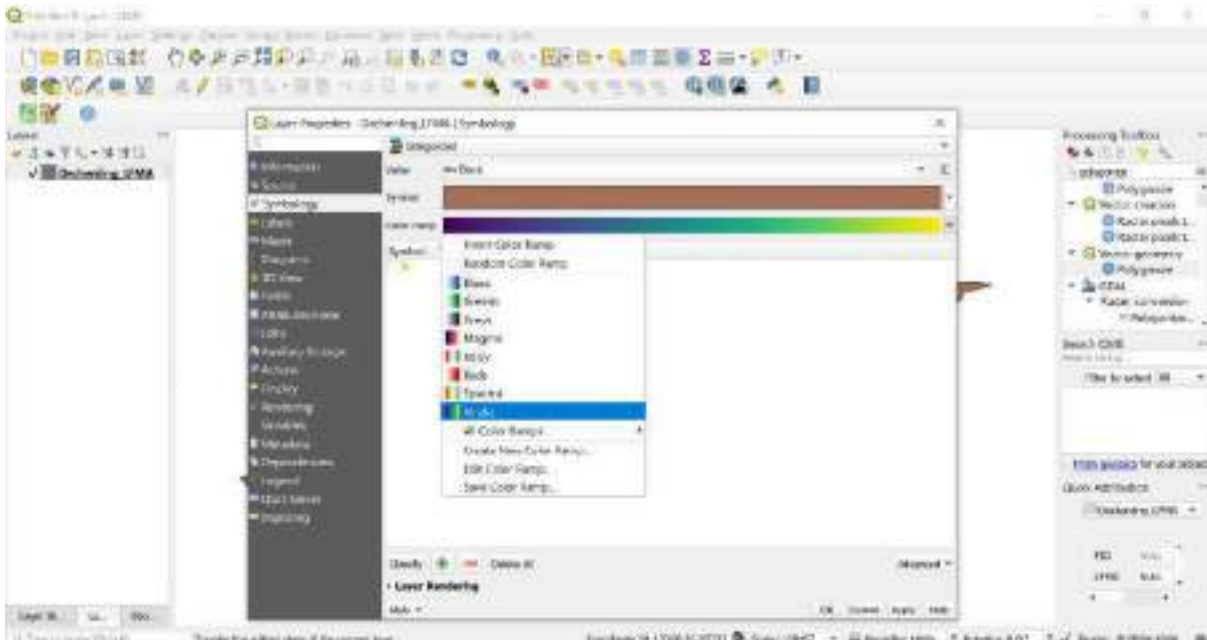
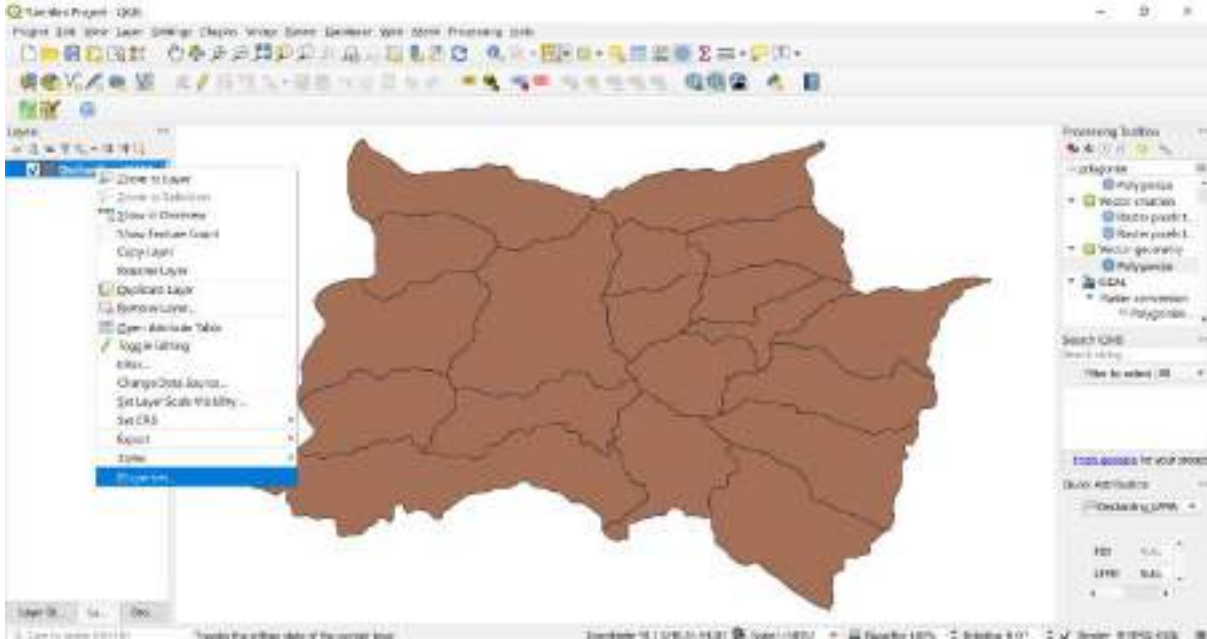
- Check Update existing field
- Select Compart
- In the expression box; type Number of Compartment within inverted coma in Roman numerals e.g. ('I') or ('II') or ('III')
- Click ok



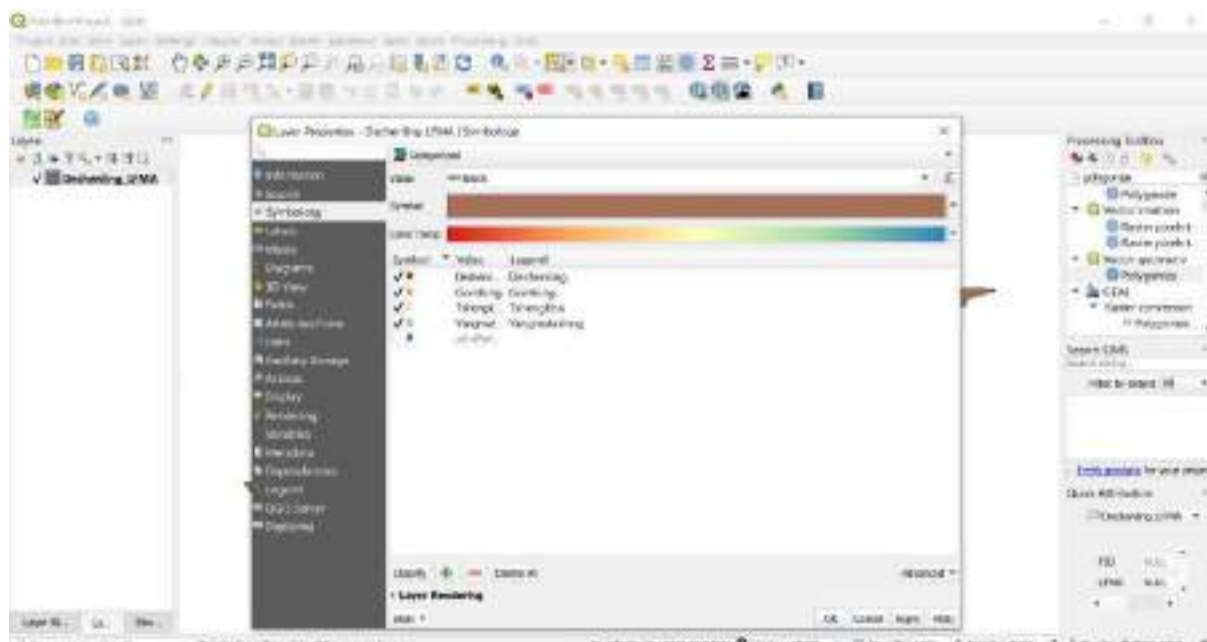
- Minimize attribute table
- Click Select Feature
- Identify each different Compartment, we need to name the Compartment one at a time
- Move your mouse and click one polygon (it shall be highlighted yellow).
- Open/maximize attribute table
- Select Show Selected Features (this shall show only polygon that is selected)
- Click Open Field Calculator
- Check Update existing field
- Select Compart





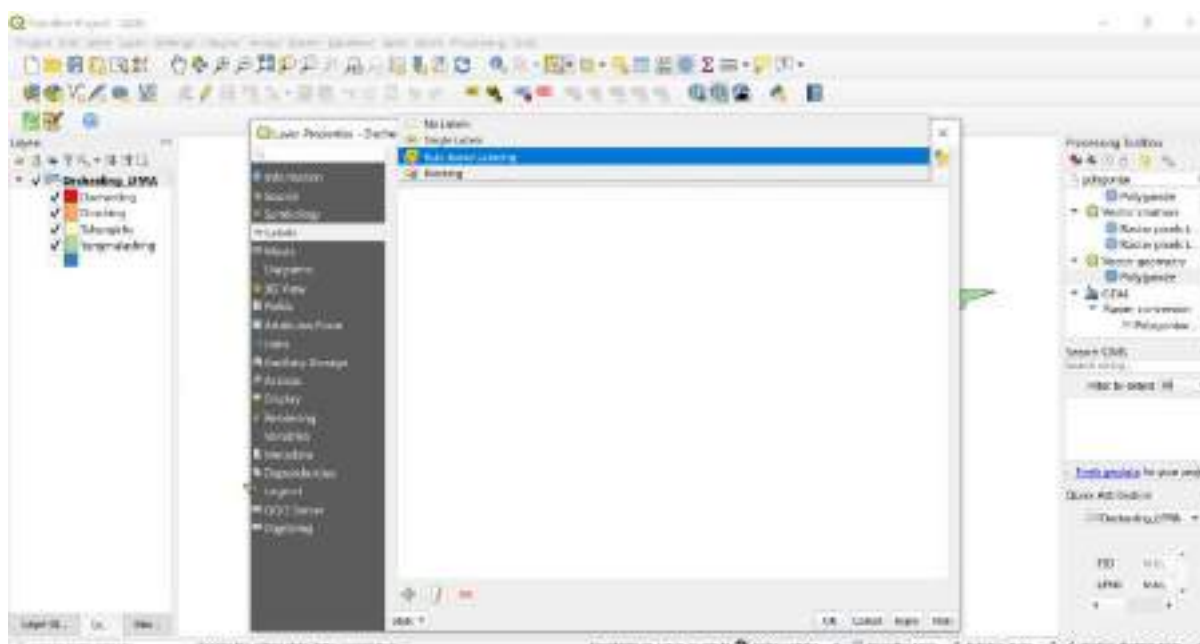




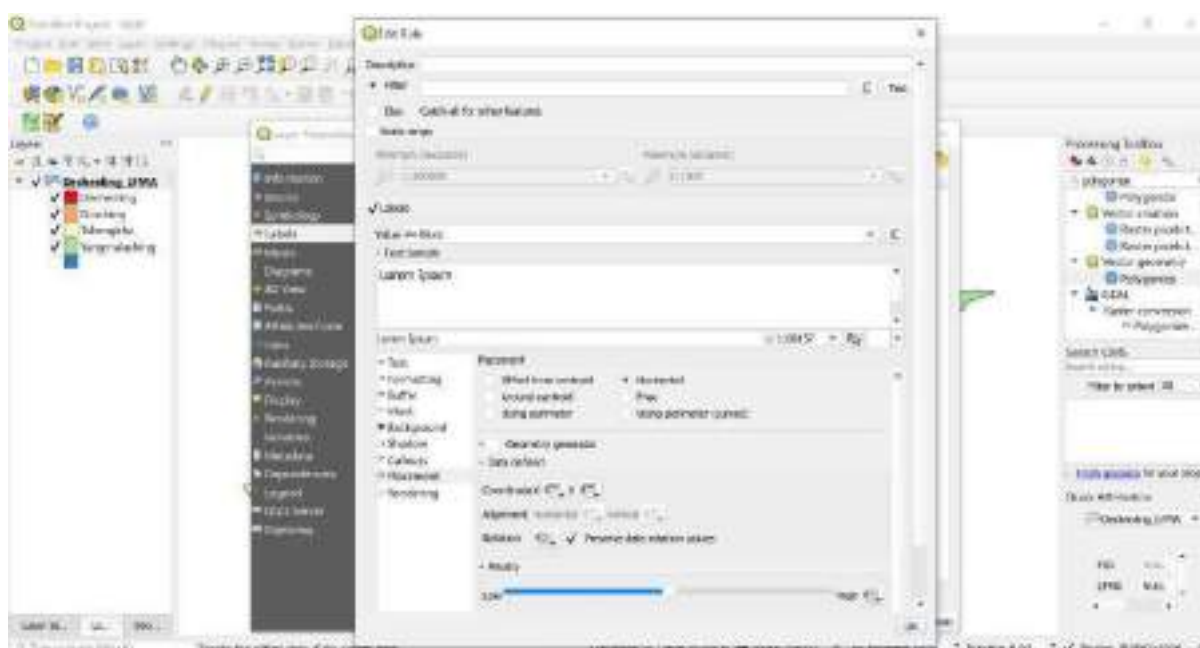


Display the name of Blocks, Compartments and Sub-compartments in Map Viewer

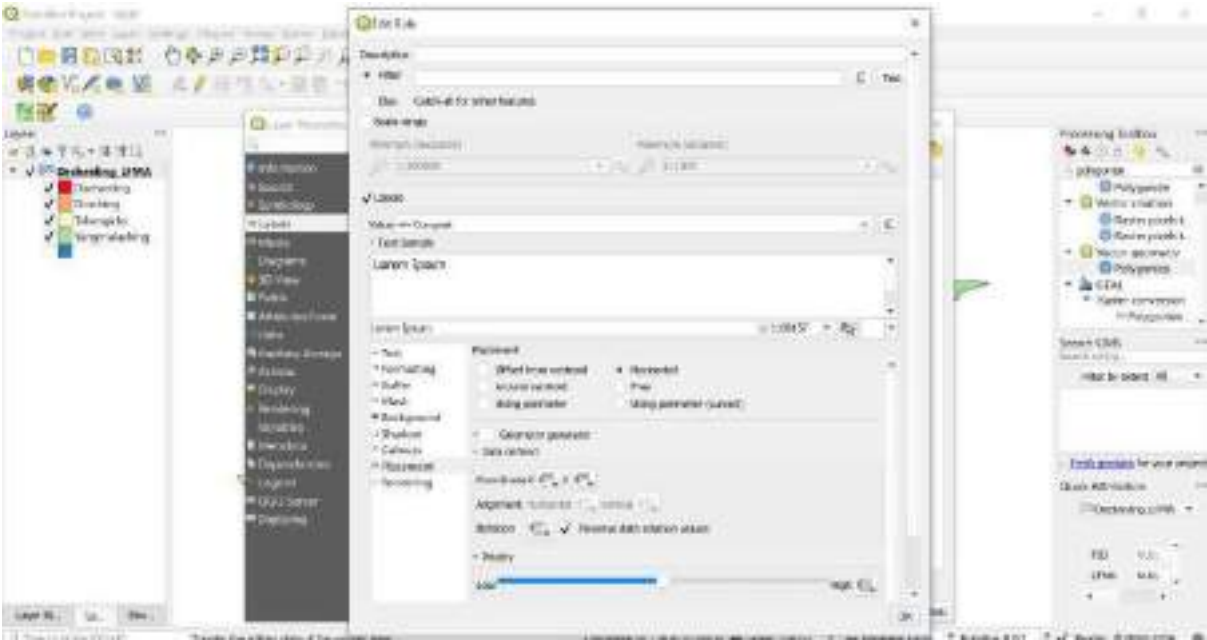
- *Click Labels > Select Rule-based Labelling*



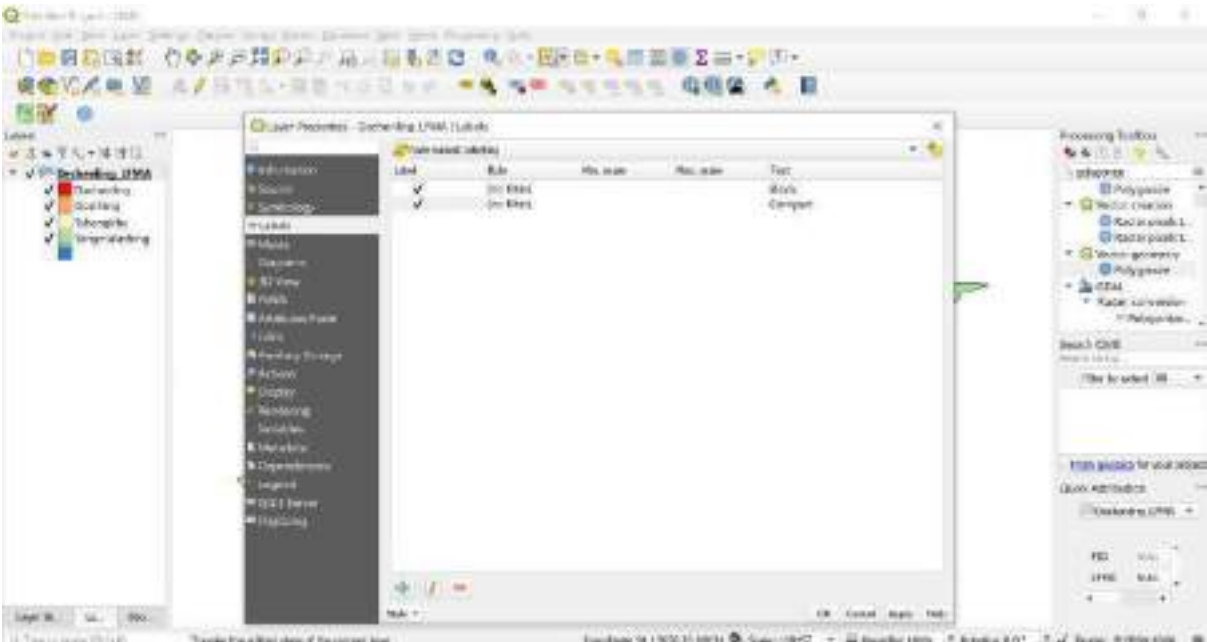
- Click Add Rule
- In the Label Value: Select Blocks
- In Placement: Select Horizontal
- Click OK



- To add more rules :click Add Rule
- In the Label Value: Select Compart
- In Placement: Select Horizontal
- Click OK



➤ In the Layer Properties dialogue box click Apply and OK

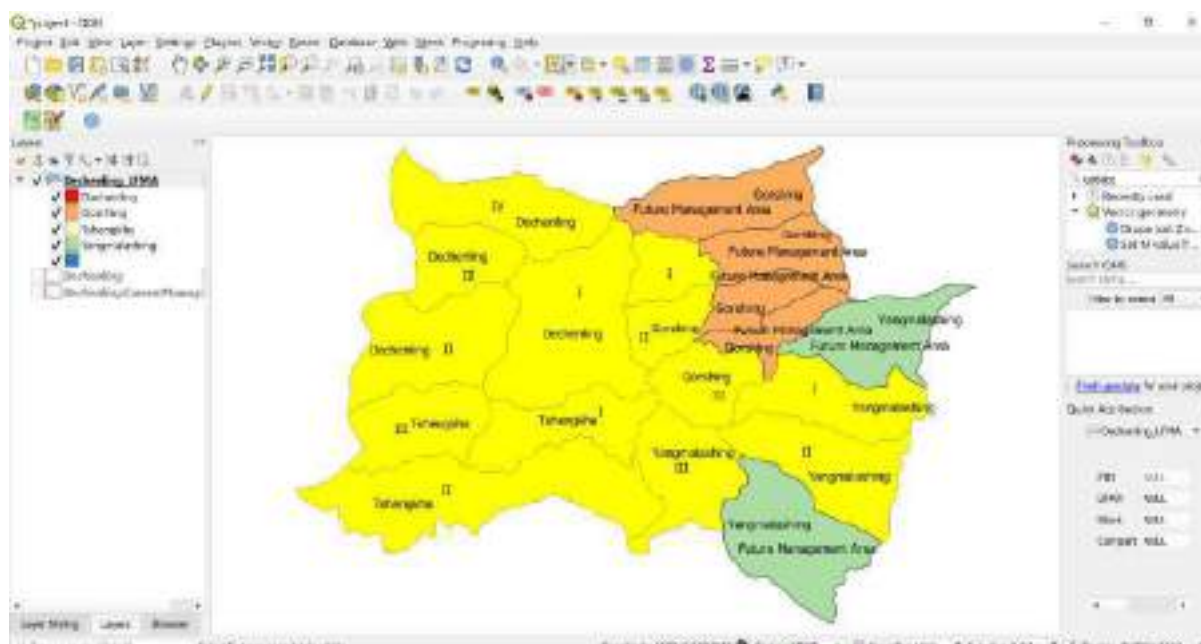


➤ *Click on Select features by area or single click*

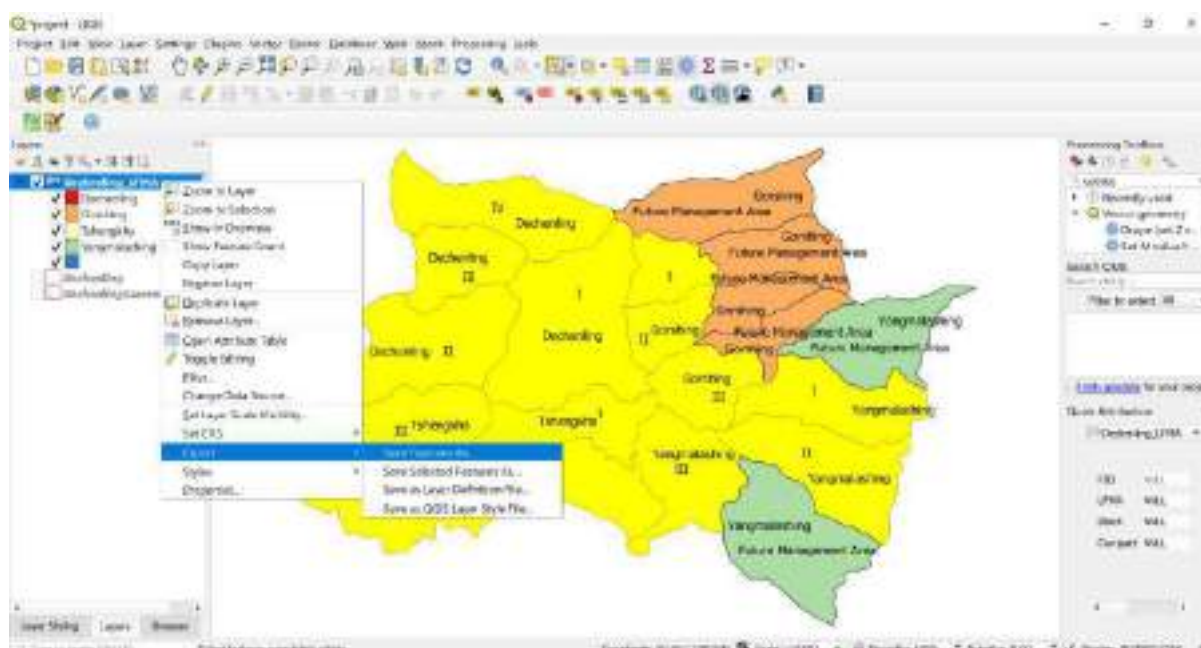


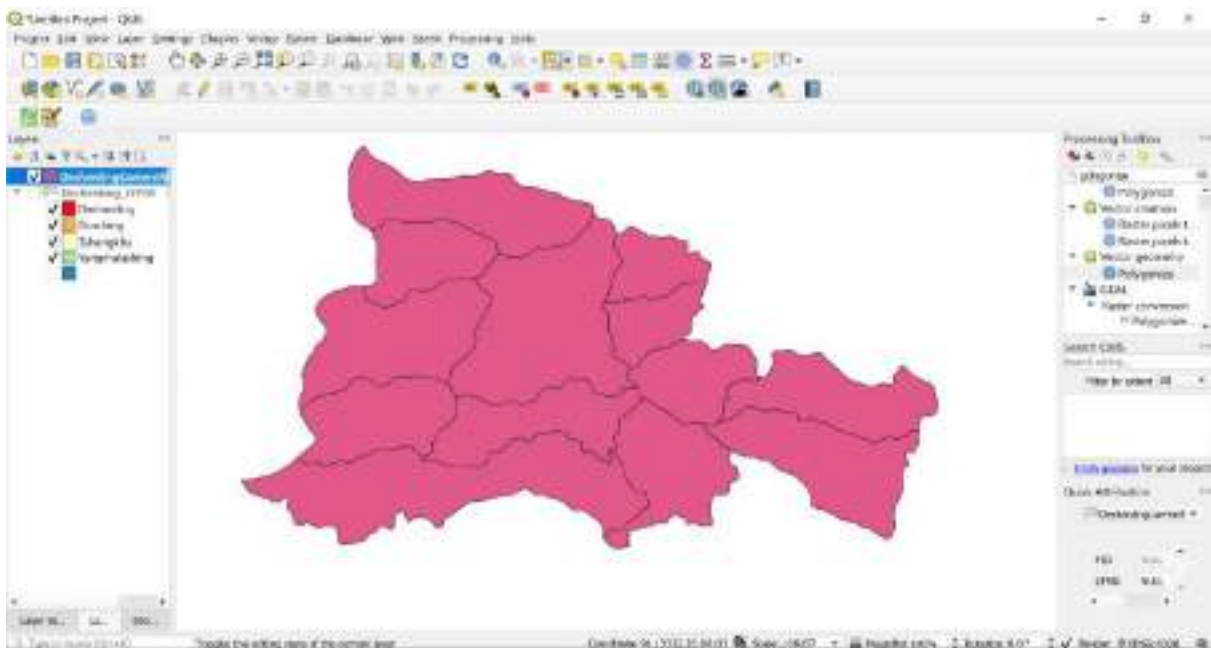
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- *Right click on layer > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *CRS: DRUKREF 03/ Bhutan National Grid*
- *Save the file with appropriate name in working directory*
- *Encoding: Check Save only selected features*
- *Click OK*





## Objective

The main objectives of Forest Function Mapping are to provide spatial information on:

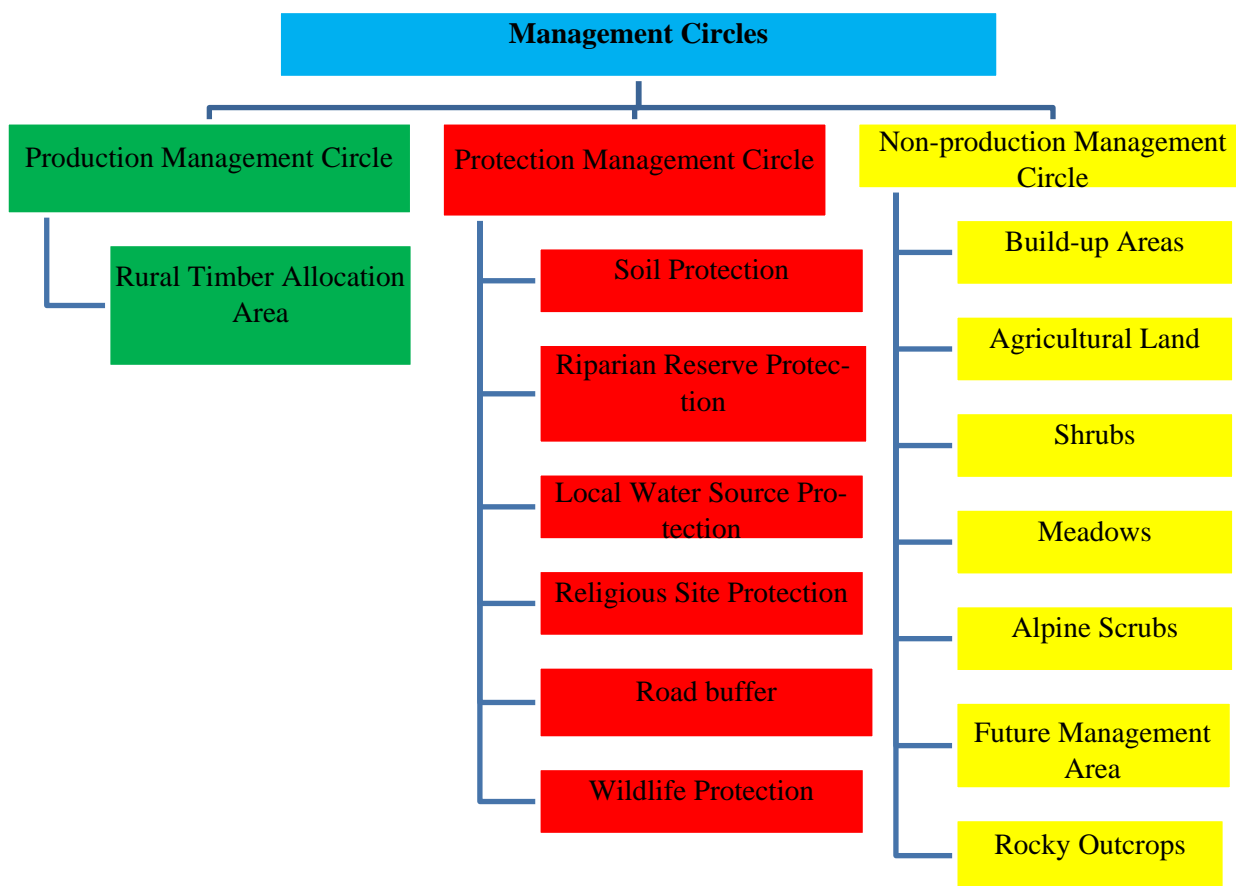
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- non-forested area for management intervention (Non-production); and
- the total area that can be brought under sustainable forest management to meet the rural timber demand (production).

### Scope

Forest function mapping shall be carried out only within **Current Forest Management area** as identified under section 3.3.2.3. Based on the forest function mapping, the entire Management Area is segregated into three management circles viz Protection Management Circle, Production Management Circle and Non-Production Management Circles (Figure 3.3 Management Circles and its components). In addition to these three Management circles, Non-Wood Forest Product Management Circle shall be an overlapping Management Circle which may cover all the other three regular management circle.



*Figure 3.3 Management Circles and its components*

#### 3.3.3.1 Management Circles

Management circle is defined as specific area within Management area which is designated to cater to specific socio-environmental functions based on its topography, land use type and forest functions.

##### Protection Management Circle

The Protection Management Circle is an area under protection where timber extraction activities cannot take place. However, extraction of timber may be permitted under specific circumstances such as outbreak of pest and diseases, forest fire and other unforeseen natural hazards with prior approval of the Head of the

Department. The Protection Working Circle is the sum of all protection functions such as wildlife protection, soil protection, riparian reserve protection, religious site protection, road buffer protection and local water supply protection as indicated in Figure 3.3 Management Circles and its components.

The mapping of all protection functions under Protection Management Circle can be carried out in GIS. The slope classification can be done using Digital Elevation Model (DEM) preferably of higher resolutions. In addition to the protection areas mentioned above, areas of wildlife importance (key biodiversity areas or wildlife hotspots) should be mapped out and demarcated under protection management circle. The criteria for mapping for each of these protective functions is as mentioned under Chapter 1: Forest Management Units, section 1.9 (Forest Function Mapping) of this *Code*.

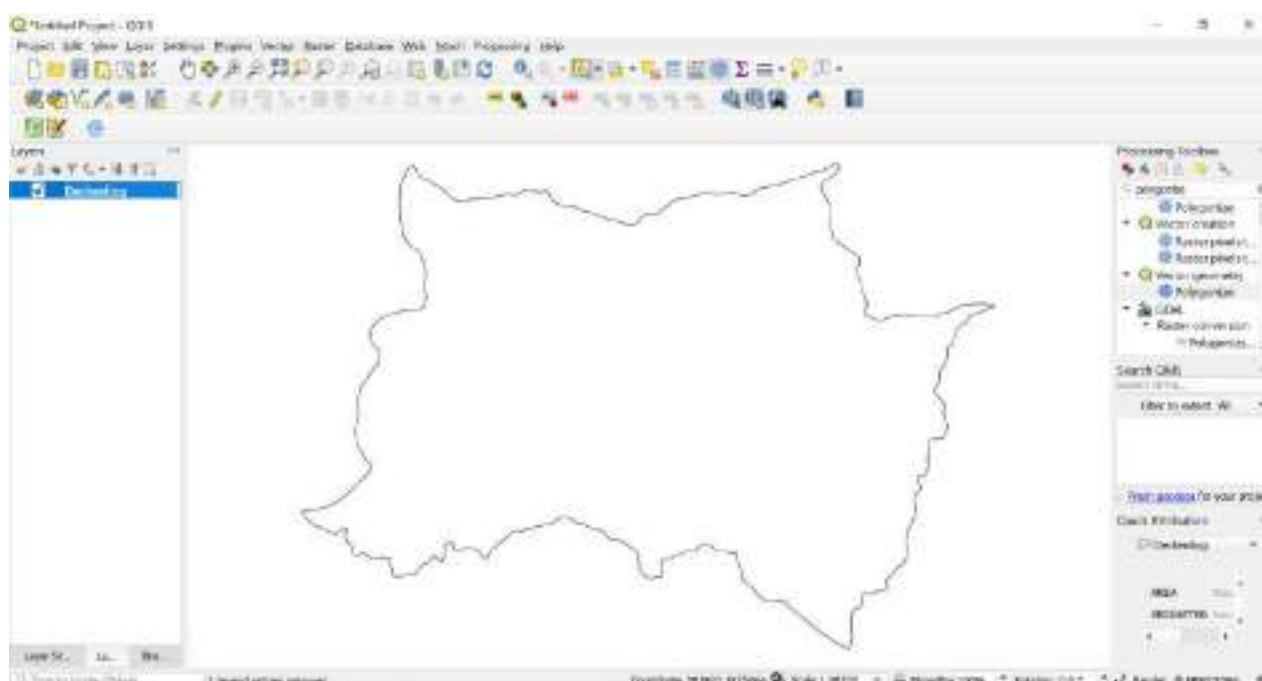
#### Soil Conservation Function

#### GIS Steps

This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

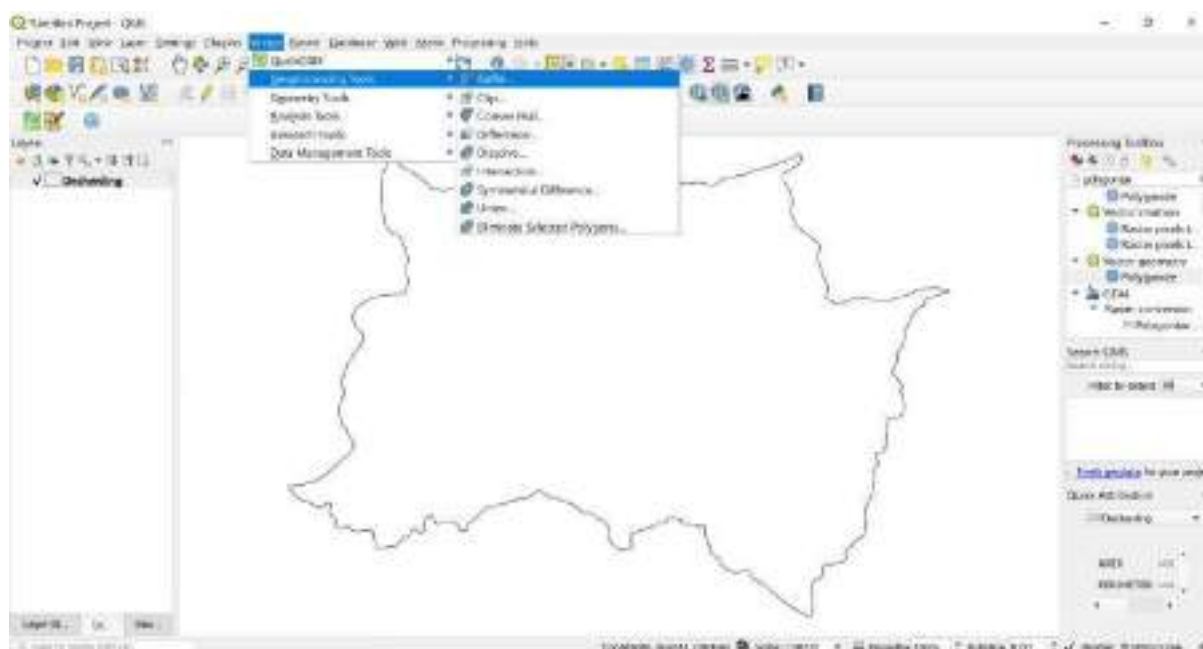
#### Open QGIS

- *Add Local Forest Management Area (LFMA) boundary layer*

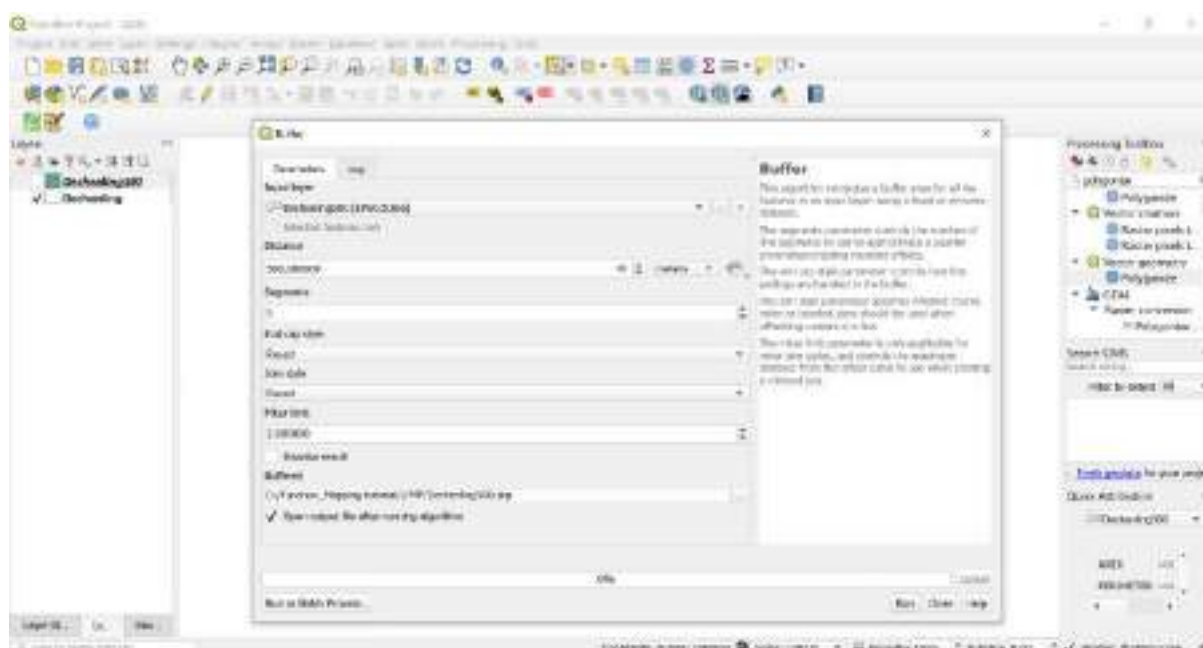


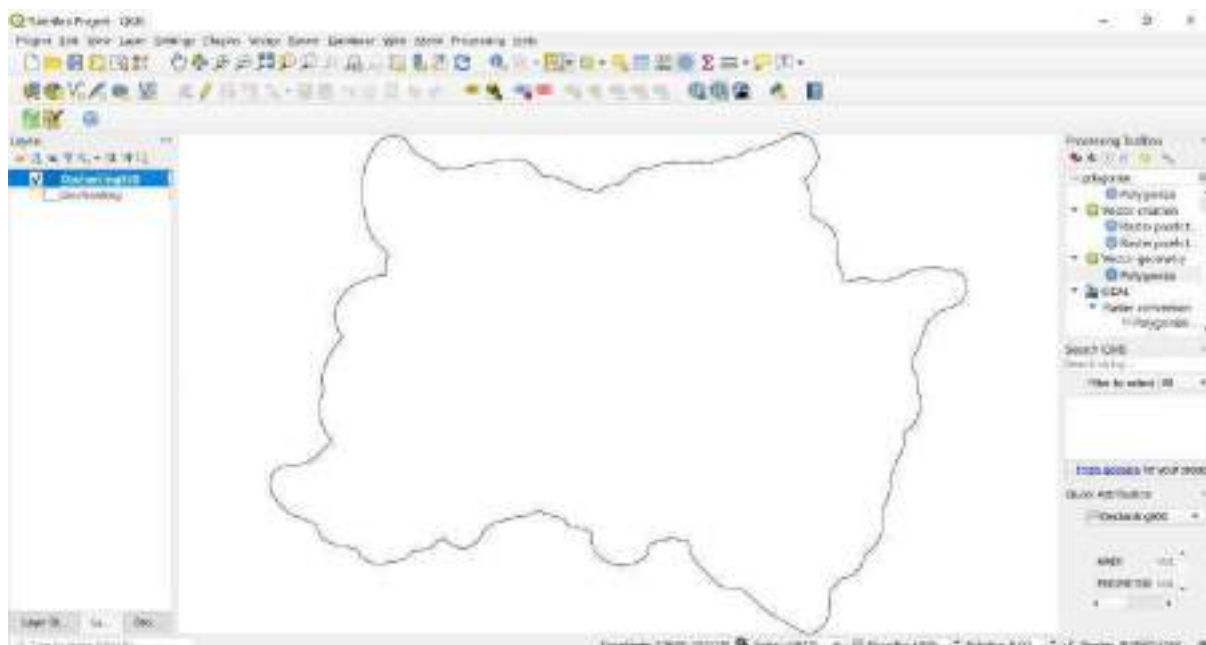
Create a buffer of 500 m around the LFMA boundary to use it as area of interest (aoi). Buffer is being created to increase the extent of LFMA as next steps involve using combination of vector and raster file.

- *Click Vector > Geoprocessing Tools > Buffer*

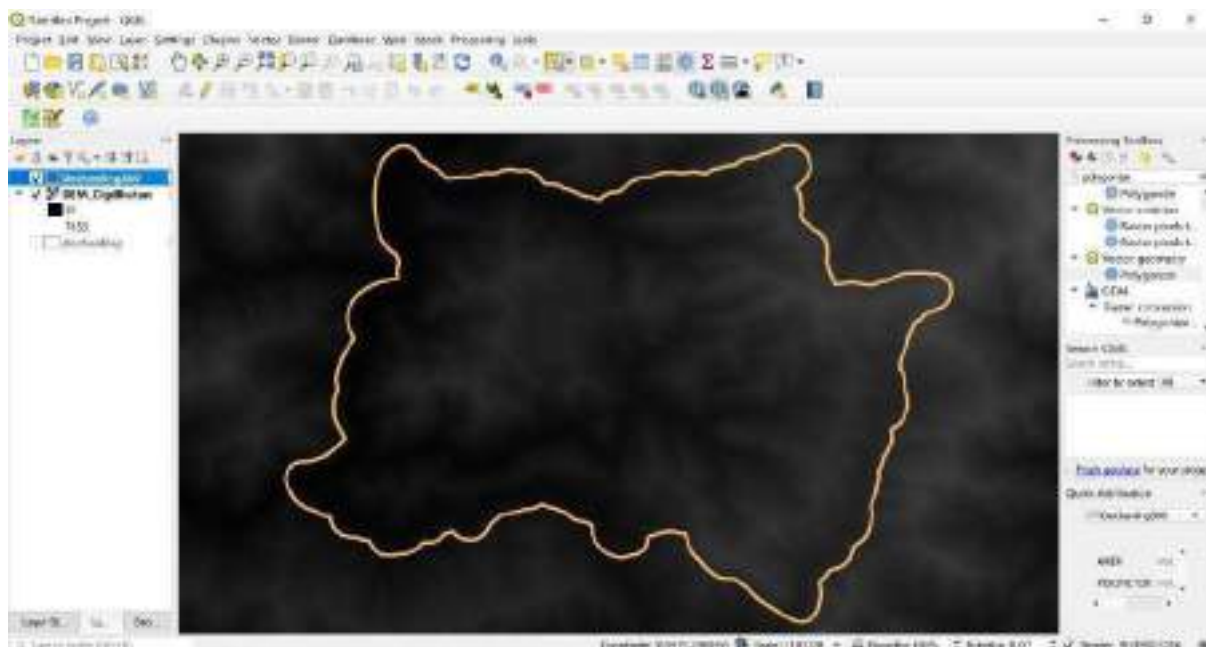


- *Save the buffer layer with appropriate name in working directory*



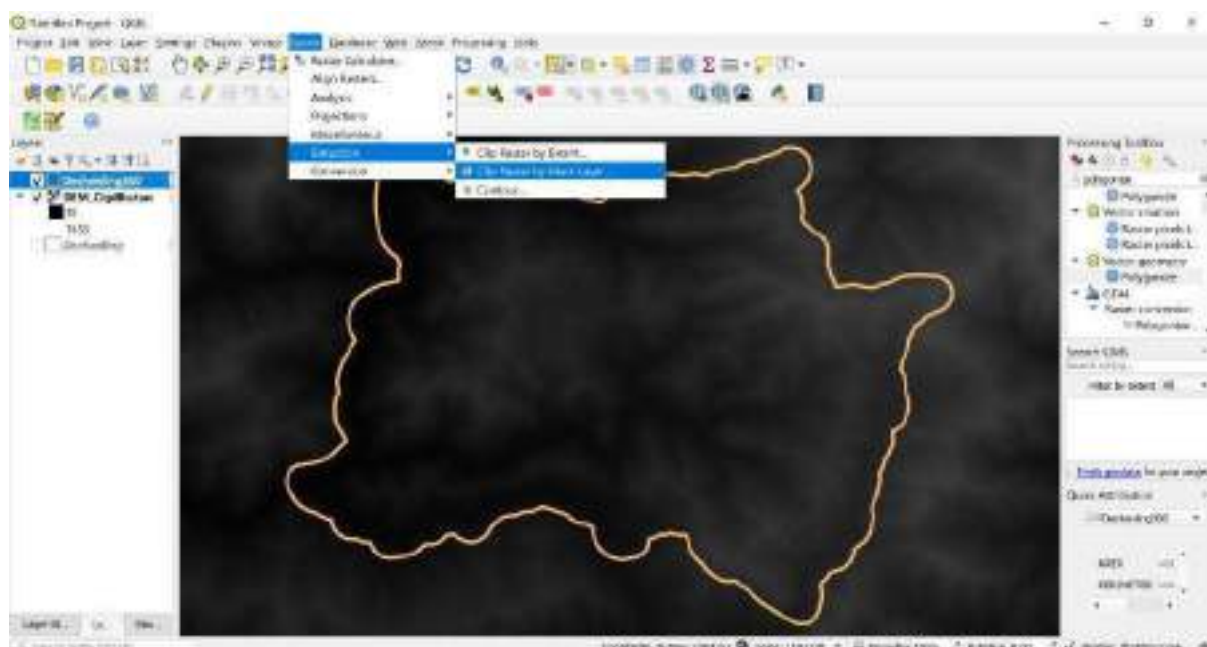


- Add Digital Elevation Model (DEM). DEM is raster data.



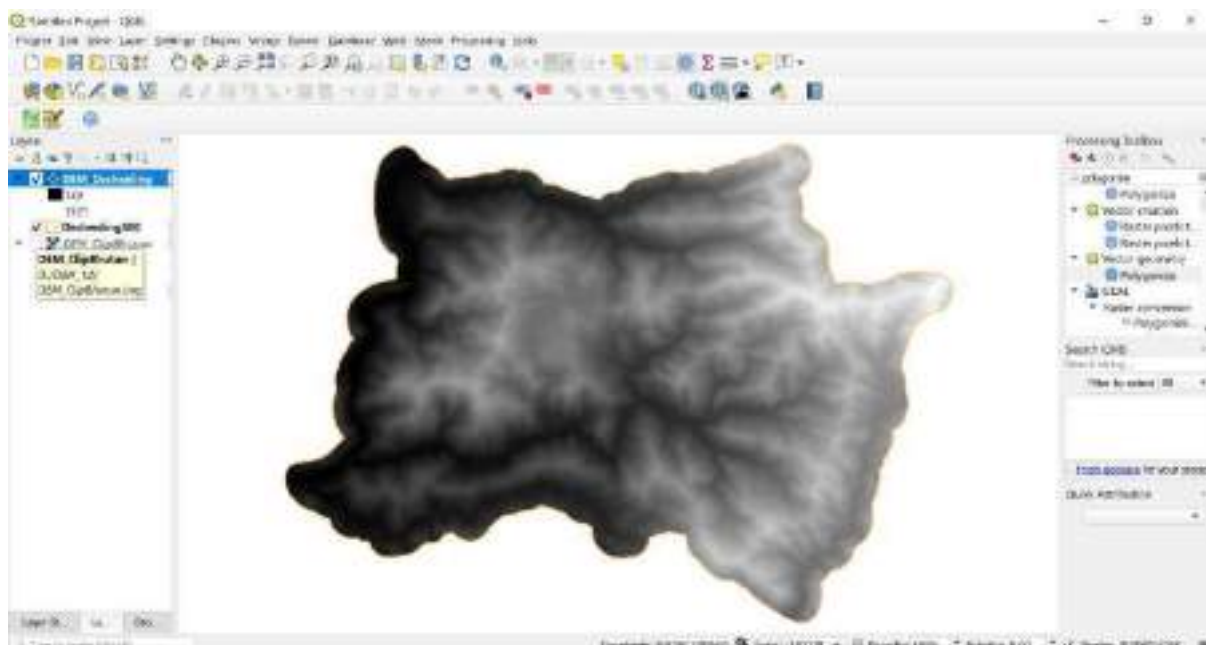
Clip the DEM within the aoi (500m buffer LFMA boundary layer)

- Click *Raster > Extraction > Clip Raster by Mask Layer*



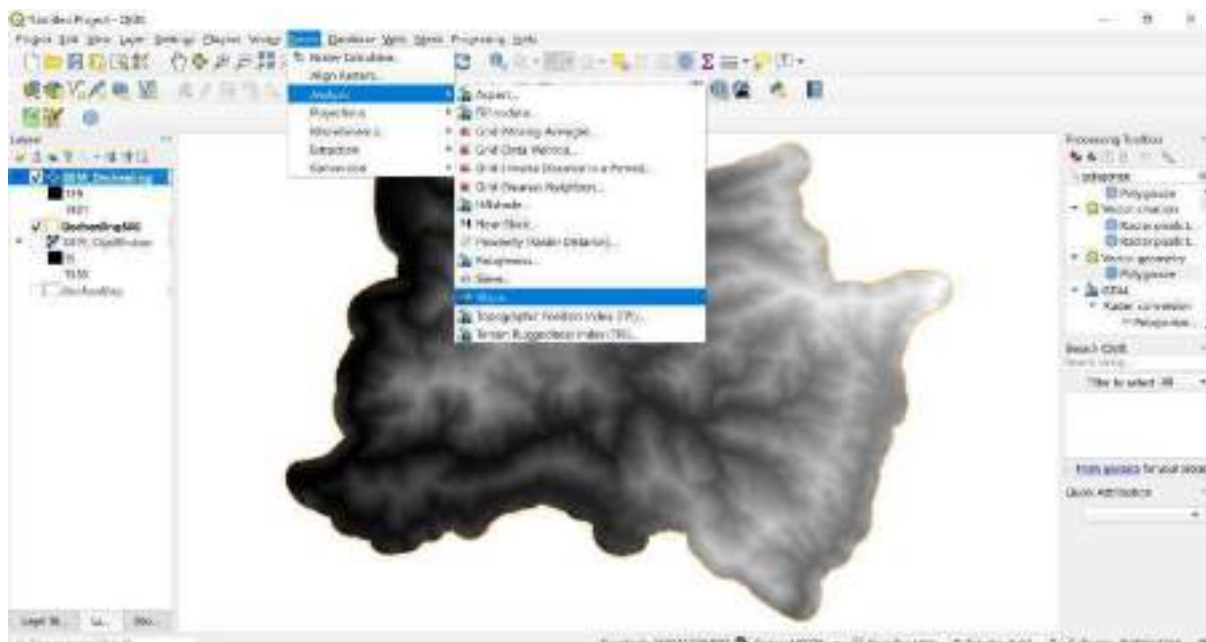
- *Input layer: Select DEM of Bhutan*
- *Mask layer: Buffered LFMA boundary shapefile*
- *Target CRS: Select EPSG:5266-DRUKREF 03/Bhutan National Grid*
- *Save the clipped DEM with appropriate name in working directory*





Generate SLOPE using DEM

- *Click Raster > Analysis > Slope*



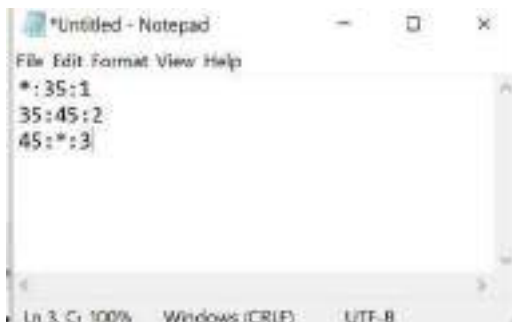
- *Input layer: select LFMA Dem*
- *Leave the rest default*
- *Save the SLOPE with appropriate name in working directory*





\*:35:1

35:45:2

 $45:*:3$ 

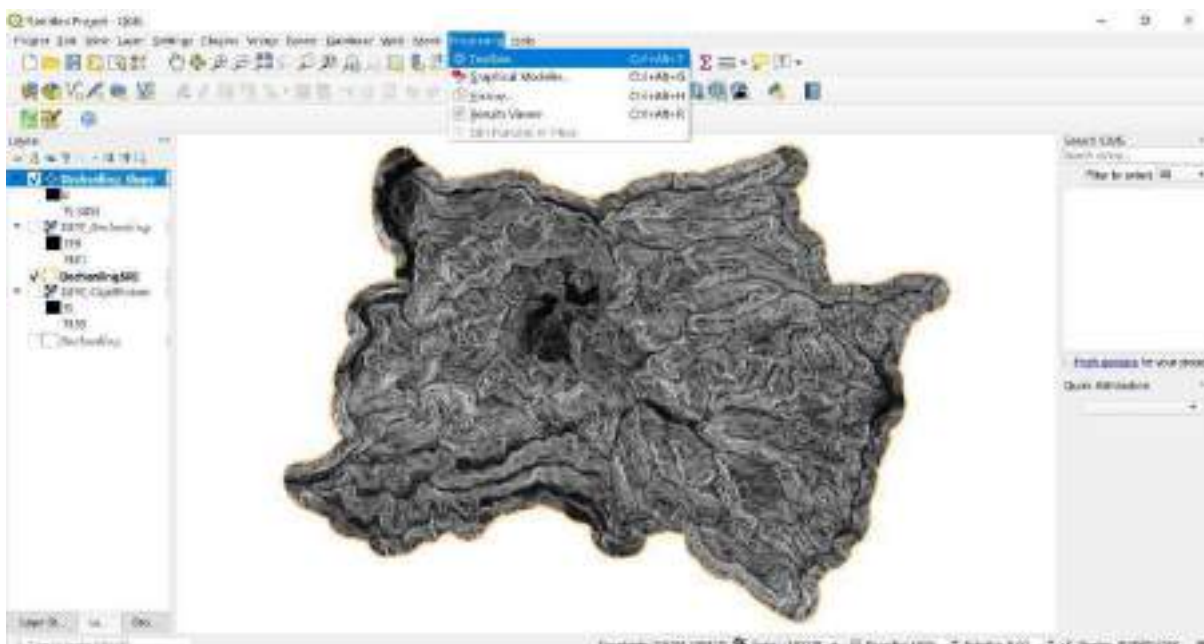
1 means 35 degree and below slope

2 means 35 to 45 degree slope

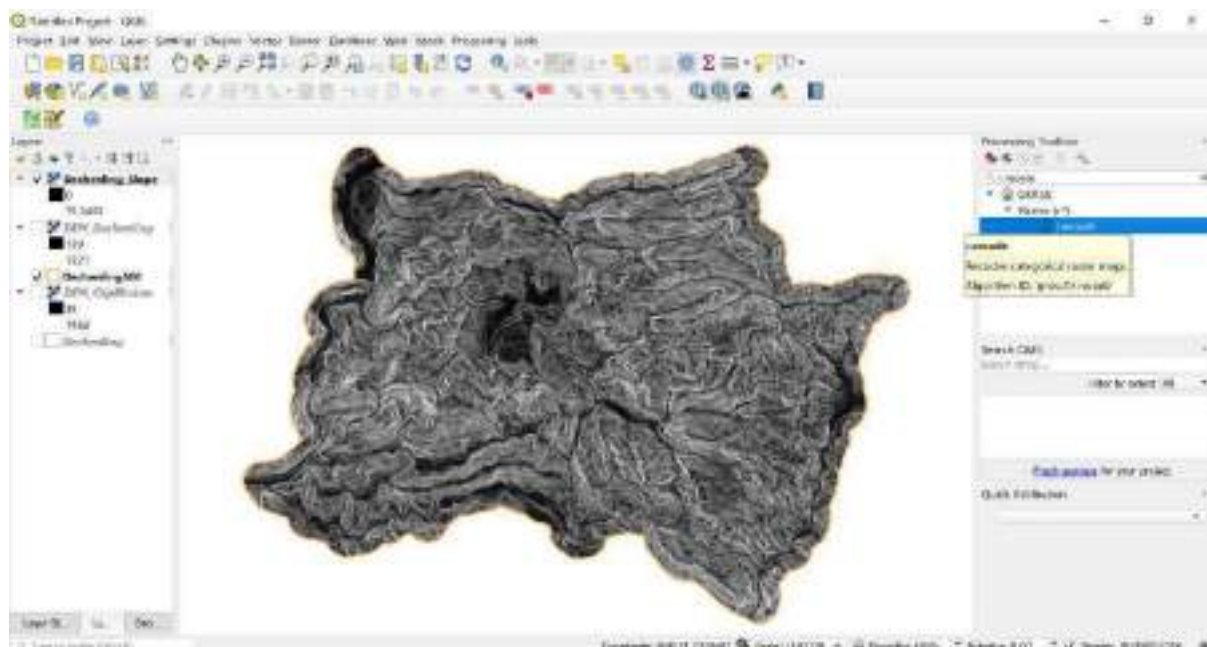
3 means 45 degree and above slope

Open the processing toolbox, if the toolbox is not open

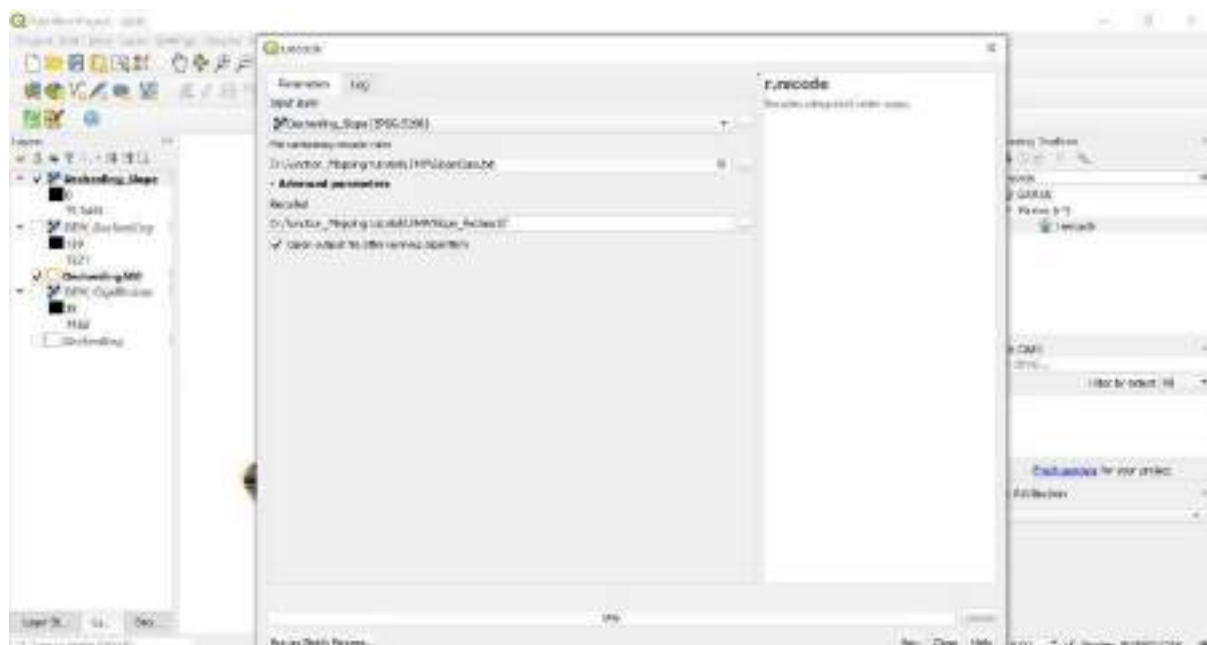
➤ *Click Processing > Toolbox*

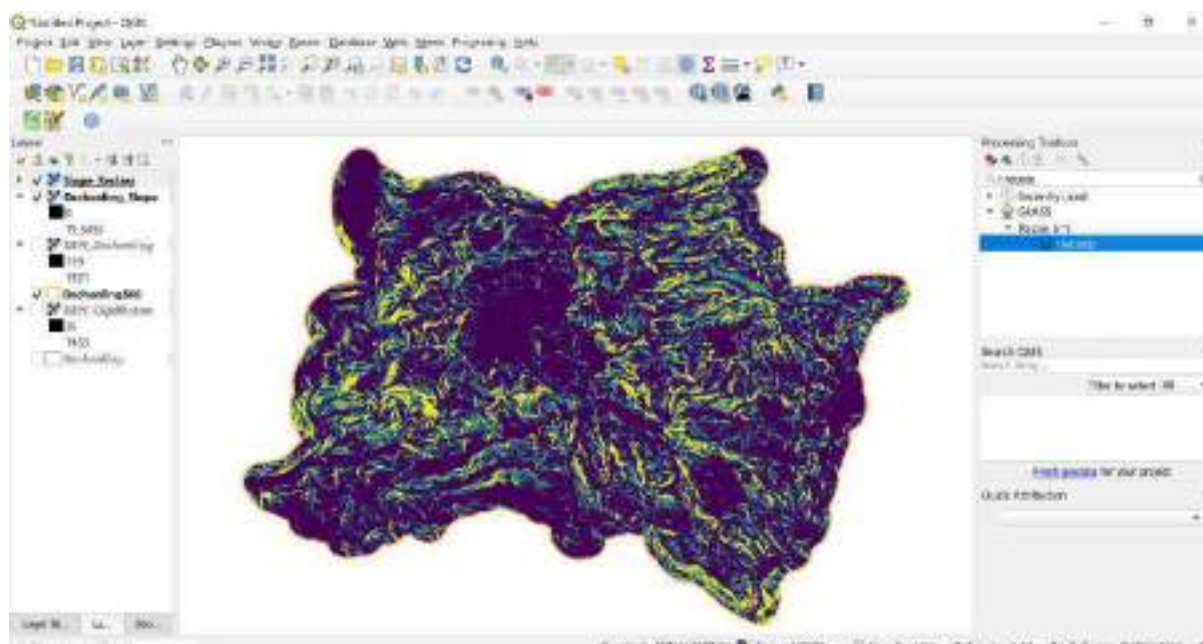


- Type `r.recode` in the search box of processing toolbox and open script by double clicking



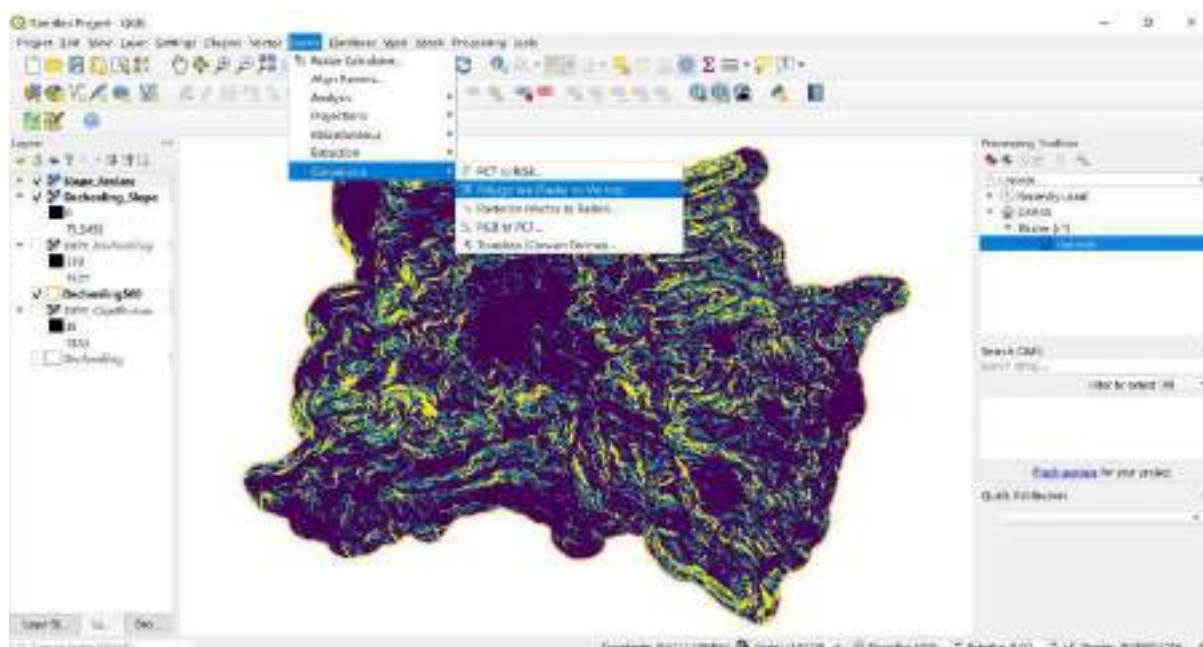
- *Input layer: select LFMA Slope*
- *File containing recode rules: browse the text file containing reclassification code and insert*
- *Recoded: Save the reclassified SLOPE with appropriate name in working directory*
- *Click Run*





Convert the reclassified slope raster file into vector file

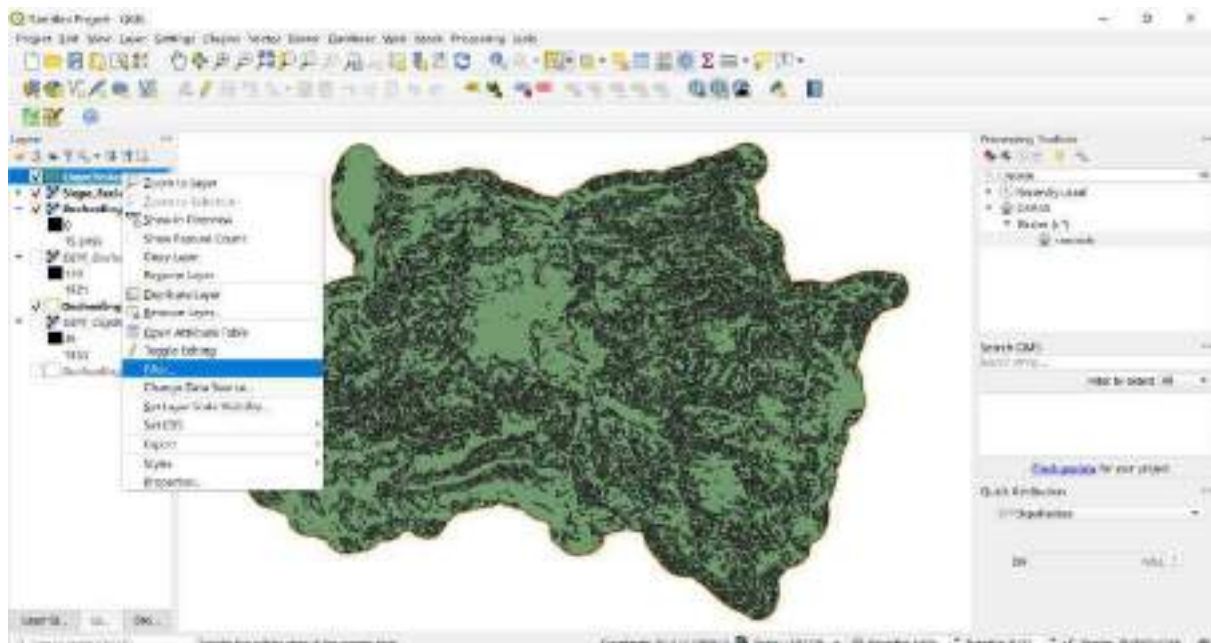
- *Click Raster > Conversion > Polygonize (Raster to Vector)*



- *Input: Select reclassified slope*
- *Leave the rest default*
- *Vectorized: Save the file with appropriate name in working directory*
- *Click run*

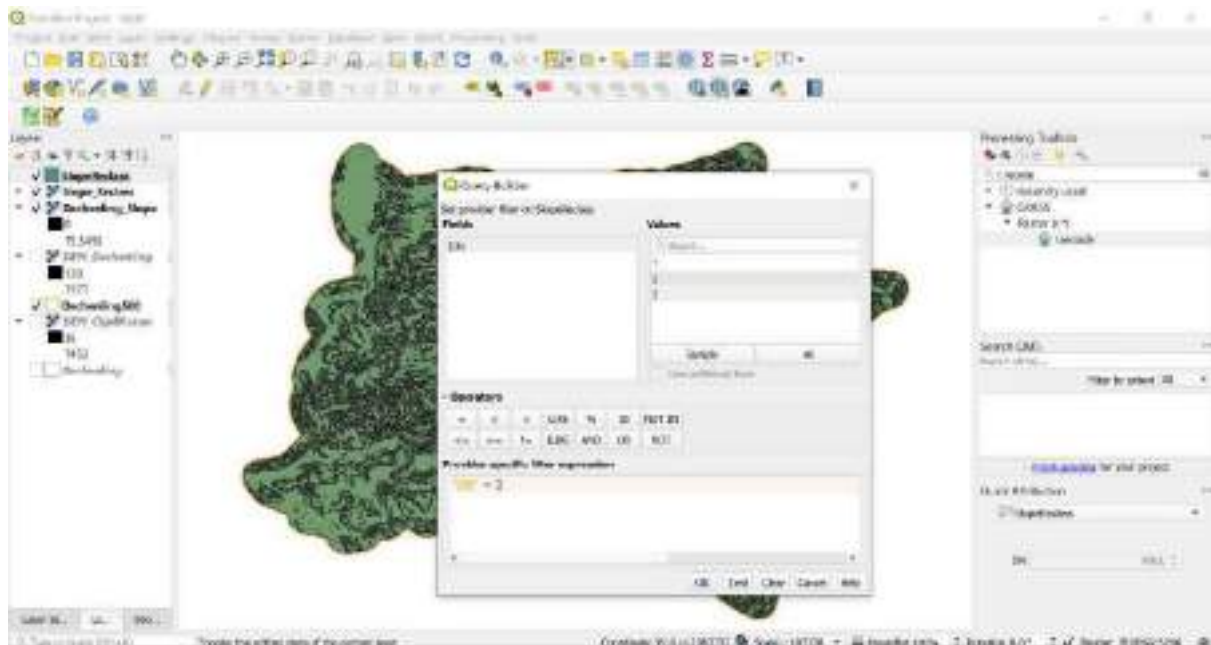




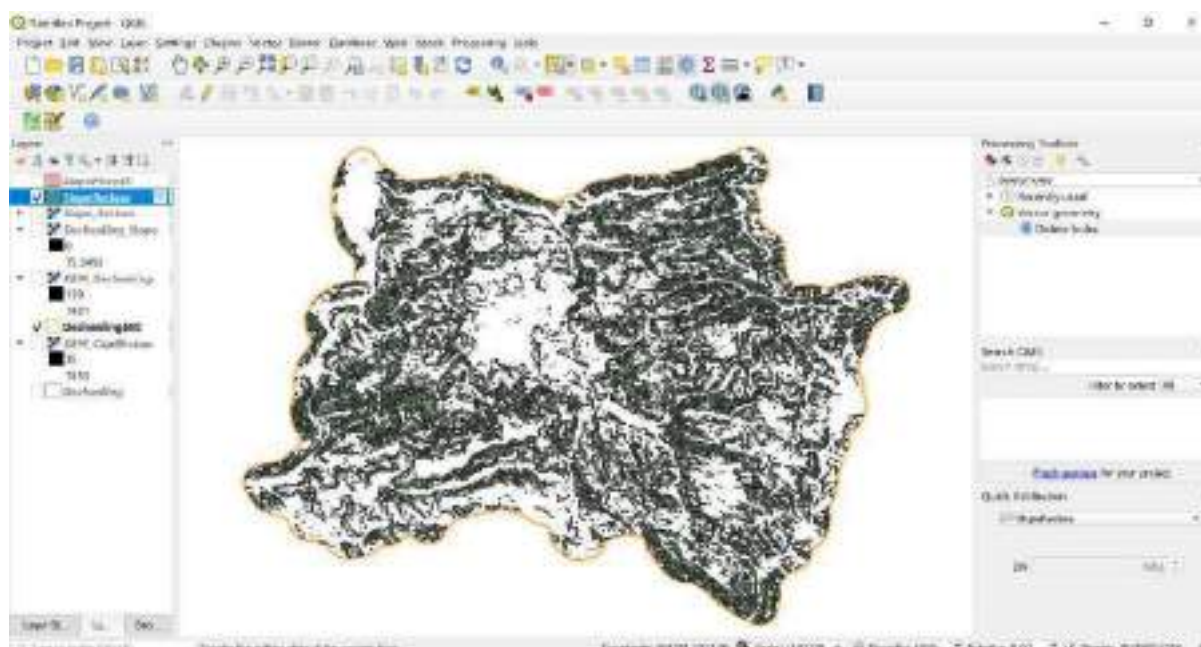


Enter expression as shown in the figure

- Double click DN > Click = sign > click All (this shall display all DN value present in attribute table) > double click 3 > ok

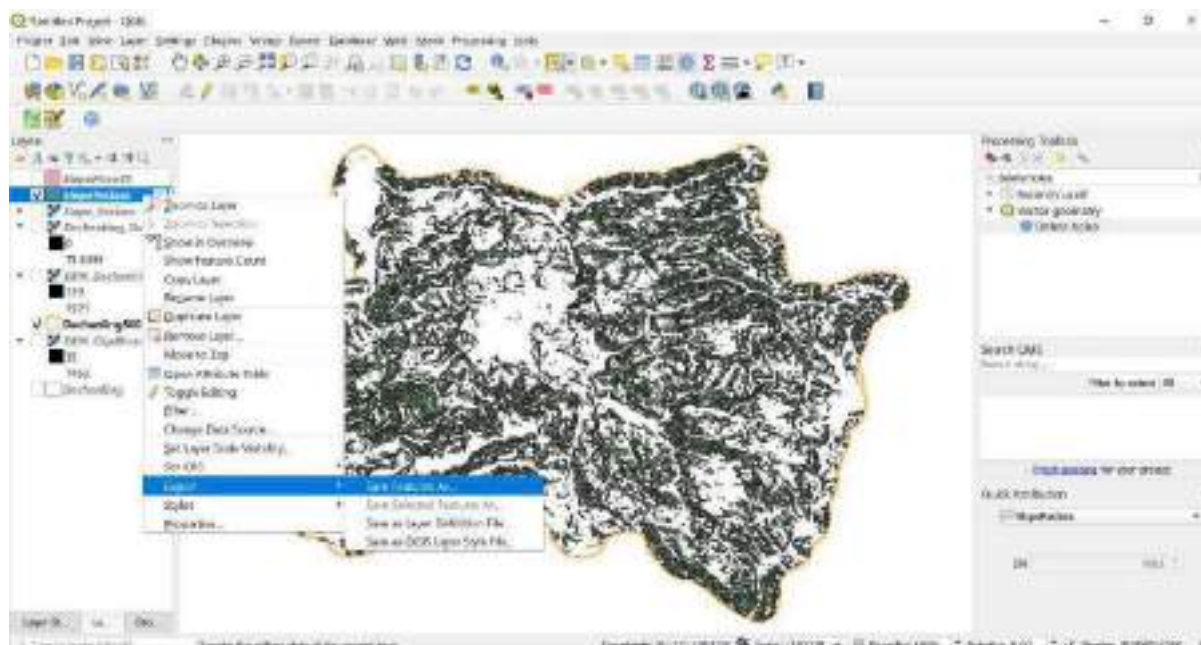


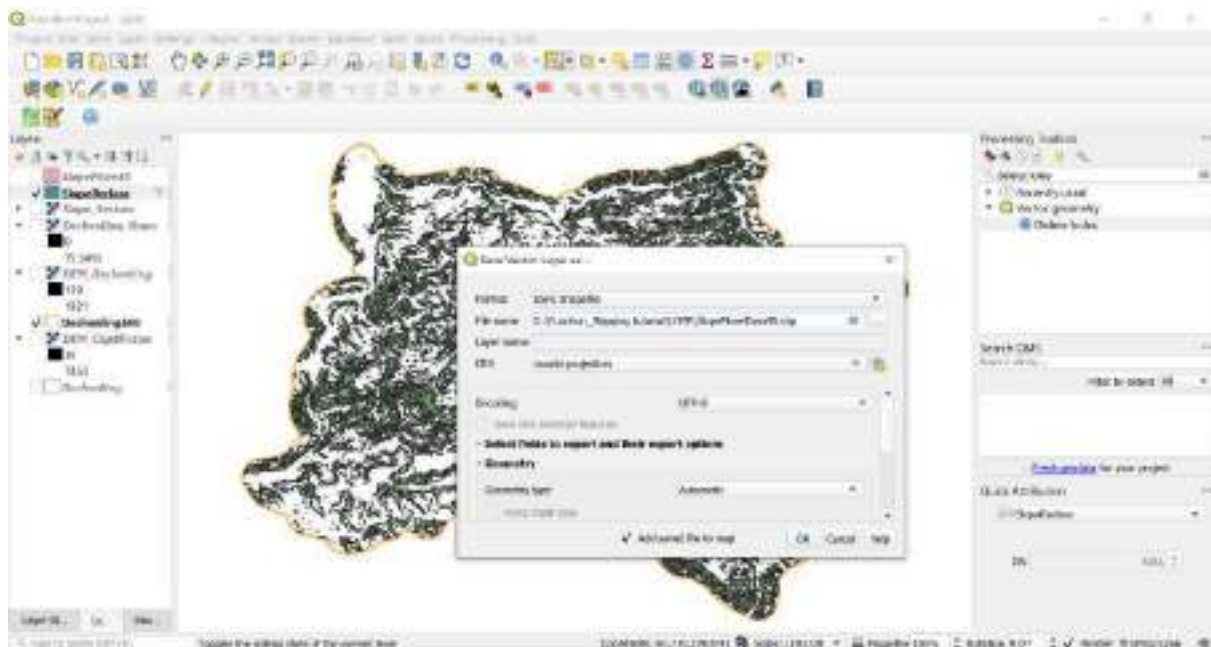




Export the selected layer

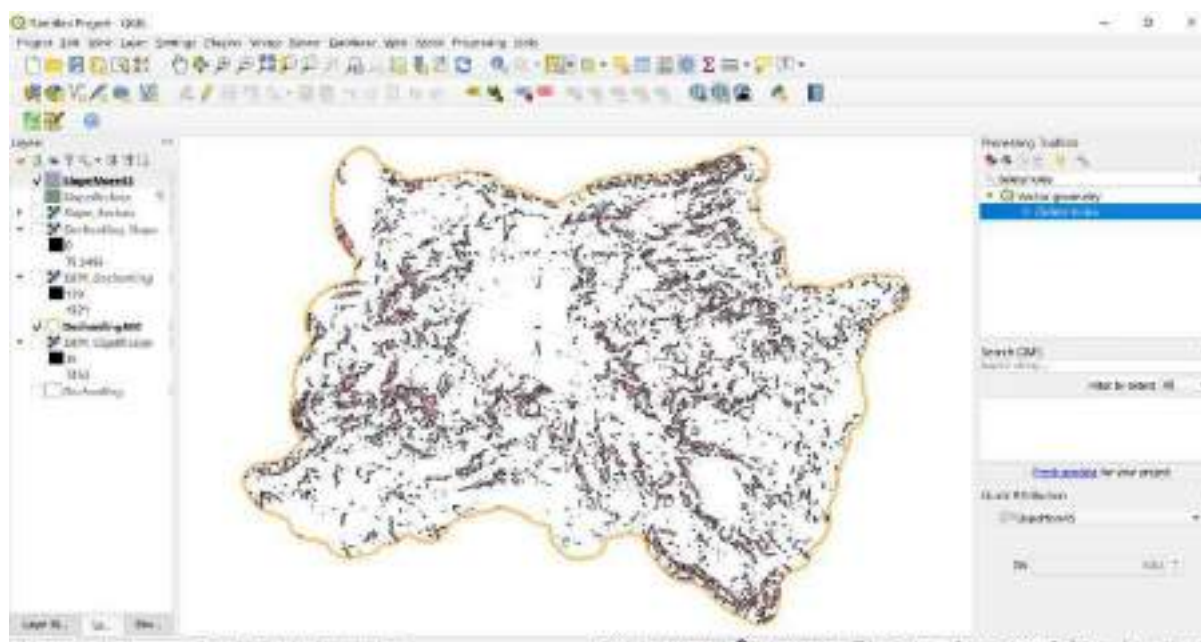
- *Right click on filtered vector reclassified slope file > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *File name: Save the file with appropriate name in working directory*
- *CRS: Select EPSG:5266-DRUKREF 03/Bhutan National Grid*
- *Click Ok*



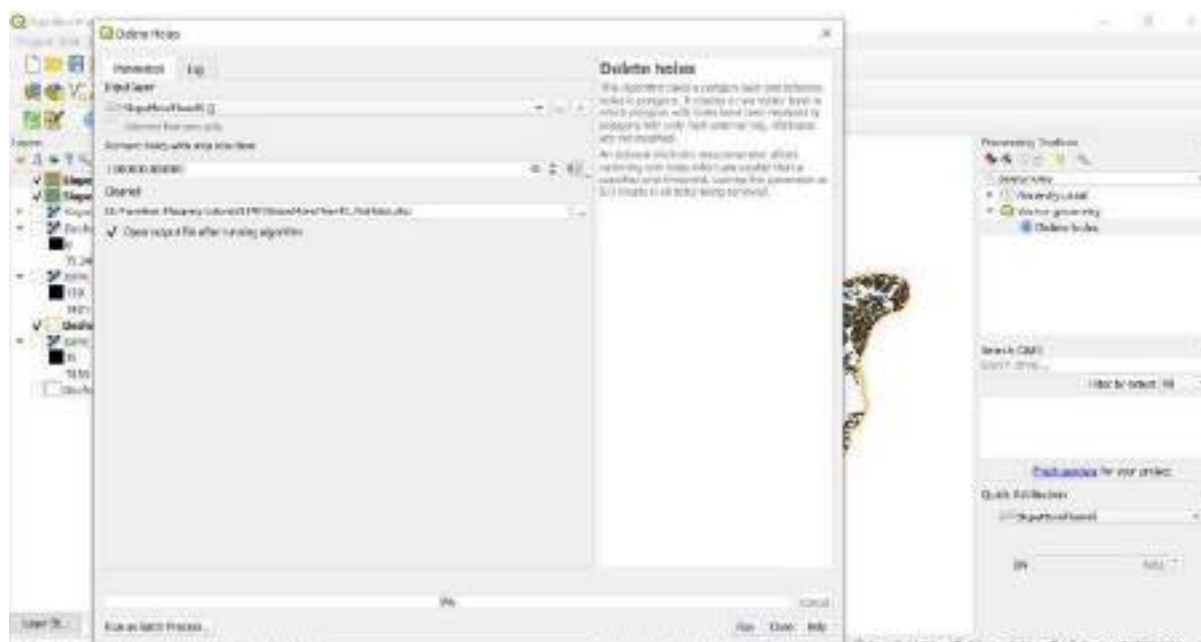


In the exported slope layer, there are several smaller areas surrounded by steep area. Accessing such areas are impossible, therefore, we need to include those areas under soil protection.

- In the Processing Toolbox type “delete holes” > double click Delete holes tools



- *In Input layer select soil protection layer*
- *In Remove holes with area less than: enter 100000 m<sup>2</sup> (10 ha)*
- *Cleaned: Save the file with appropriate name in working directory*
- *Click run*

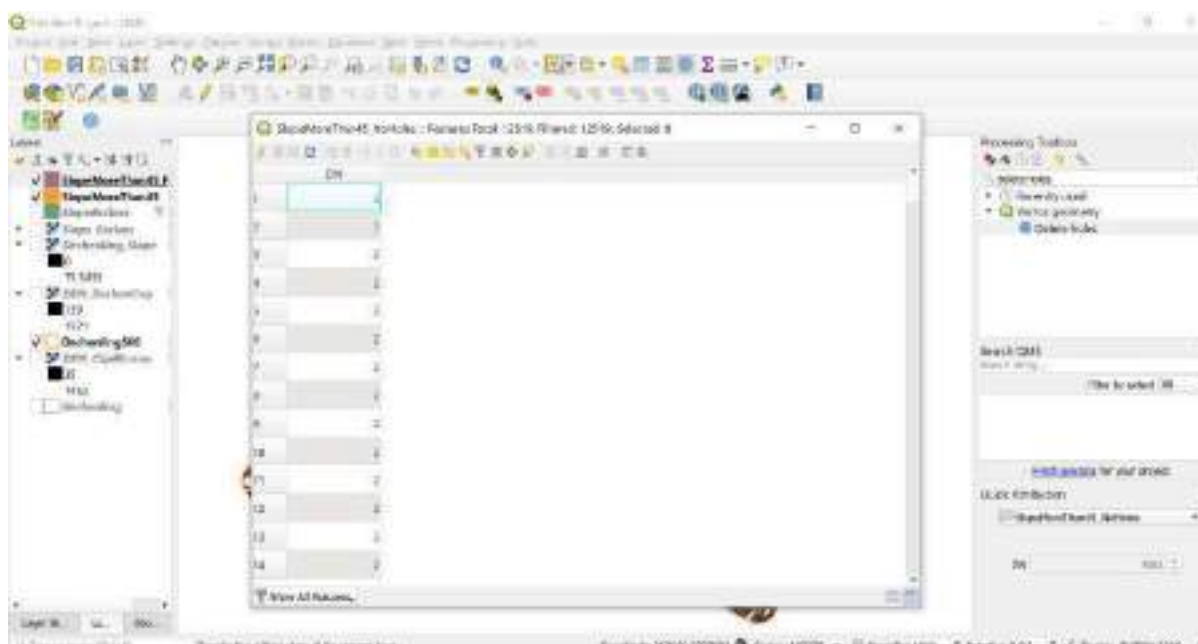
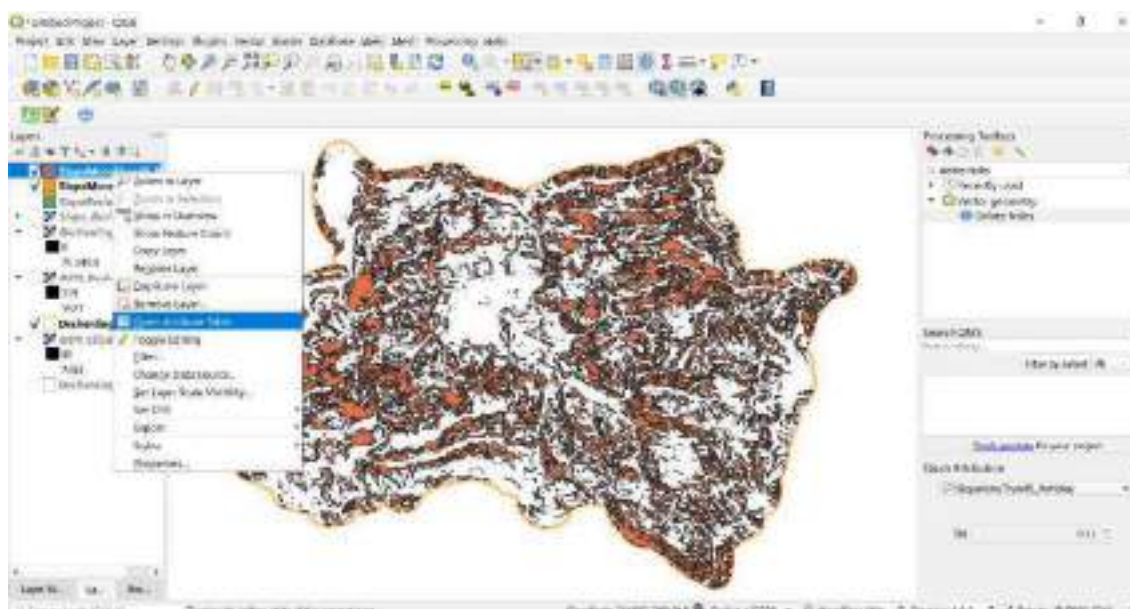






Calculate the area of layer

- Right click on layer > click Open Attribute Table

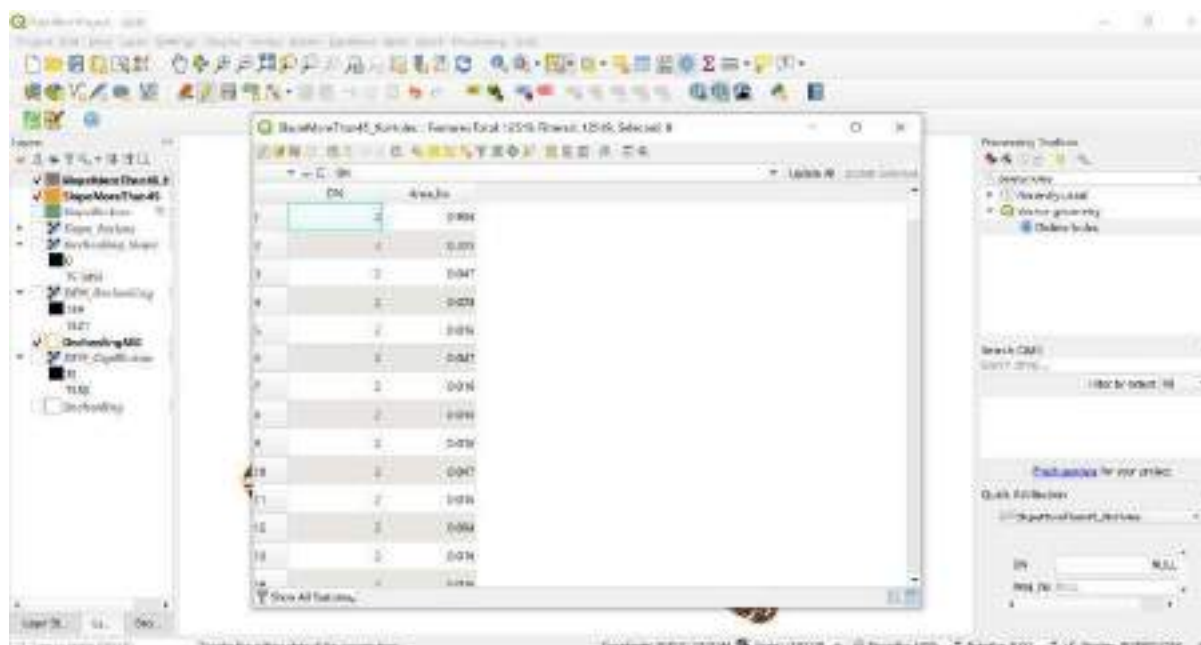
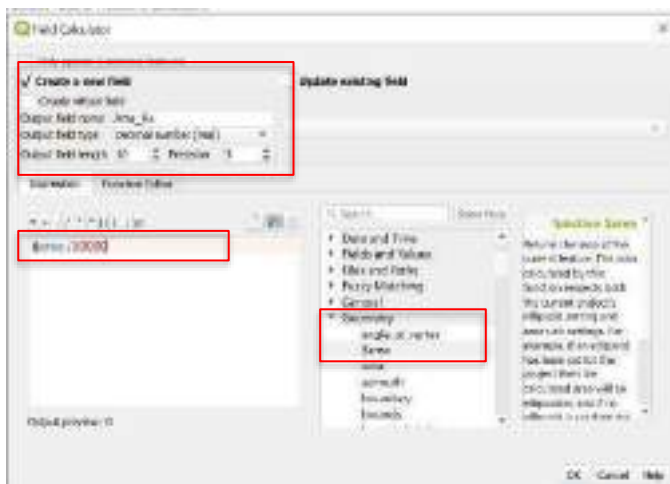


Calculate the area of each polygon

- Click Toggle editing mode > Click Open Field Calculator
- Check in the Create a new field and type as follows
  - Output field name: Area\_ha
  - Output field type: Decimal number (real)
  - Output field length 10 and Precision 3

The expression field should be filled with area calculating expression

- Click Geometry > double click \$area
- In the expression box divide \$area with 10000; this is to convert the calculated area unit from m<sup>2</sup> to hectare.

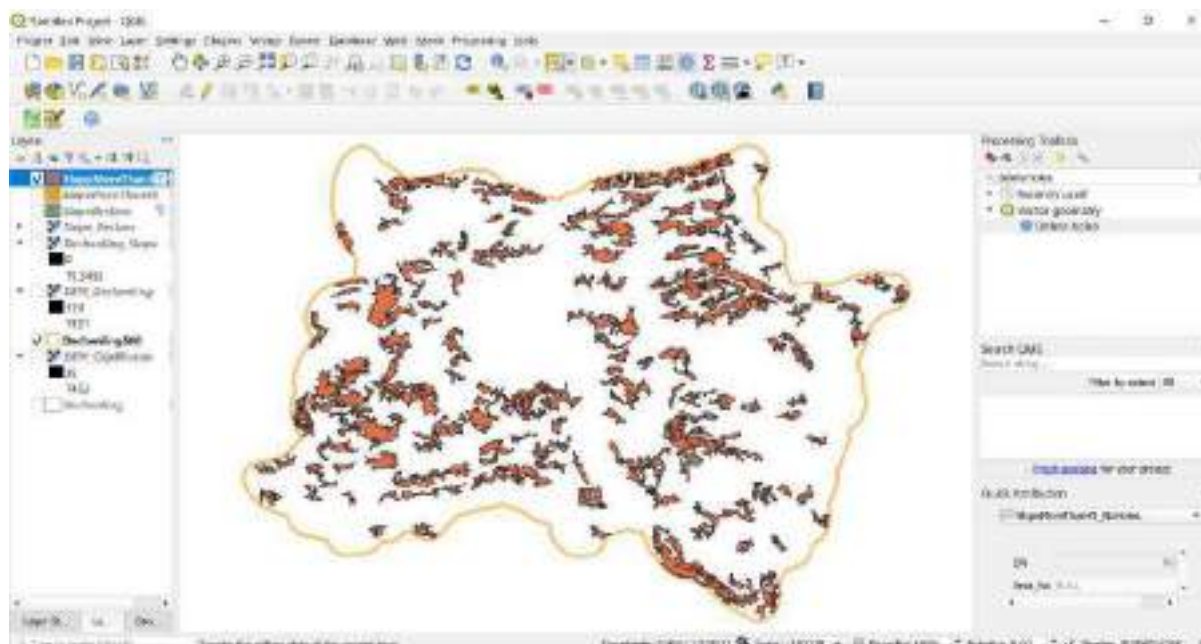
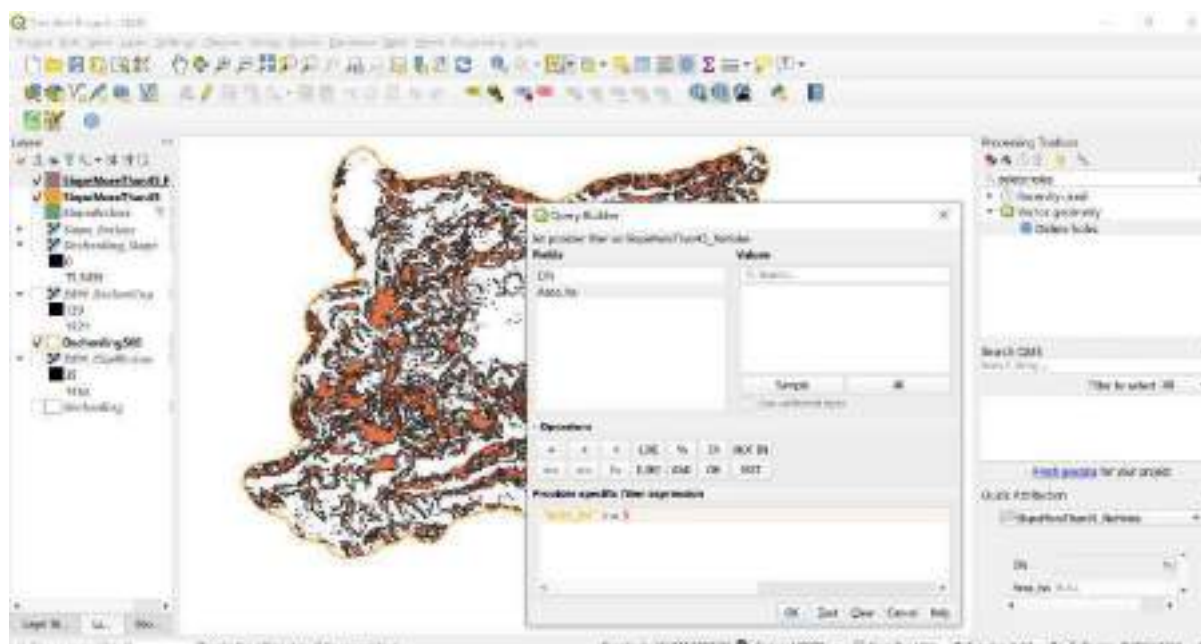


- Close the editing mode by undo toggle editing

There are also several isolated smaller steep areas, this should be removed from soil protection layer.

To remove the isolated small patches (of area less than 5 ha) of steep area, filter the area of the soil protection layer for area greater than or equal to 5 ha ( $\geq 5$  ha)

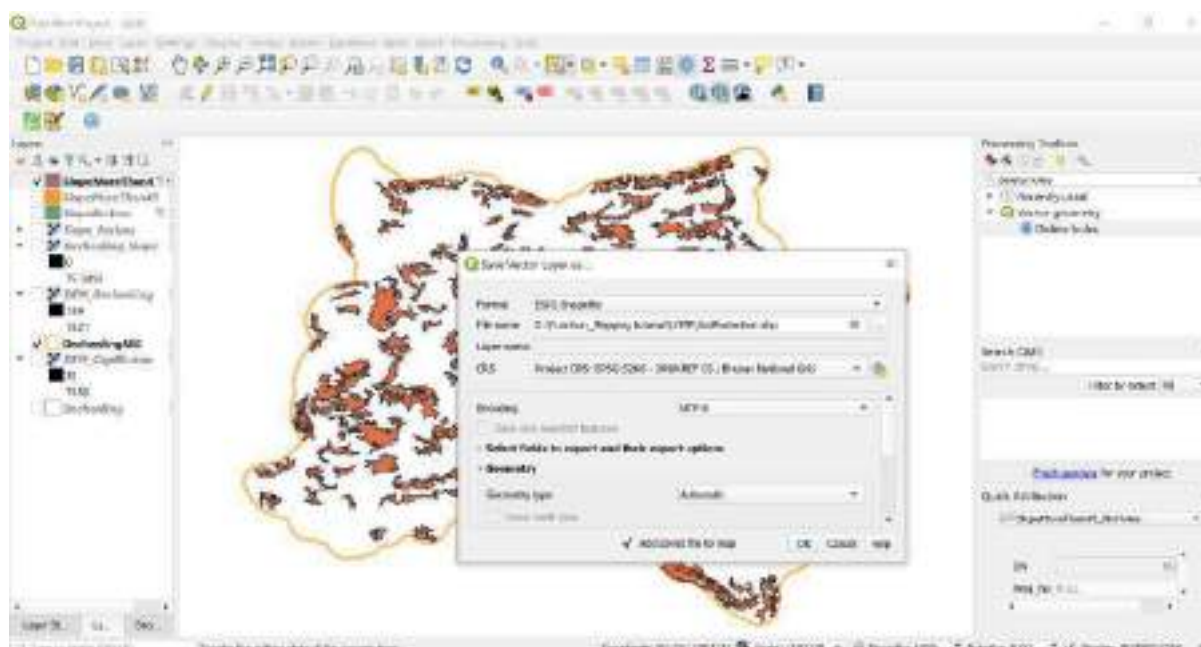
- Right click on working layer > click filter > and enter the expression as shown in picture below in Query Builder



Export the filtered layer and save it as soil protection layer

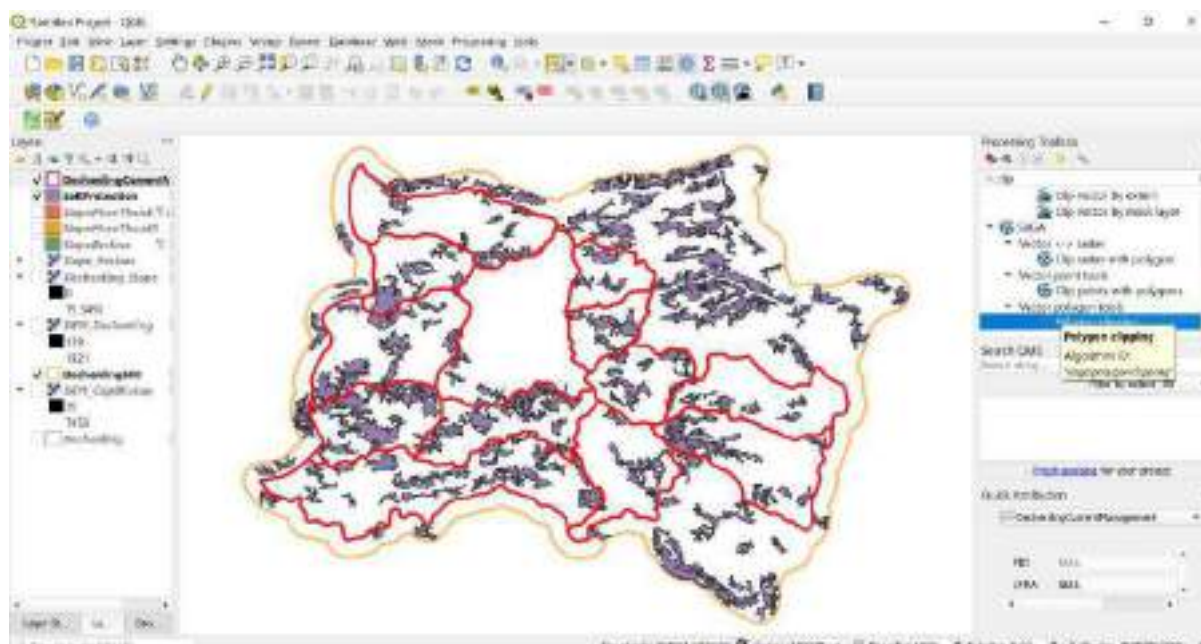
- Right click on filtered vector reclassified slope file > Export > Save Features As
- Format: Select ESRI Shapefile
- File name: Save the file with appropriate name in working directory
- CRS: Select EPSG:5266-DRUKREF 03/Bhutan National Grid
- Click Ok



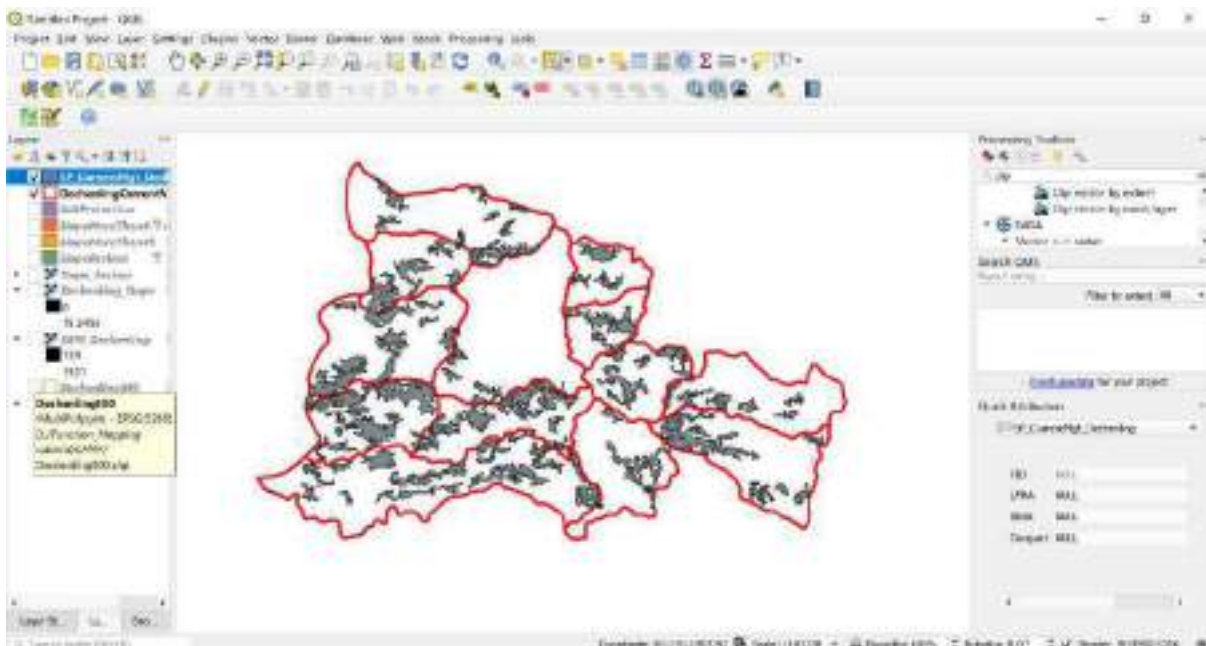
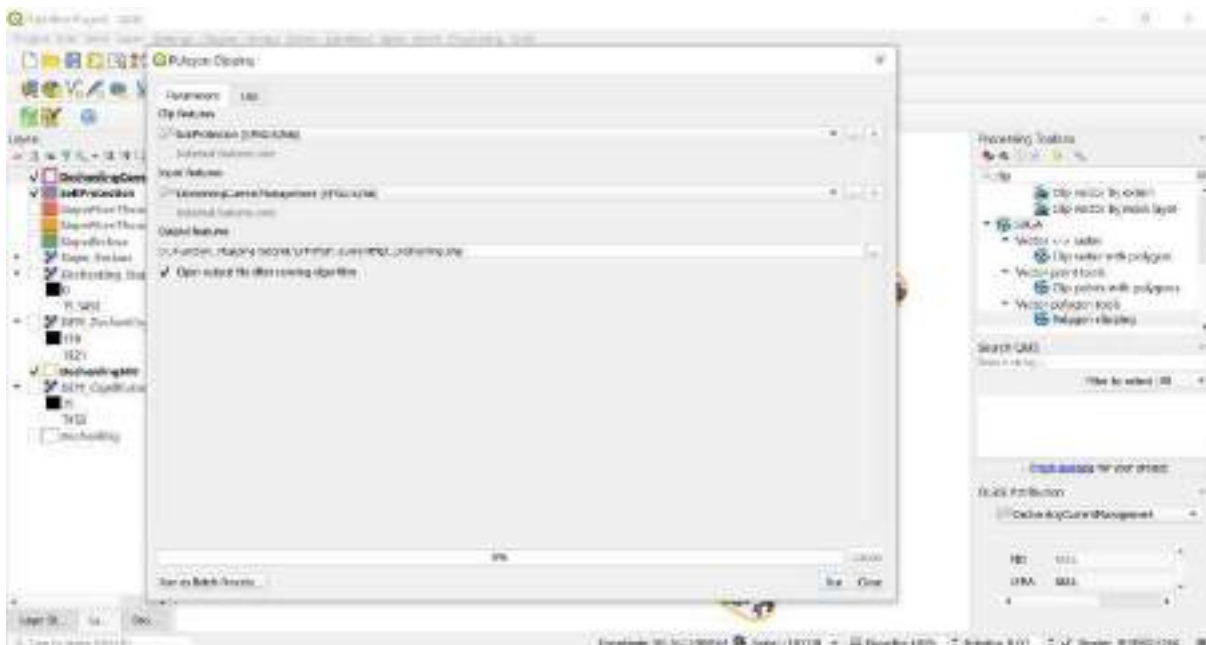


The exported soil protection layer contains area even outside the LFMA boundary as we generated the slope for 500 m buffered LFMA boundary. We also don't need soil protection in future management area. Therefore, we need to extract soil protection layer within current management LFMA boundary

- *Add current management*
- *Type clip in processing toolbox*
- *Navigate to SAGA > Vector polygon tools*
- *Select Polygon clipping*



- *In Clip features: select whole Soil protection layer*
- *In input features: select current management LFMA boundary layer*
- *Output features: Save the file with appropriate name in working directory*
- *Click run*



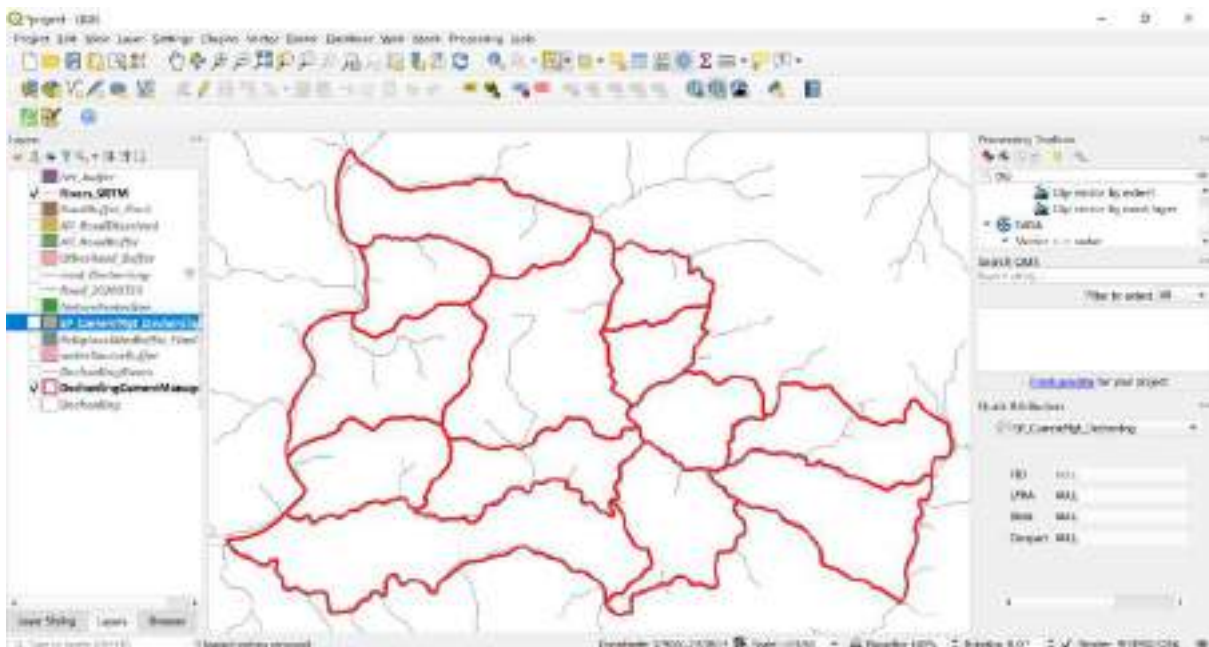
Creation of soil conservation (Protection) function is complete.

Water and Watershed Conservation Function

GIS Steps

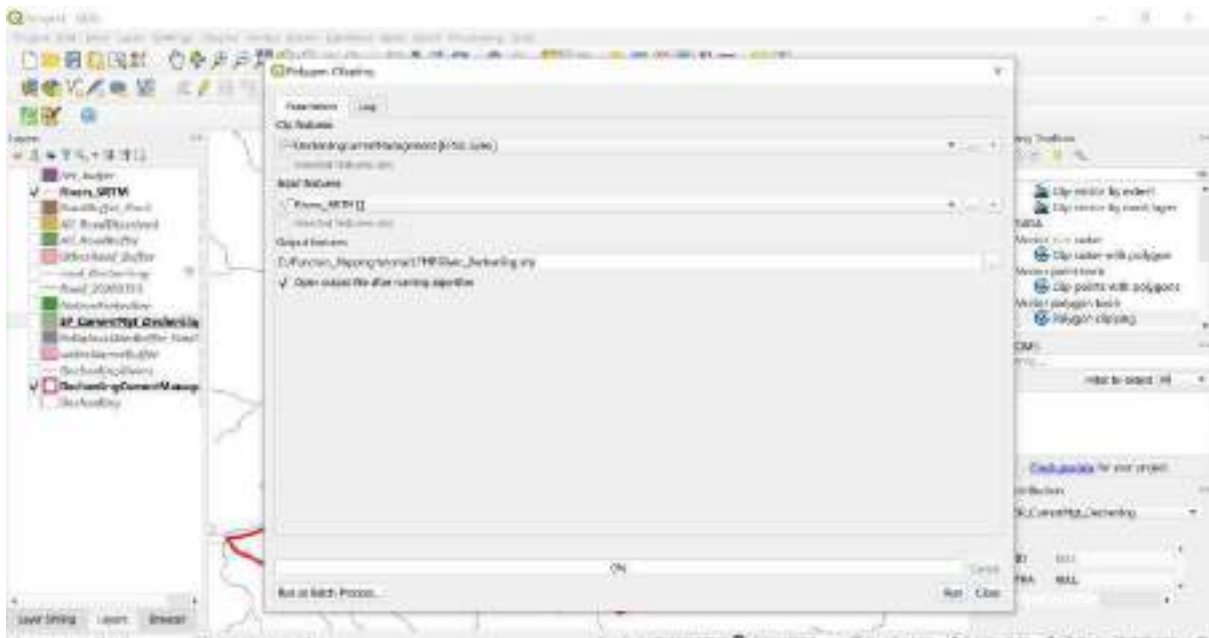
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to used QGIS version 3.12 and above.

- *Open QGIS*
- *Add LFMA boundary layer*
- *Add River networks layer*

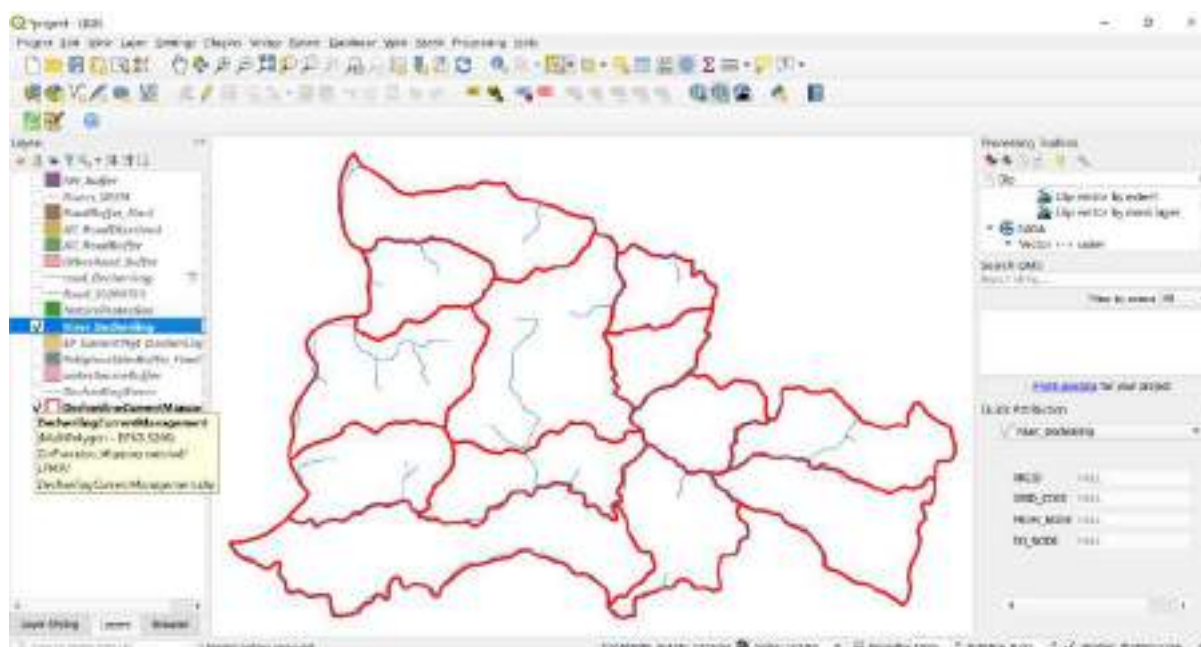


#### Clip with LFMA Boundary

- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select LFMA boundary layer*
- *In input features: select River network layer*
- *Output features: Save the file with appropriate name in working directory*
- *Click Run*

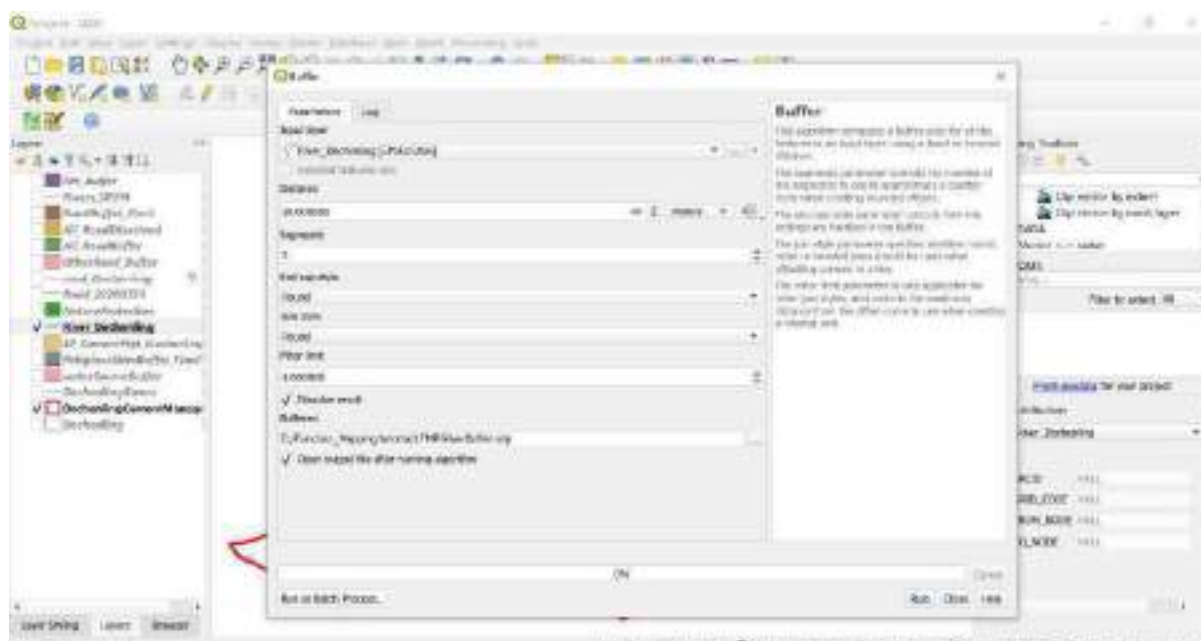


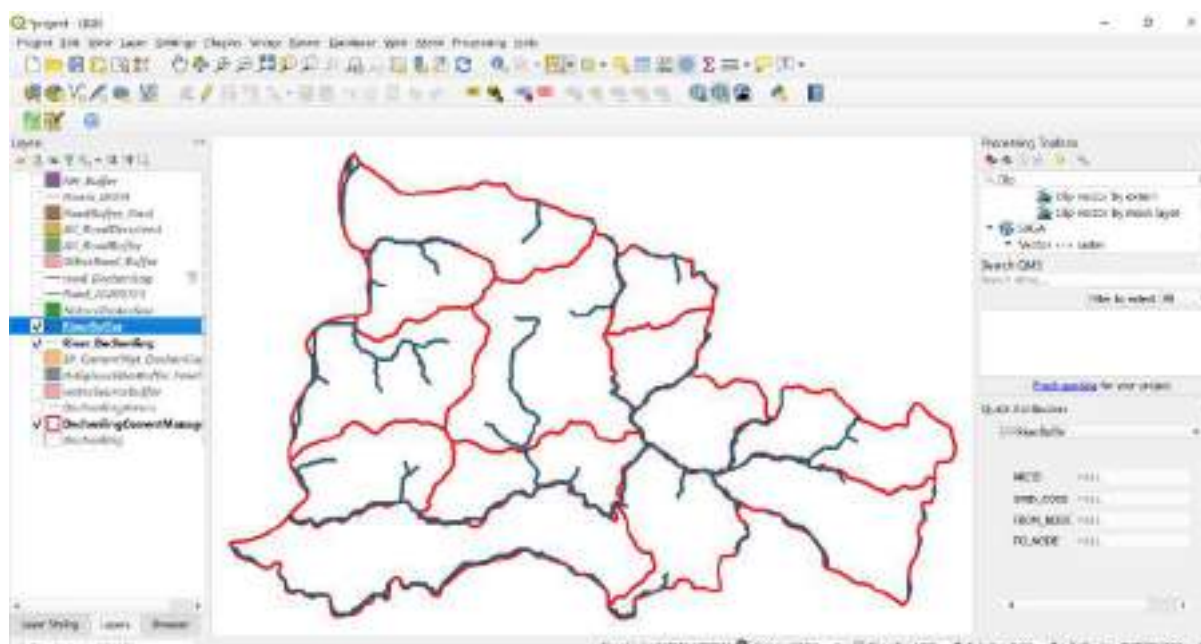




Create buffer of 30m around the rivers

- Click Vector > Geoprocessing Tools > Buffer
- In Input layer: Select river layer
- In distance: enter 30
- Check dissolve result
- Rest parameter leave as default
- Buffered: Save the file with appropriate name in working directory
- Click run

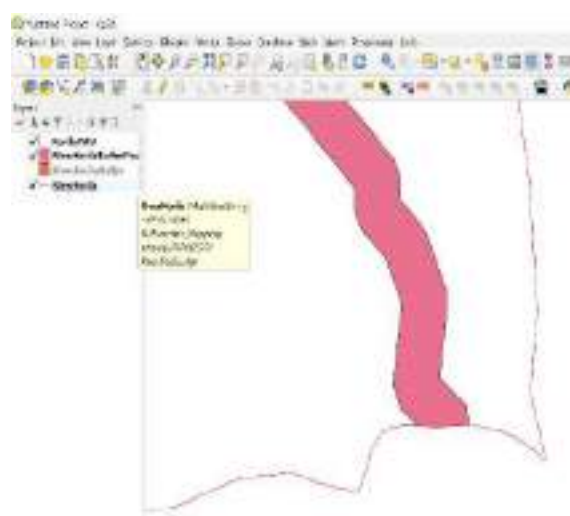
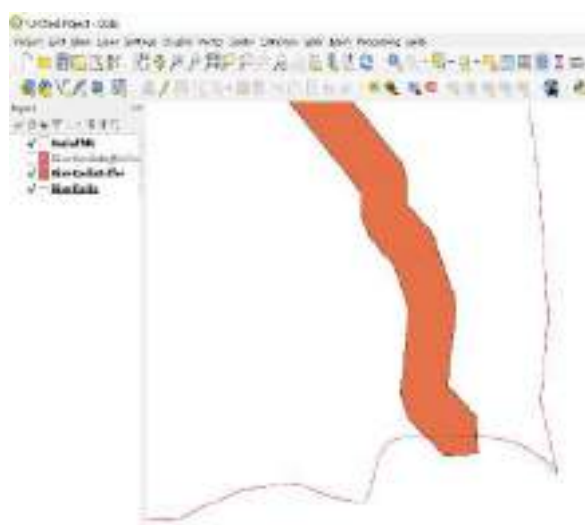




The exported river buffer layer extends beyond current management LFMA boundary. Therefore, we need to extract river buffer layer within LFMA boundary

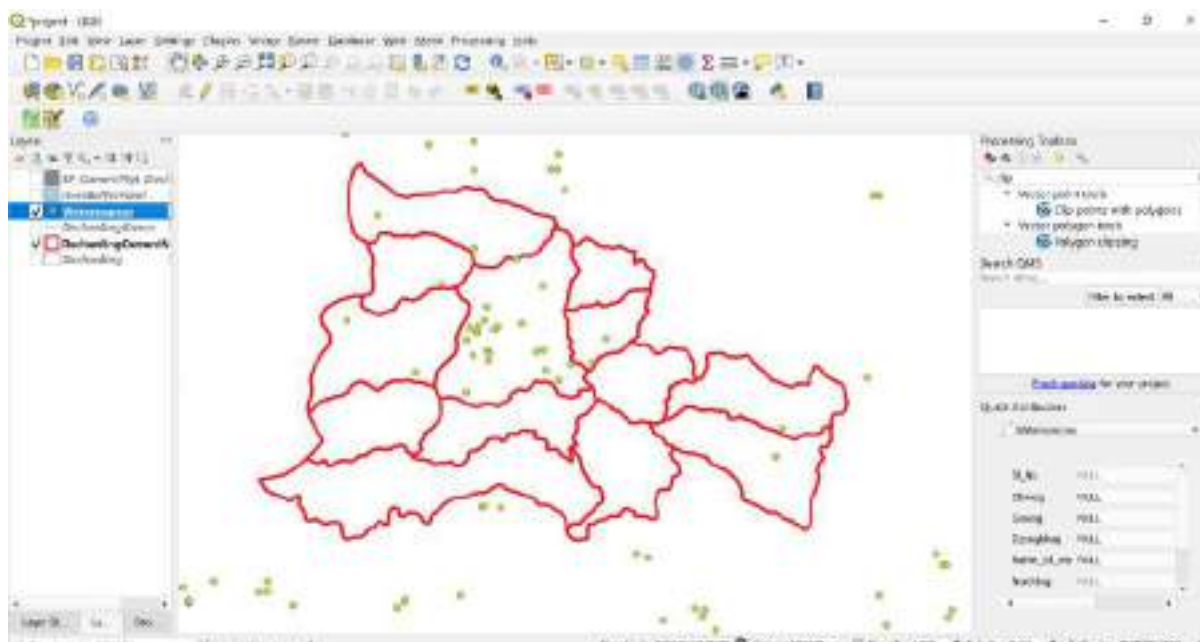
#### Clip with LFMA Boundary

- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select LFMA boundary layer*
- *In Input features: select river buffer layer*
- *Output features: Save the file with appropriate name in working directory*



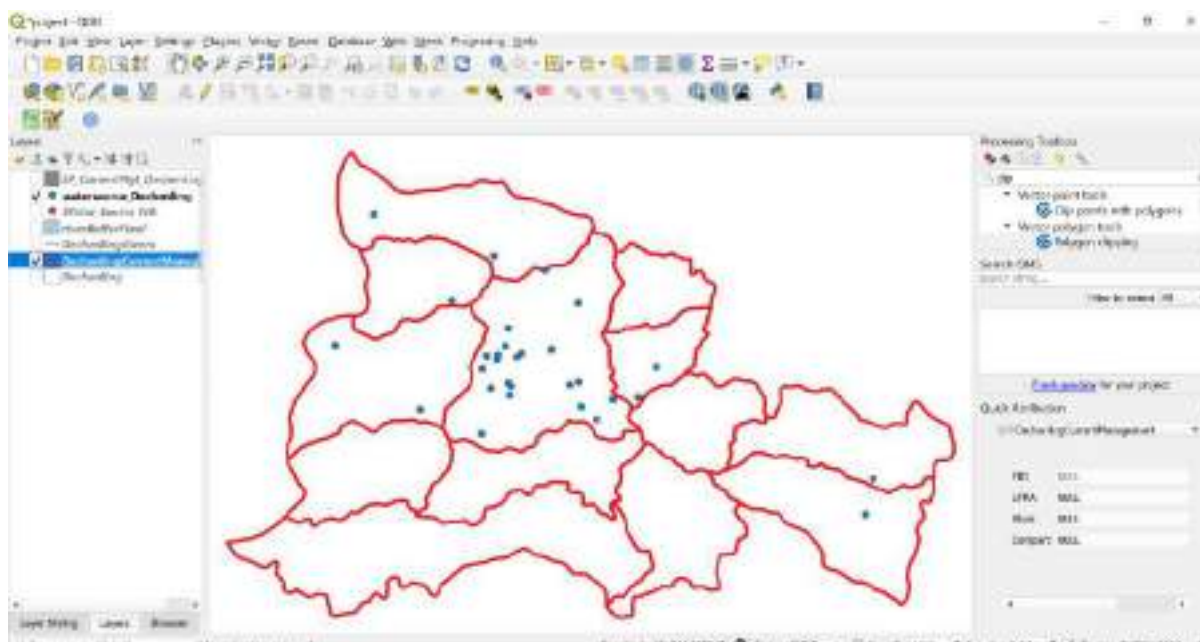
Note: Any stream that is being used as source of local water supply needs to be mapped as local water supply by generating 60m buffer on either side.

- *Add water source point layer*



#### Clip with LFMA Boundary

- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select LFMA boundary layer*
- *In Input features: select water source point layer*
- *Output features: Save the file with appropriate name in working directory*
- *Click Run*



#### Create buffer of 60m around the water source point

- *Click Vector > Geoprocessing Tools > Buffer*
- *In Input layer: Select water source point layer*
- *In distance: enter 60*
- *Check dissolve result*
- *Rest parameter leave as default*
- *Buffered: Save the file with appropriate name in working directory*



If the generated buffer is extending beyond LFMA boundary, it needs to be clipped with LFMA boundary.

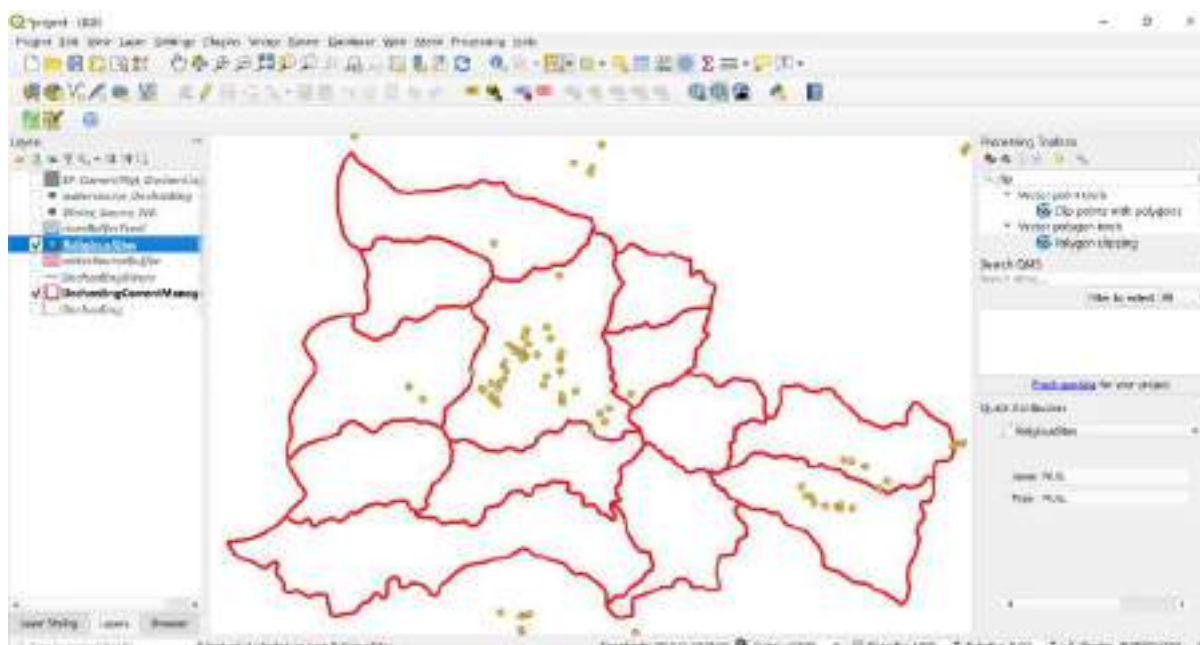
Note: If there is any wetland or watershed area that demands protection from sustainable timber harvesting, then such area can be designated as watershed special management area.

Social Function

GIS Steps

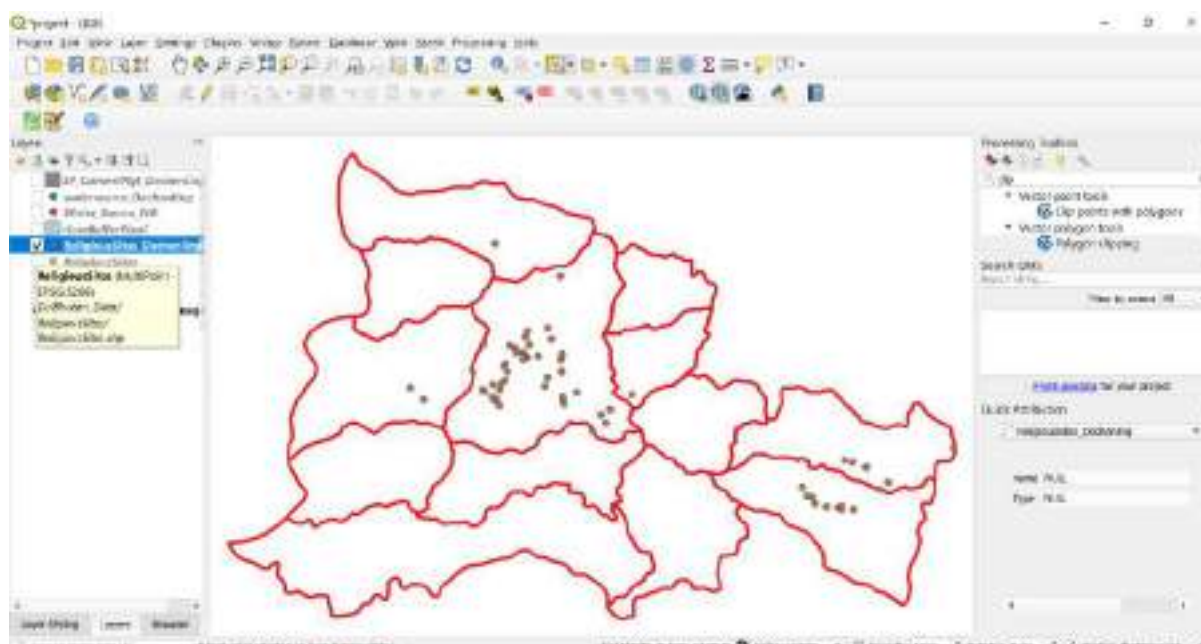
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

- *Open QGIS*
- *Add FMU boundary layer*
- *Add Religious sites layer*



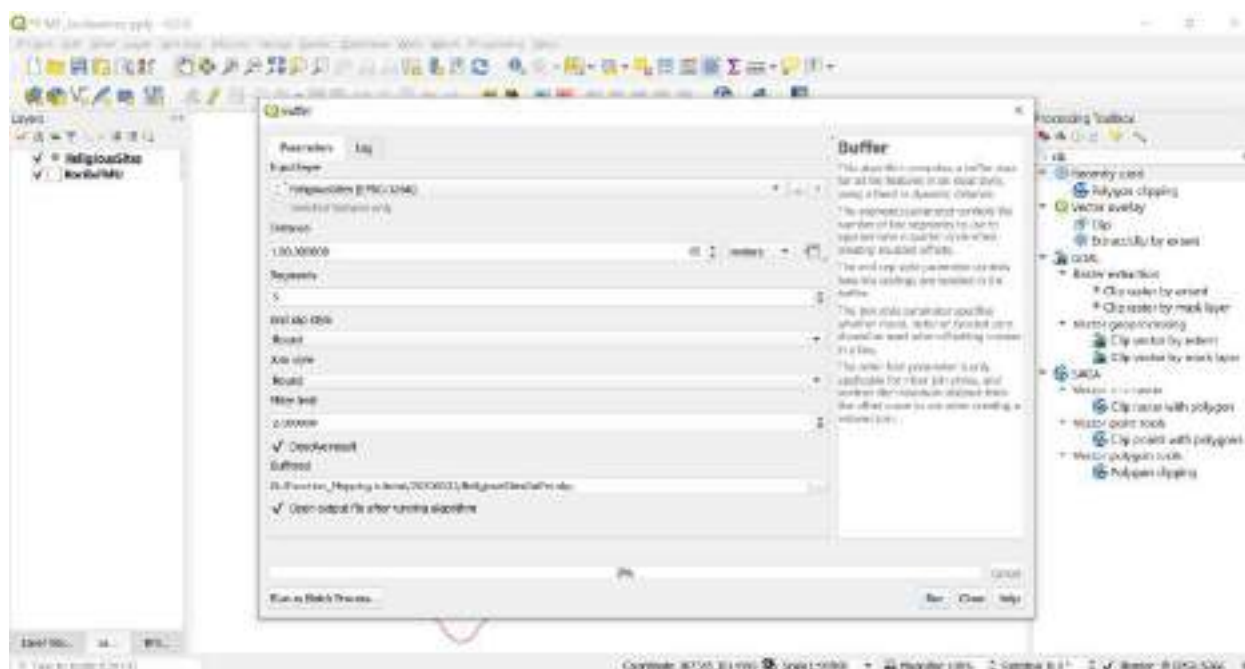
Clip with LFMA Boundary

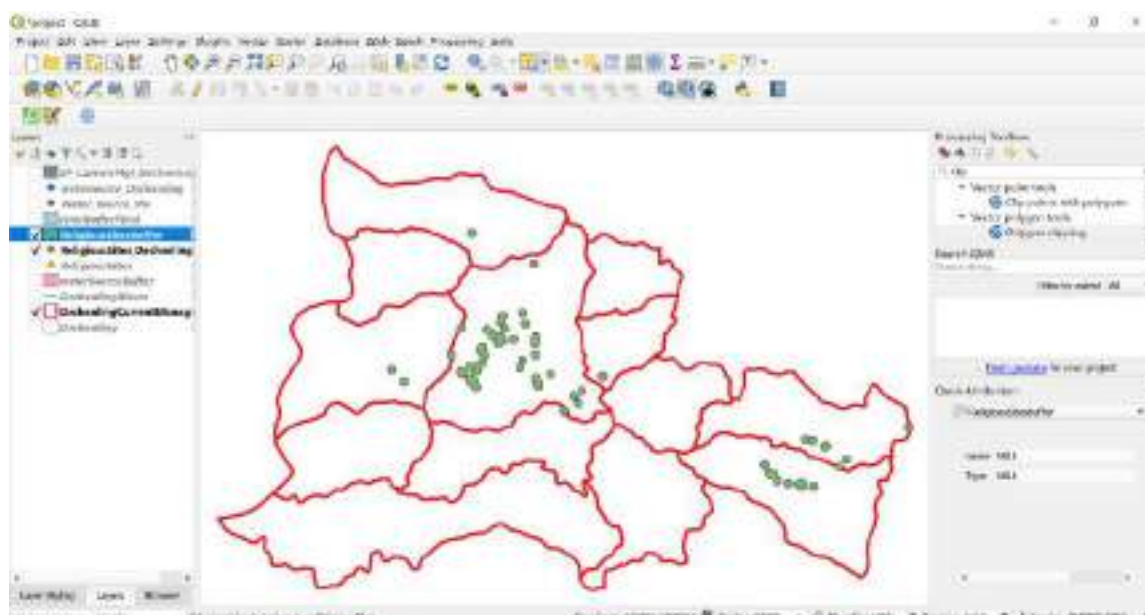
- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select LFMA boundary layer*
- *In input features: select religious site point layer*
- *Output features: Save the file with appropriate name in working directory*
- *Click Run*



Create buffer of 100m around religious sites

- Click *Vector > Geoprocessing Tools > Buffer*
- In *Input layer*: Select water source point layer
- In *distance*: enter 100
- Check *dissolve result*
- Rest parameter leave as default
- *Buffered*: Save the file with appropriate name in working directory
- Click *Run*





Since the buffer is extending beyond the current management LFMA boundary, clip religious sites buffer with LFMA boundary

Clip with LFMA Boundary

- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select FMU boundary layer*
- *In input features: select religious site buffer layer*
- *Output features: Save the file with appropriate name in working directory*
- *Click Run*

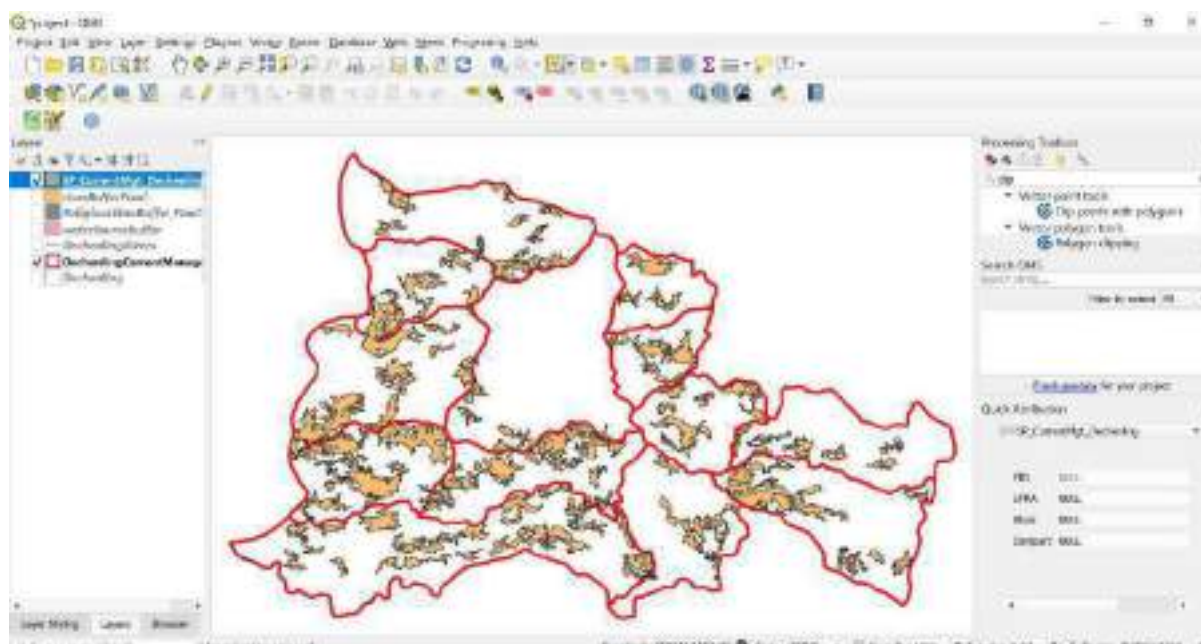


Nature Conservation Function

If there is any threatened and protected flora, fauna and avi-fauna is present within the LFMA boundary, their habitat should be mapped out using GPS or other technology. If there are no such threatened and protected species, mapping this function may not be necessary. Similarly, in this LFMA, there are no such species. In such cases, soil protection function can be an overlapping function. Soil protection function can be also mapped as wildlife protection function.

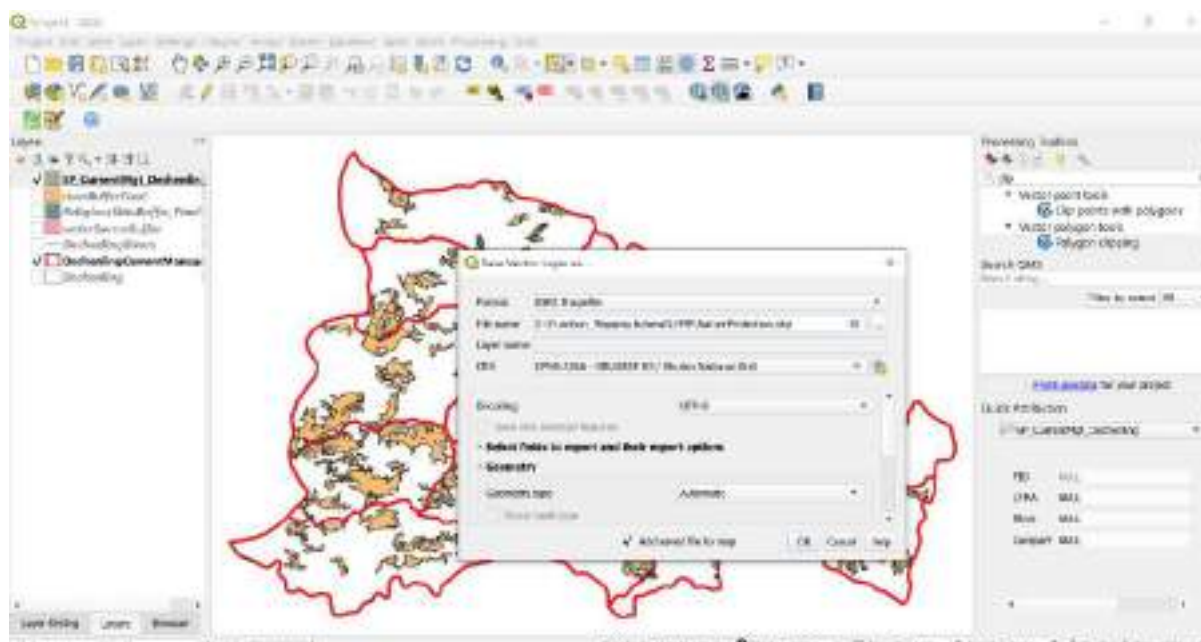
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to used QGIS version 3.12 and above.

- *Open QGIS*
- *Add FMU boundary layer*
- *Add Soil Protection layer*

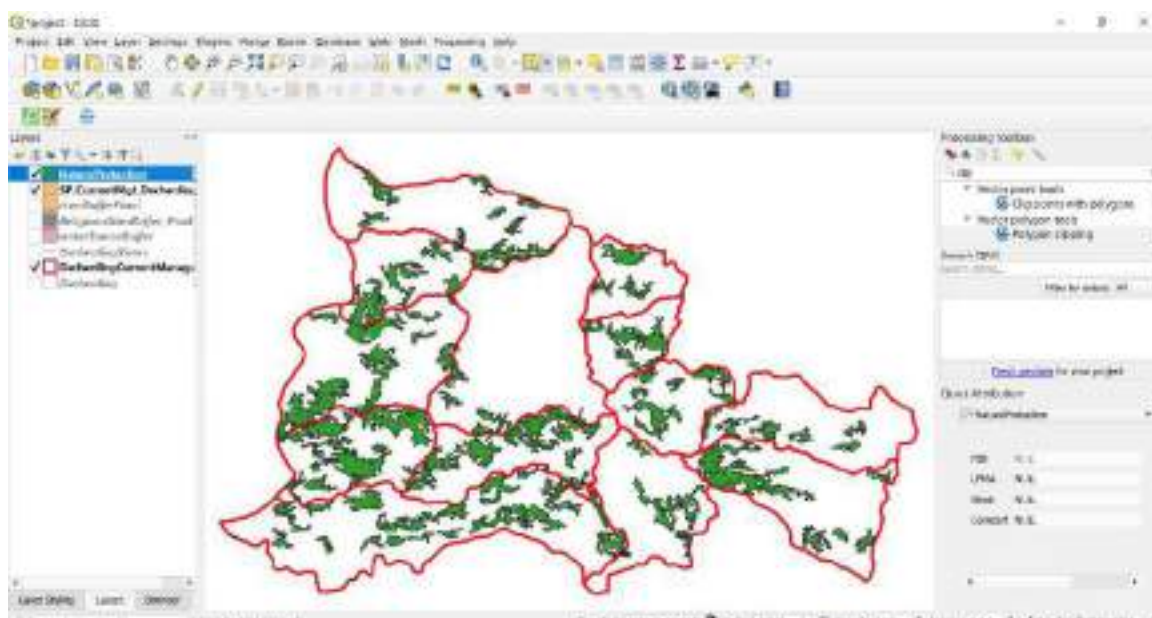


Export this soil protection layer as wildlife protection layer

- Right click on filtered vector reclassified slope file > Export > Save Features As
- File name: Save the file with appropriate name in working directory





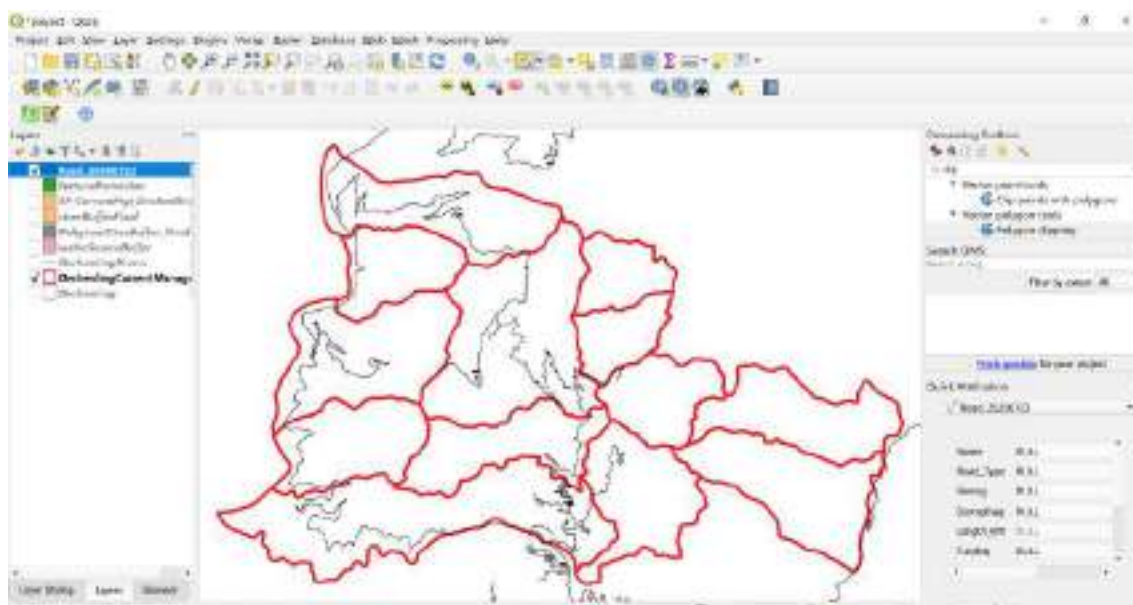


### Road Buffer

### GIS Steps

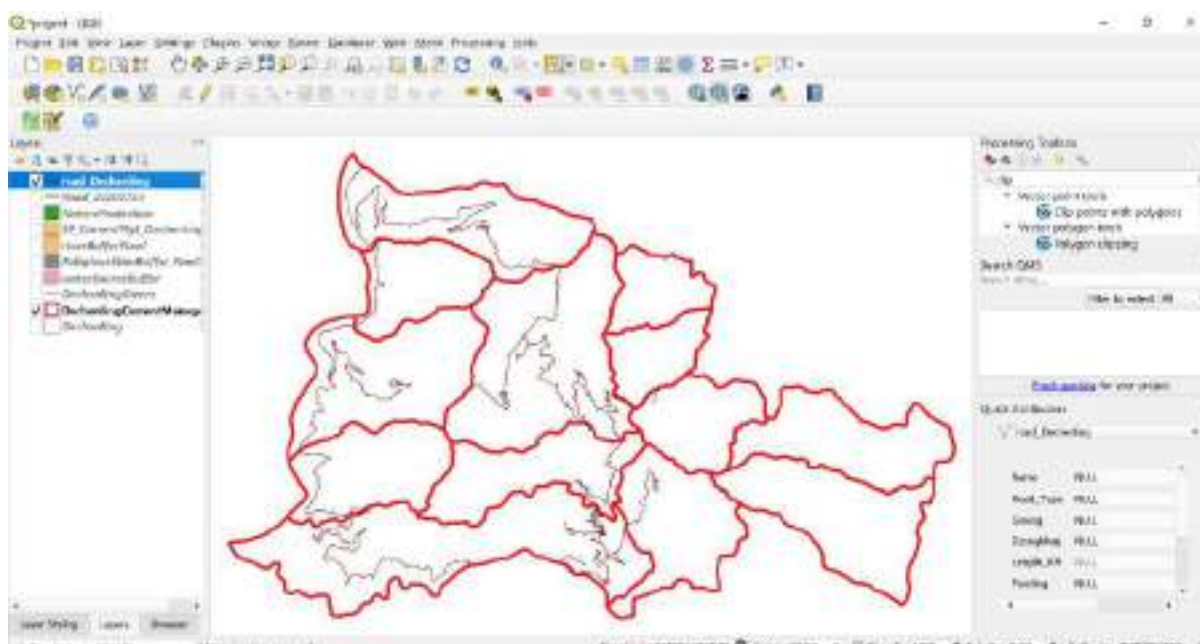
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

- *Open QGIS*
- *Add current management LFMA boundary layer*
- *Add Road network layer*



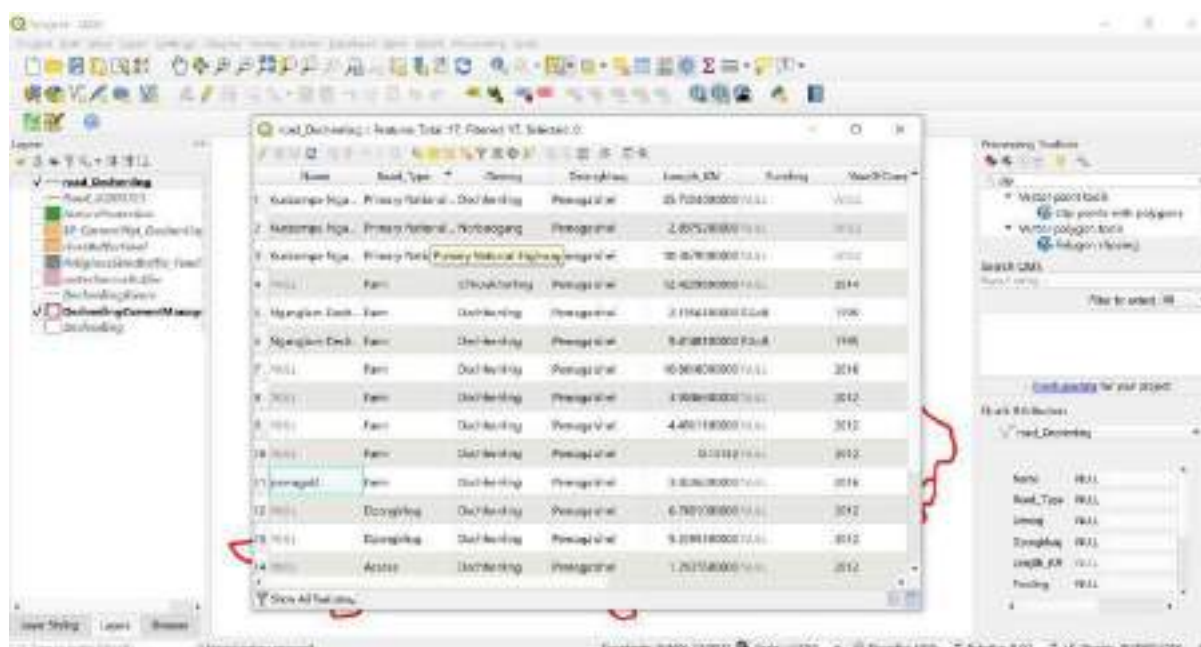
### Clip with current management LFMA Boundary

- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select LFMA boundary layer*
- *In input features: select road network layer*
- *Output features: Save the file with appropriate name in working directory*
- *Click Run*



Open attribute table and look at the column Road\_Type. There are different types of road

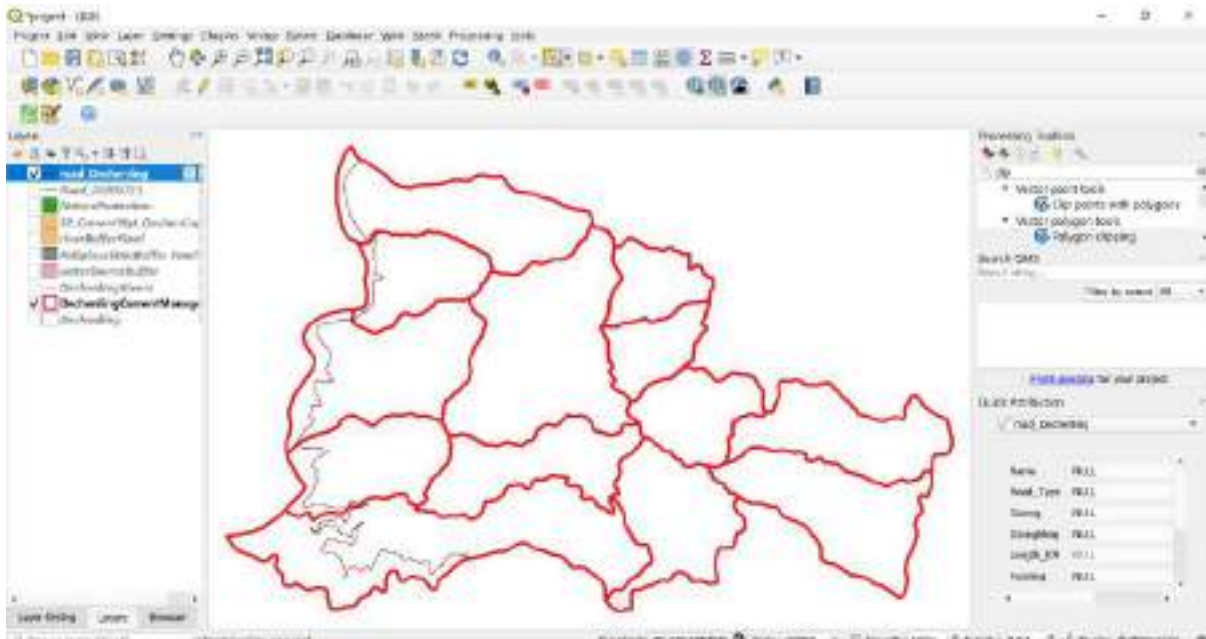
- Right click on Road layer > Click Open attribute table



Select Primary National Highway through filtering process

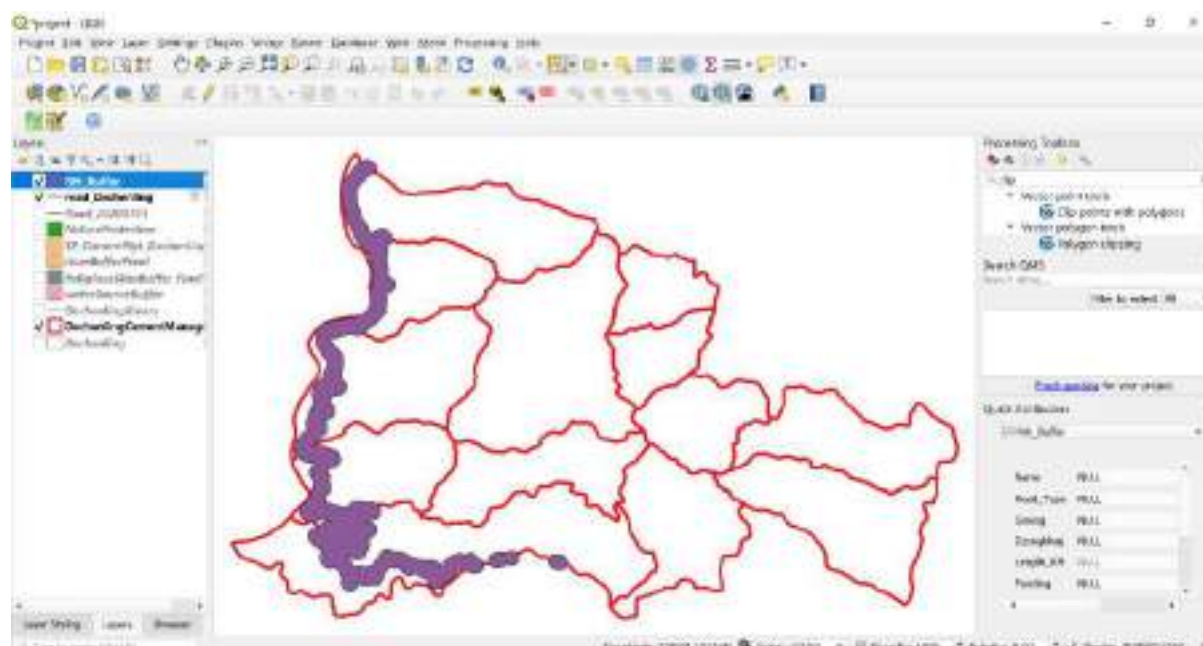
- Right click road network layer > Filter
- Enter expression as shown in the figure
- Double click Road\_Type > Click = sign > click All (this shall display road types present in attribute table) > double click Primary National Highway > ok





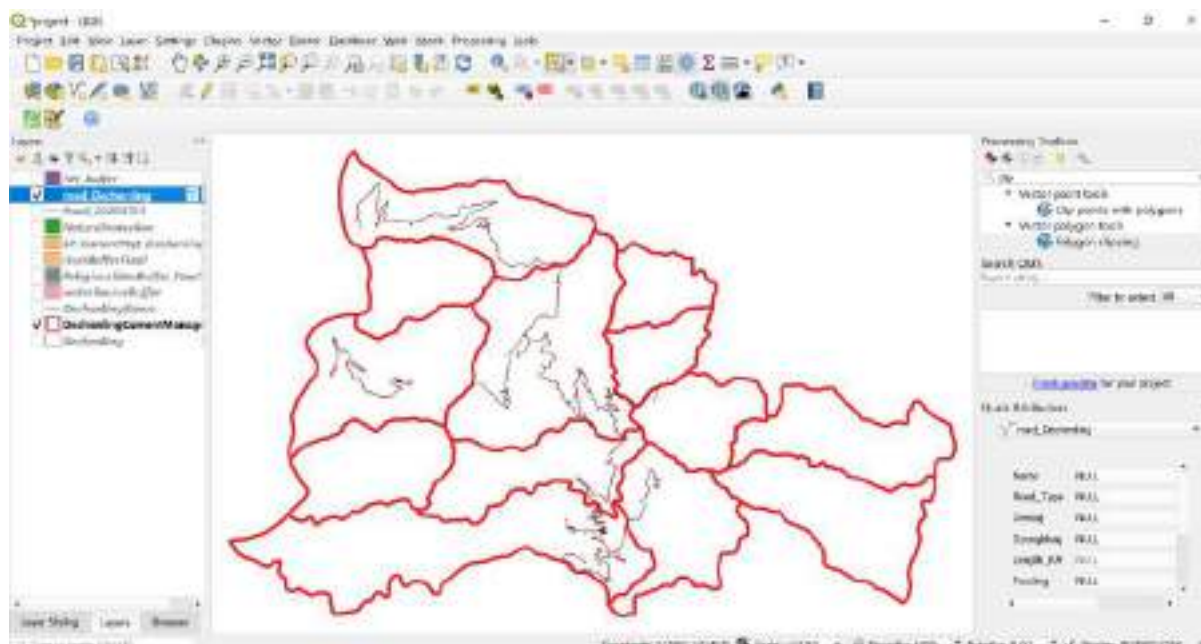
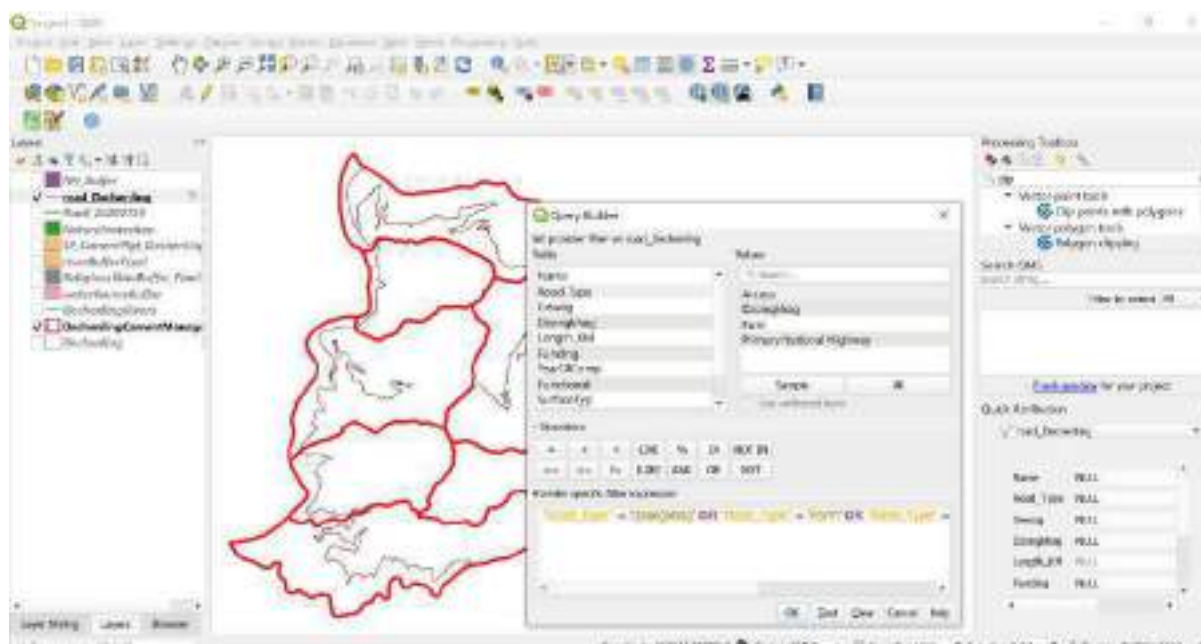
Create buffer of 180 m on either side of Primary National Highway

- Click Vector > Geoprocessing Tools > Buffer
- In Input layer: Select filtered Primary National Highway layer
- In distance: enter 180
- Check dissolve result
- Rest parameter leave as default
- Buffered: Save the file with appropriate name in working directory
- Click Run



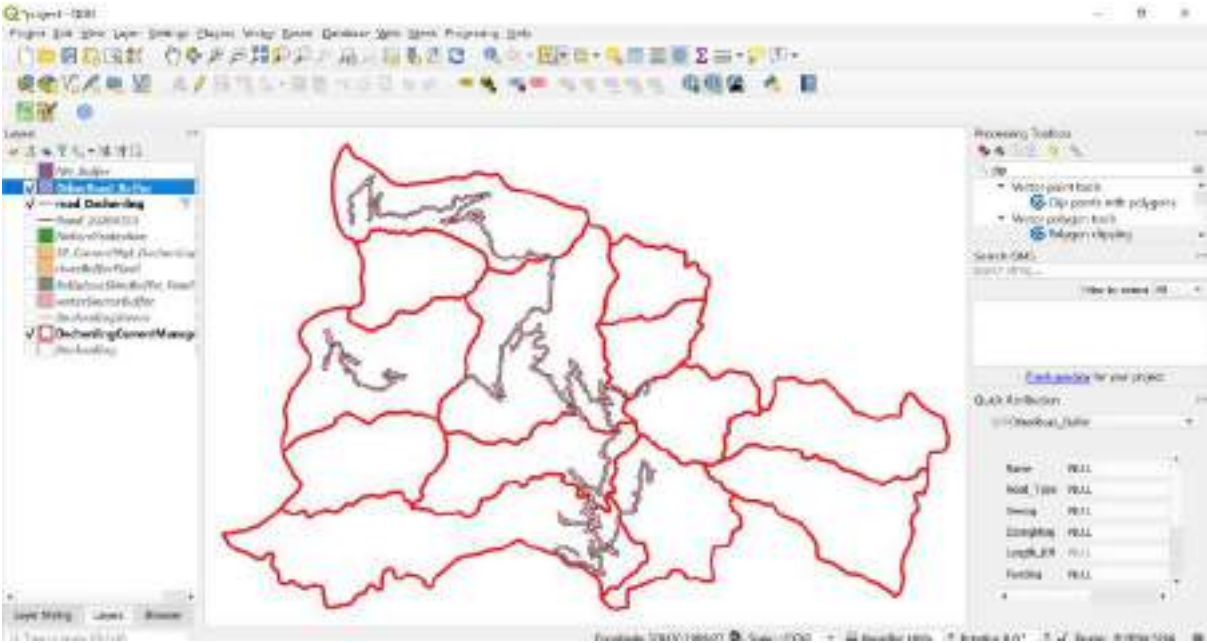
Select Dzongkhag Road, Farm Road, Access Road and Thromde Road

- Right click road network layer > Filter
- Click Clear the selection
- Enter expression following expression:  
`"Road_Type" = 'Access' OR "Road_Type" = 'Dzongkhag' OR "Road_Type" = 'Farm' OR "Road_Type" = 'Thromde'`
- Click Ok



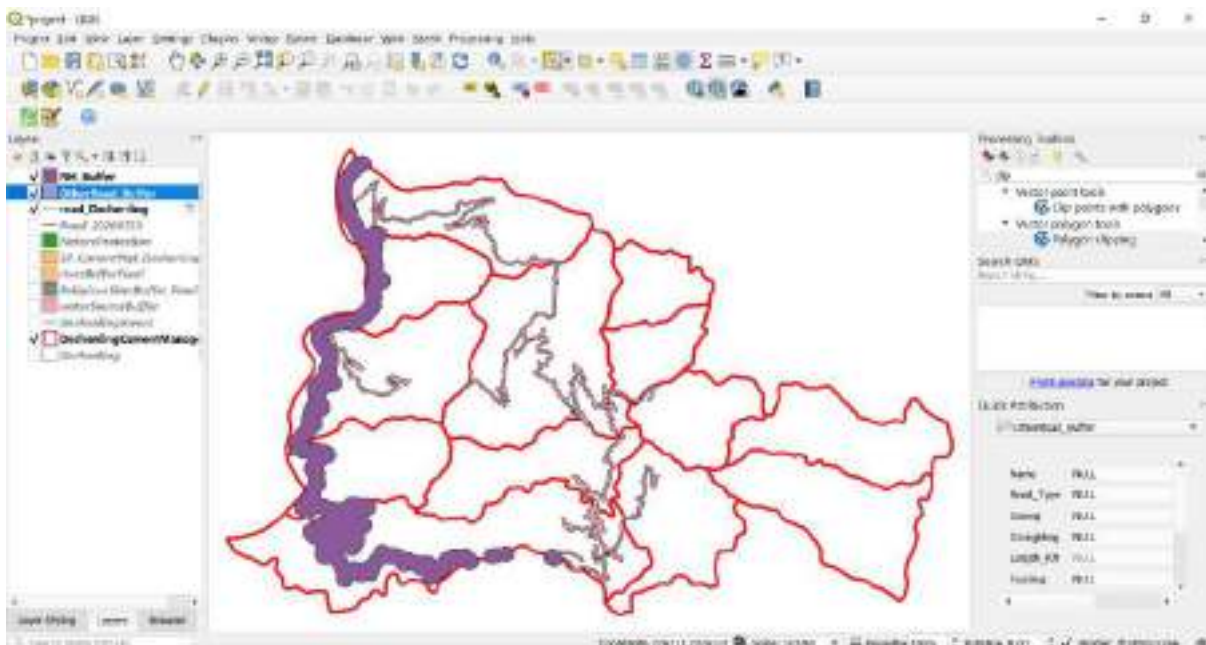
Create buffer of 30 m on either side of Dzongkhag, Farm, Access and Thromde road

- Click Vector > Geoprocessing Tools > Buffer
- In Input layer: Select filtered Primary National Highway layer
- In distance: enter 30
- Check dissolve result
- Rest parameter leave as default
- Buffered: Save the file with appropriate name in working directory
- Click Run

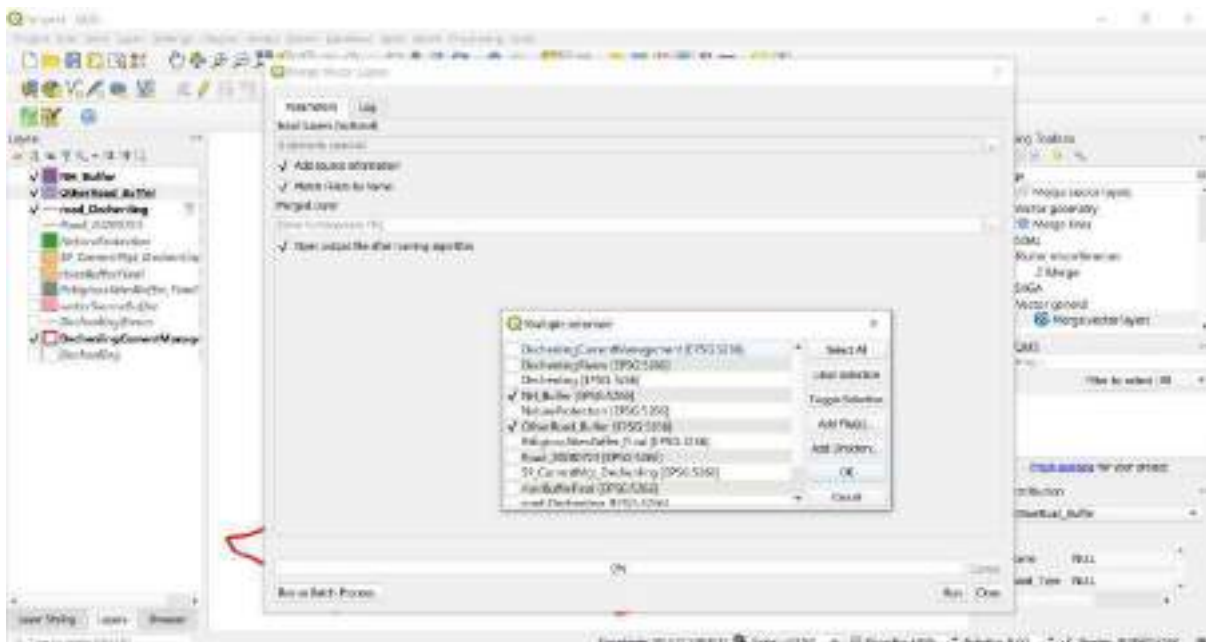


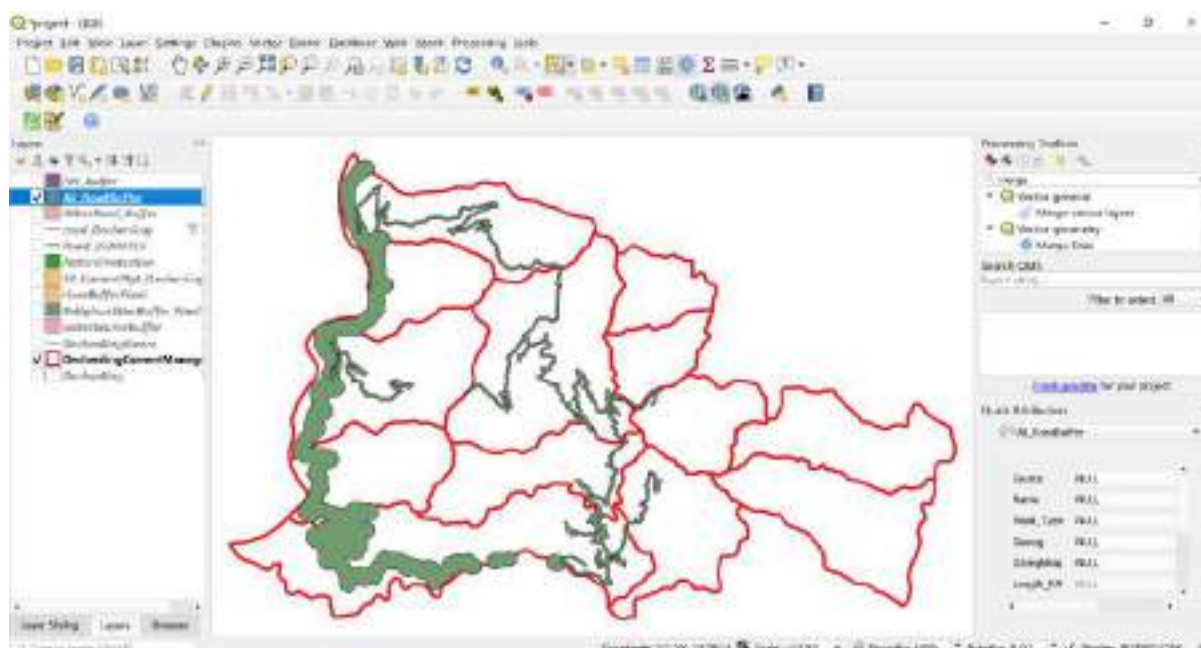
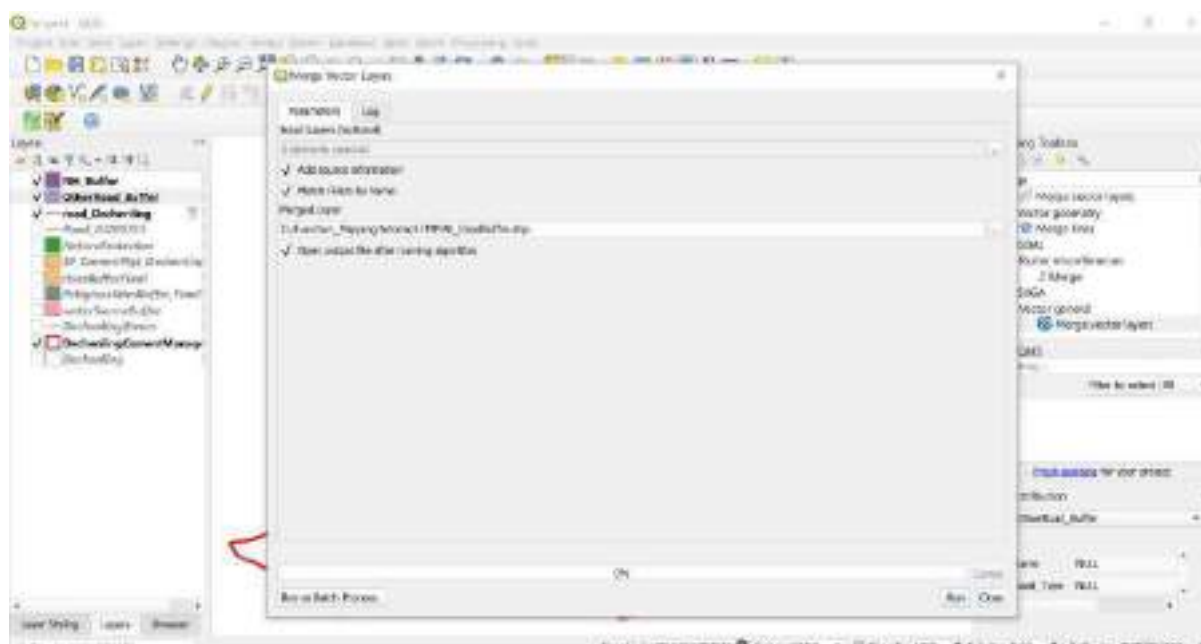
Now there are two different road buffer layers, we need to merge it together.





- Type merge in processing toolbox
- Navigate to SAGA and select Merge vector layers
- In Input Layers: Select the file you want to merge (PrimaryNationalHighway\_Buffer and Otherroad\_Buffer)
- Rest parameter leave as default
- Merged Layer: Save the file with appropriate name in working directory
- Click Run

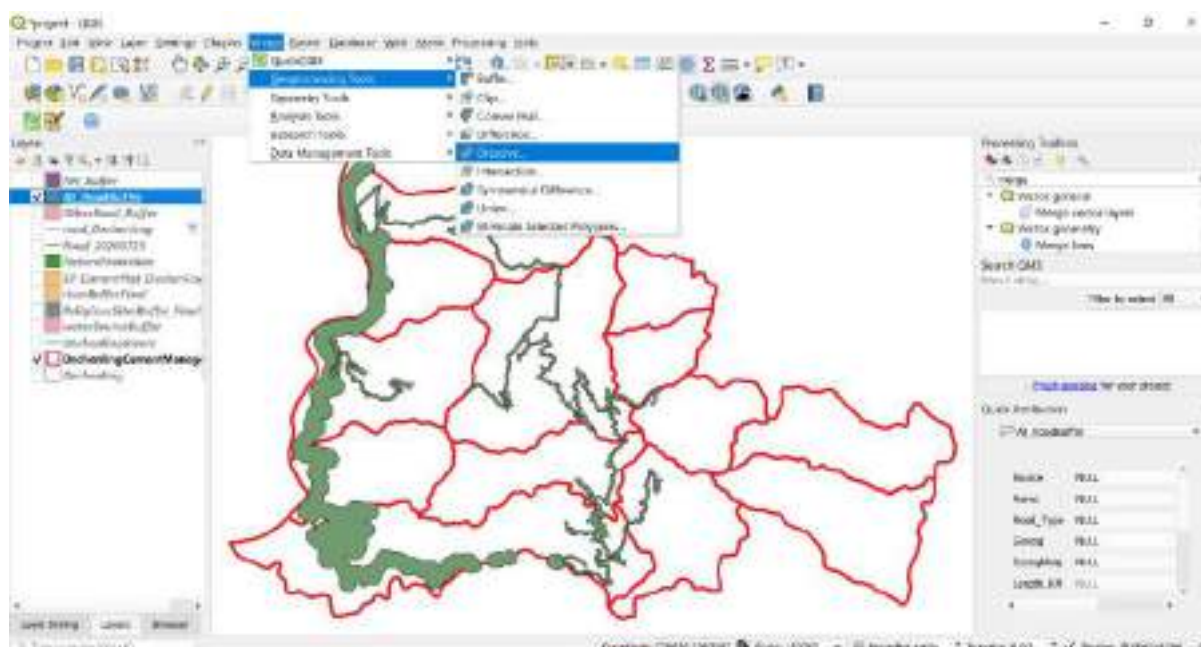




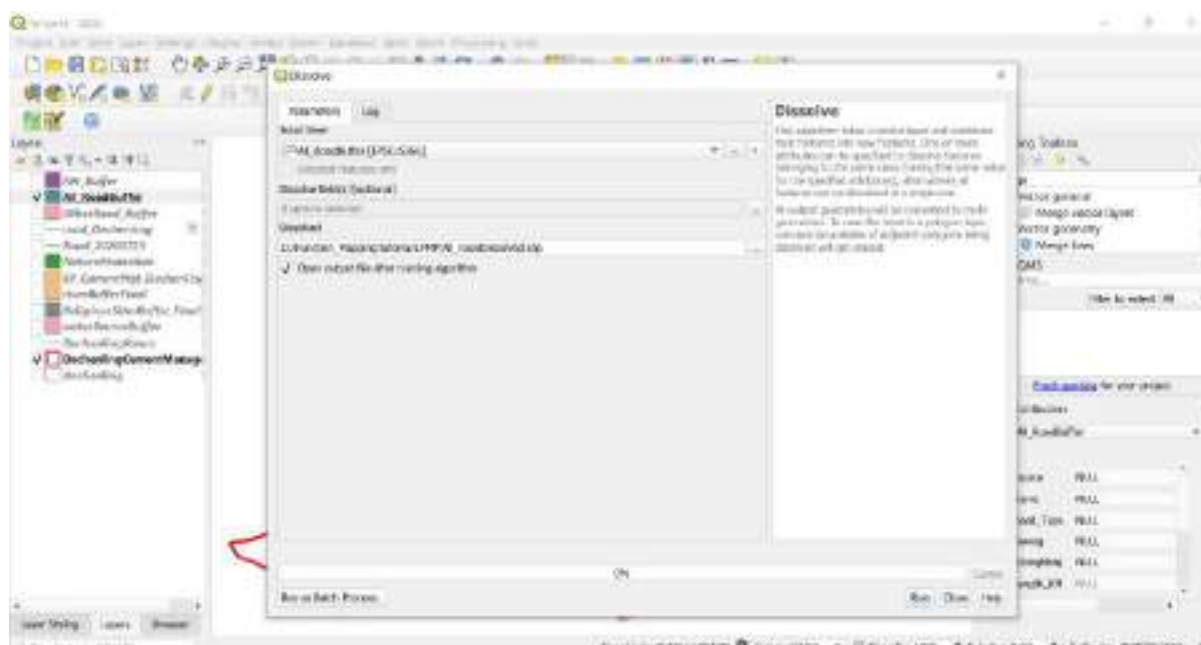
Dissolve merged layers

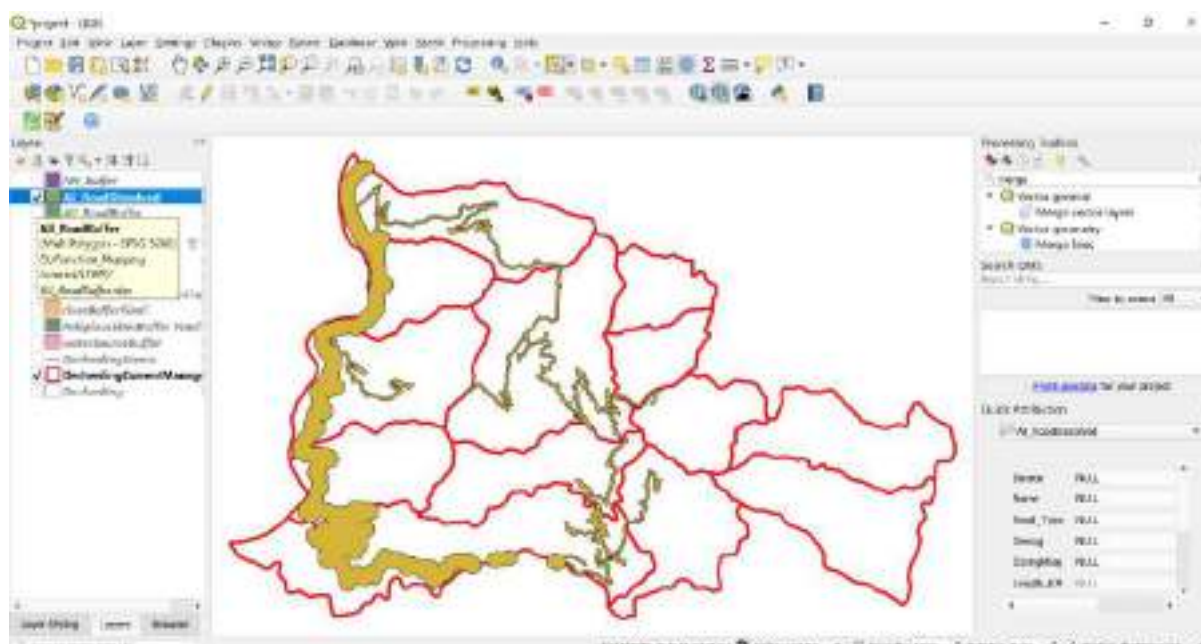
- Click *Vector > Geoprocessing Tools > Dissolve*





- In input layer: Select the layer to be dissolved
- Dissolved: Save the file with appropriate name in working directory

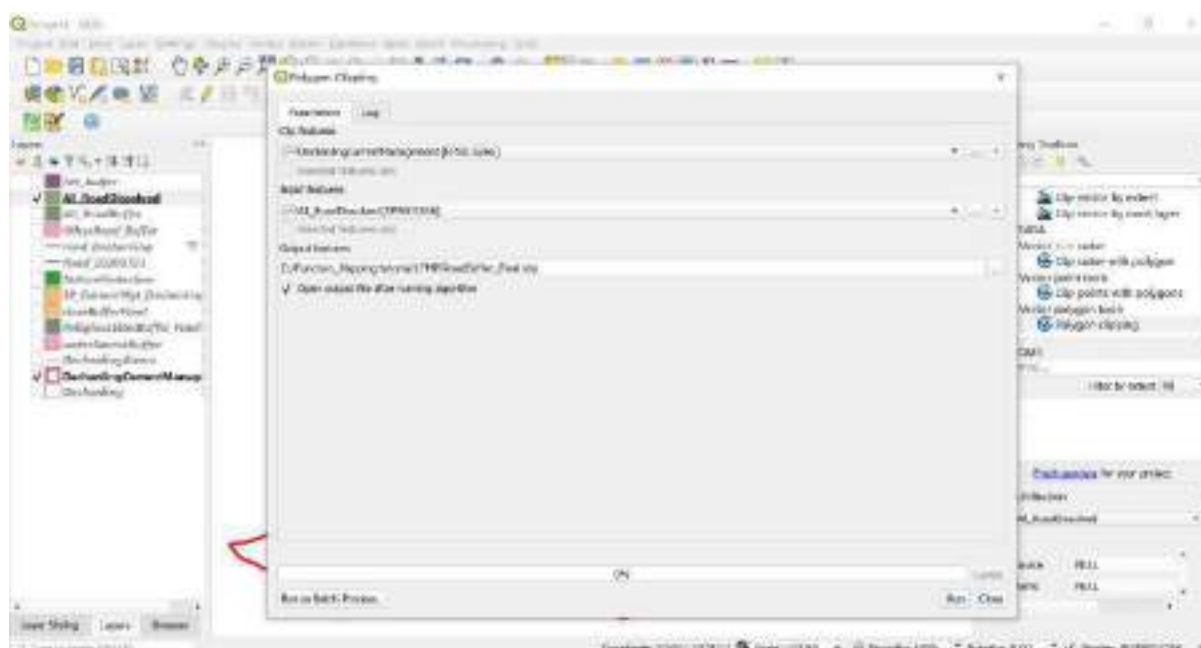


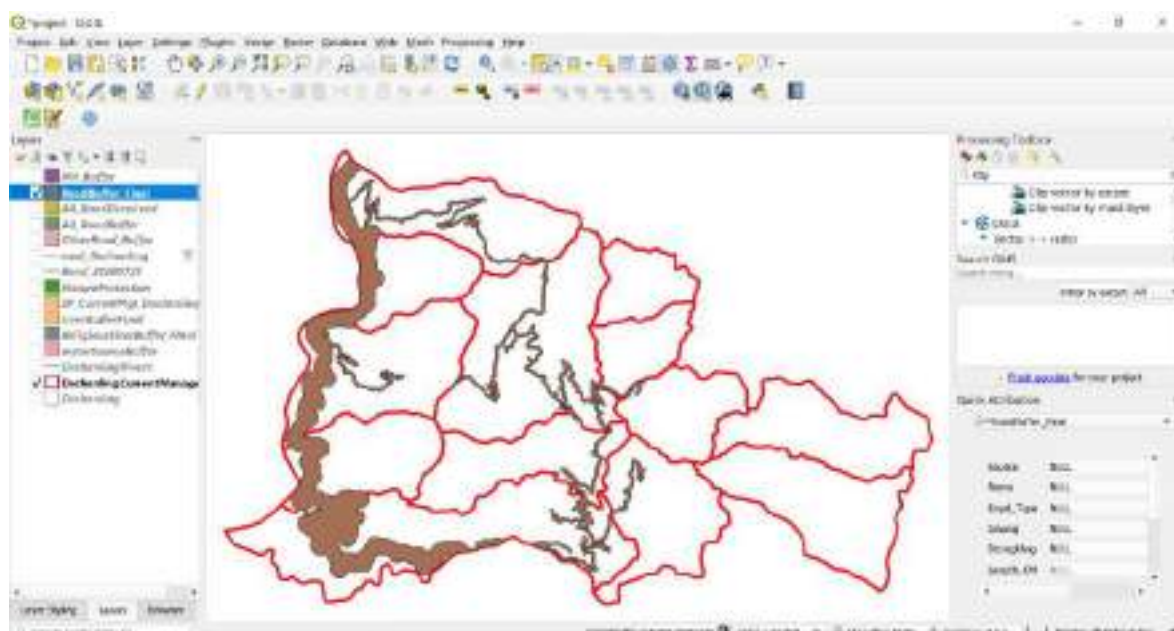


Dissolved road buffer layer extends beyond current management LFMA boundary

Clip with LFMA Boundary

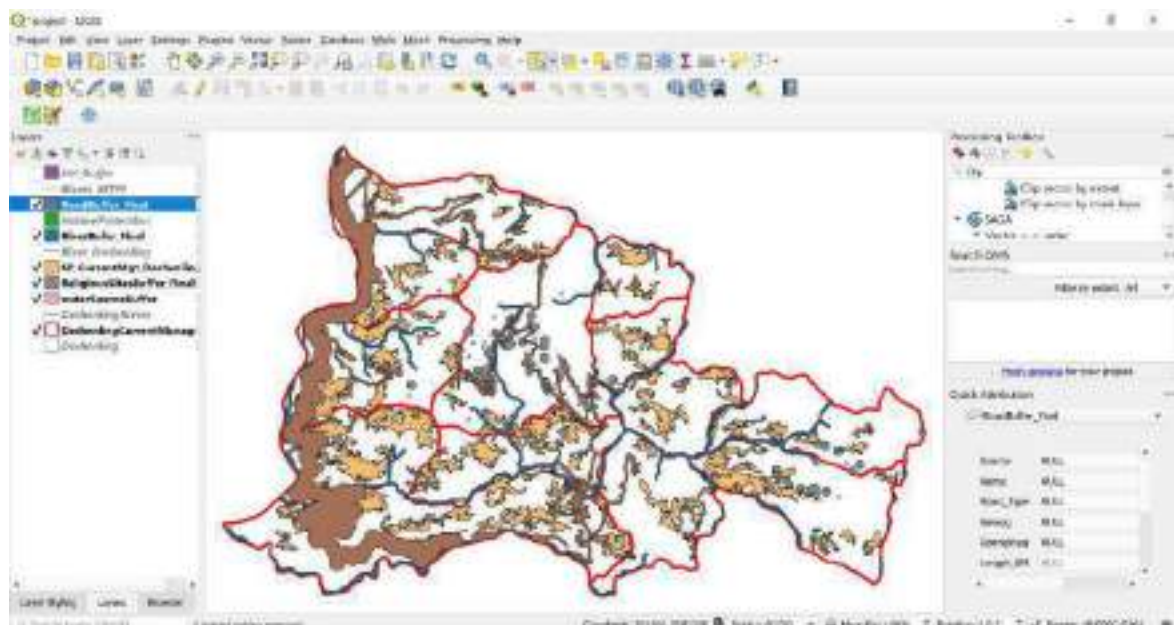
- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select LFMA boundary layer*
- *In input features: select dissolved road buffer layer*
- *Output feature: Save the file with appropriate name in working directory*
- *Click run*





Soil protection layers, water and watershed conservation layer, religious sites protection layers, nature conservation layers, and road buffer needs to be considered as protected areas where timber harvesting is restricted.

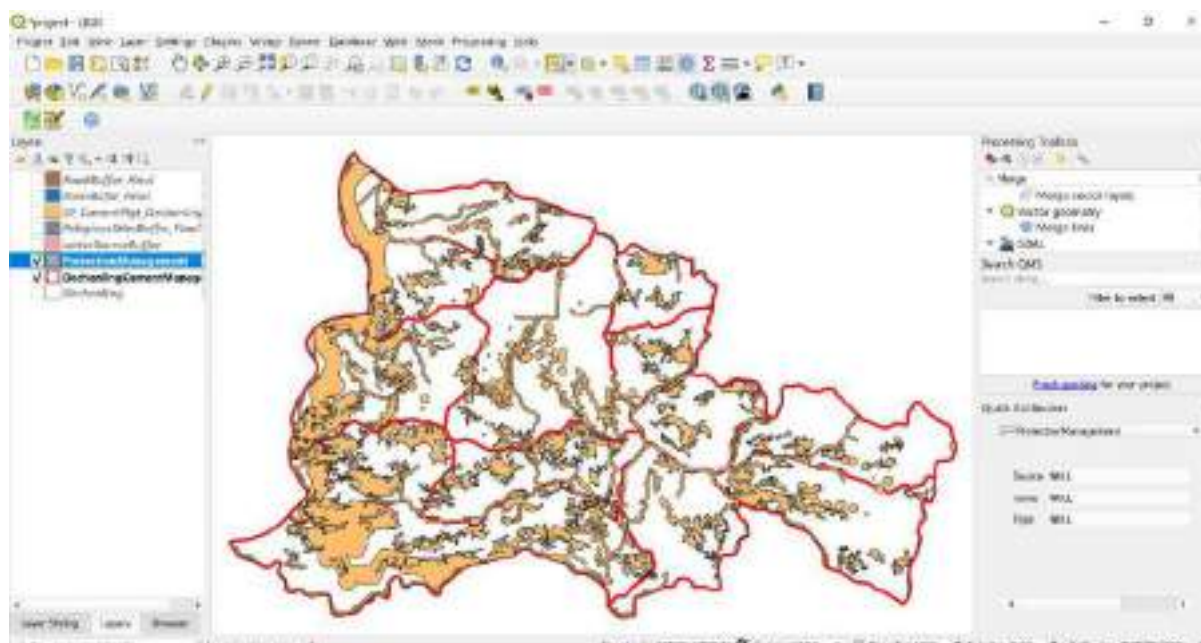
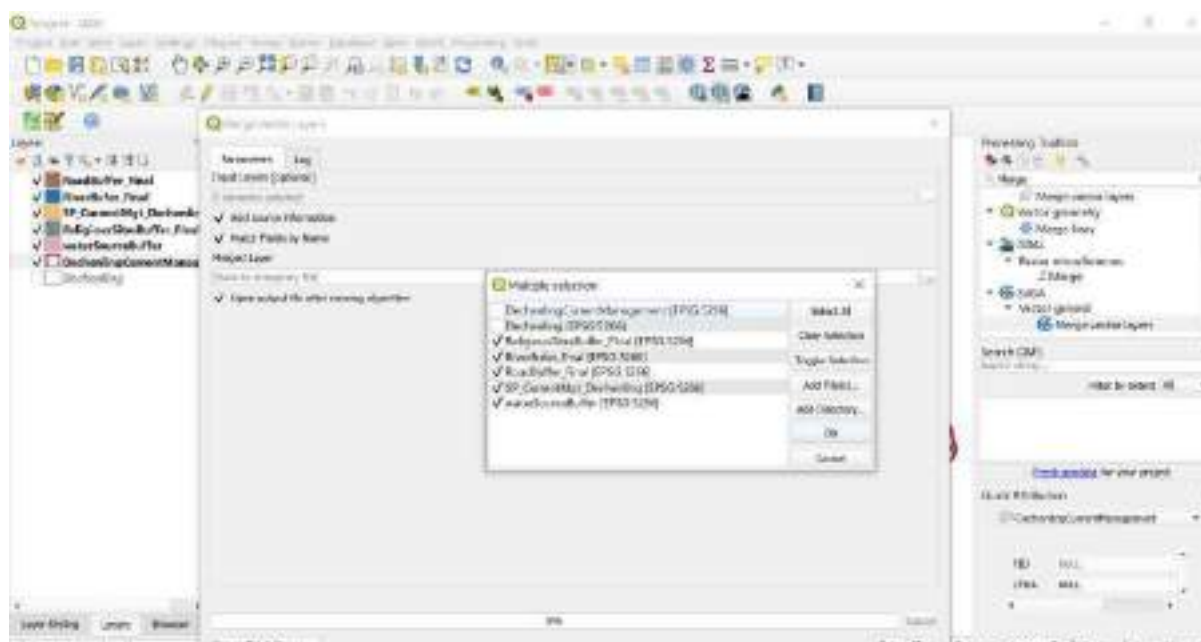
- *Add soil protection layers*
- *Add riparian reserve buffer layer*
- *Add local water supply buffer layer*
- *Add religious site buffer layer*
- *Add road buffer layer*



Merge all these layers as one layer

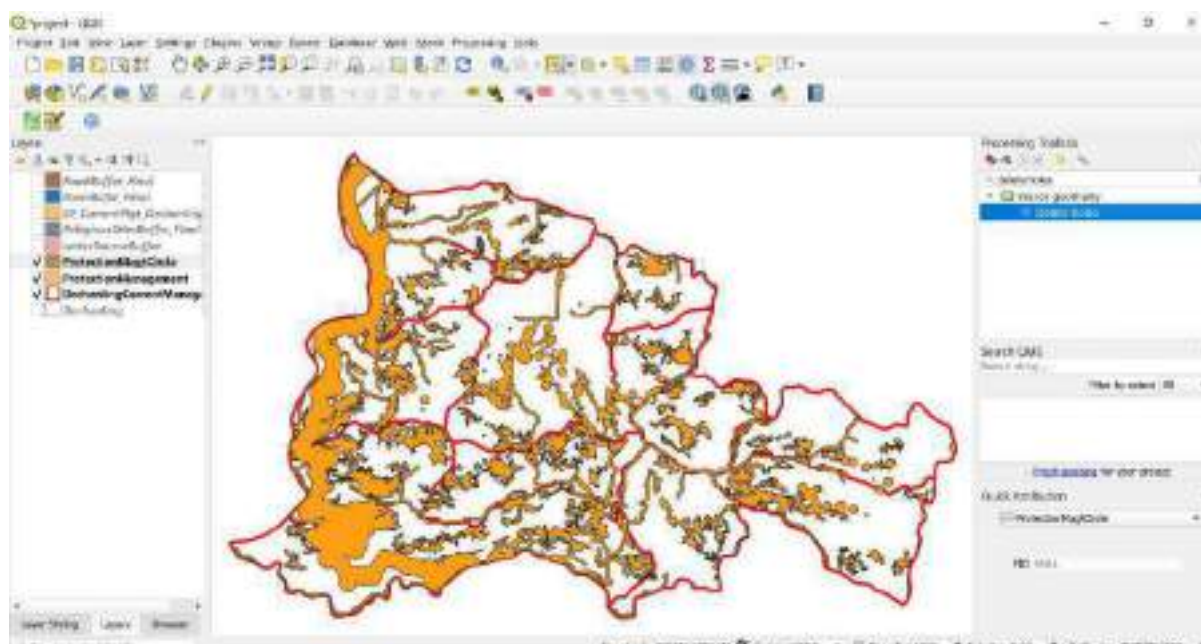
- *Type merge in processing toolbox*
- *Navigate to SAGA and select Merge vector layers*
- *In Input Layers: Select the file you want to merge (Soil protection layers, Riparian reserve buffer layer, Local water supply buffer layer, Religious site buffer layer and road buffer layer)*
- *Rest parameter leave as default*
- *Save the file with appropriate name in working directory*





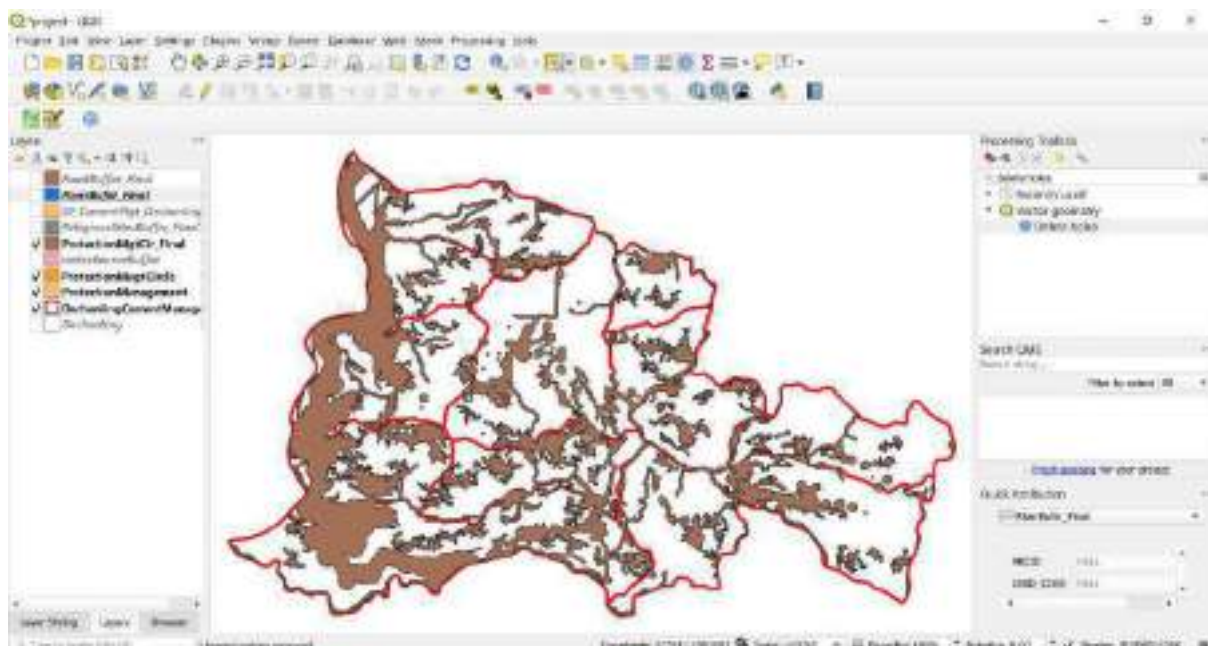
Dissolve the merged layers

- *Type dissolve in Processing Toolbox*
- *Navigate to GDAL tool and select Dissolve > double click to open the toolbox*
- *Input layer: Select merged protection layers*
- *Save the file with appropriate name in working directory*



If we closely check the dissolve layers there are smaller polygons surrounded by protection layers after merging and dissolving the protection layer. We need to delineate these smaller polygons under protection management circle as these areas shall be inaccessible due to surrounding protection layer.

- In the Processing Toolbox type “delete holes” > double click Delete holes tools
- In Input layer select protection management layer
- In Remove holes with area less than: enter 100000
- Cleaned: Save the file with appropriate name in working directory
- Click run



The Non-Production Management Circle comprises of non-forested areas which includes built up areas, rocky outcrops, settlements, agricultural use areas (*Kamzhing* and *Chuzing*), shrubs, alpine scrubs, meadows, etc. (Figure 3.3) Further, the Future Management Area must also be included under Non-Production Management Circle as no resources shall be extracted from these areas due to remoteness of the area. In non-production management circle, reforestation, afforestation and soil/water conservation activities can be carried out.

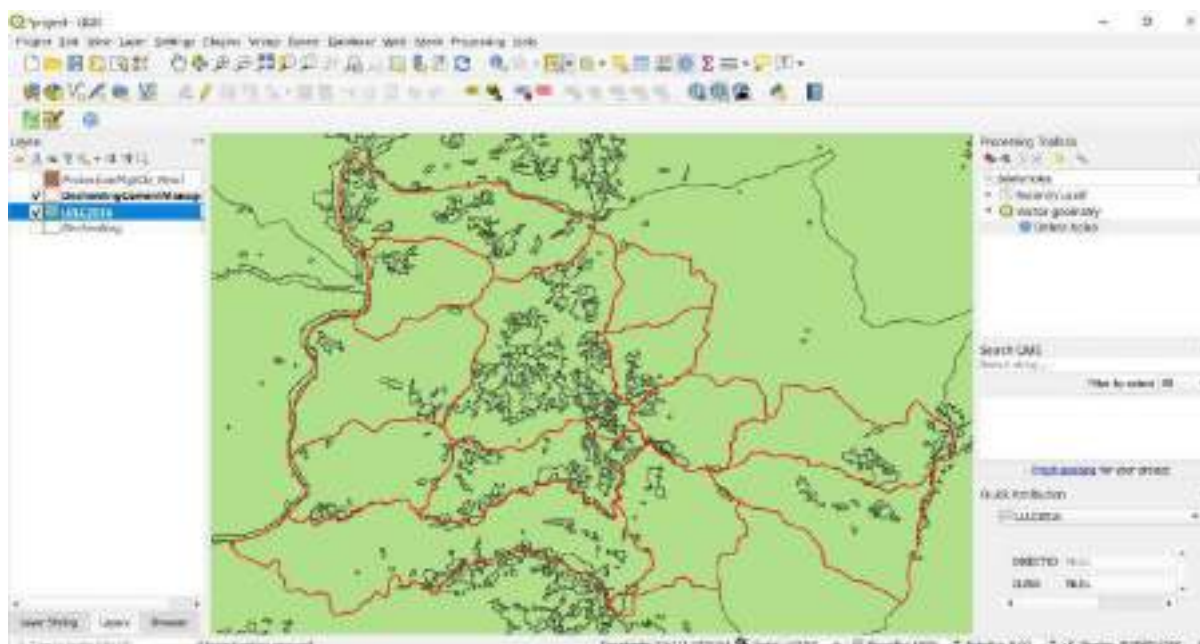
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## GIS Steps

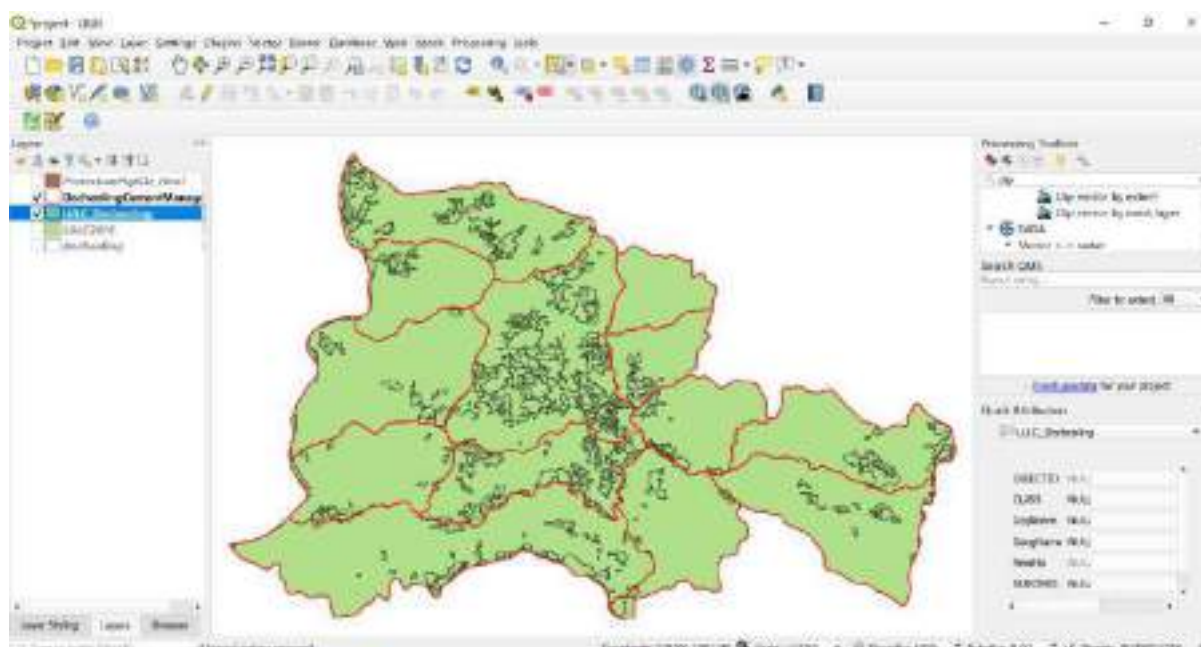
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to use QGIS version 3.12 and above.

- *Open QGIS*
- *Add LFMA boundary layer*
- *Add Land use and land cover (LULC) layer*



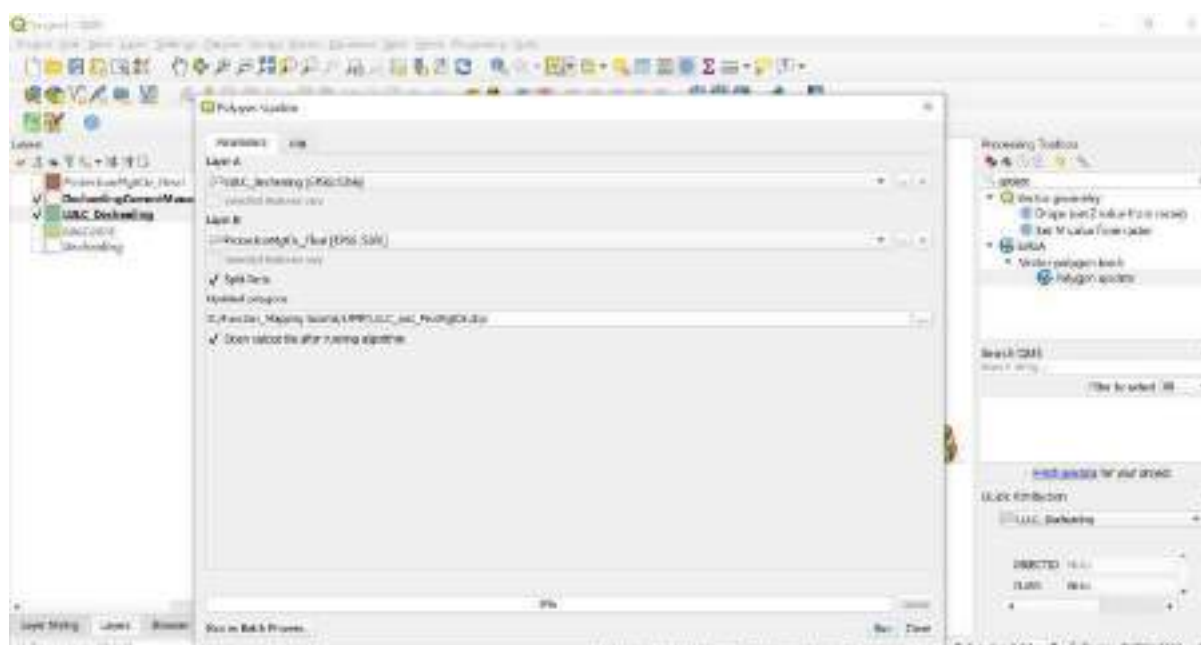
Clip with current management LFMA Boundary

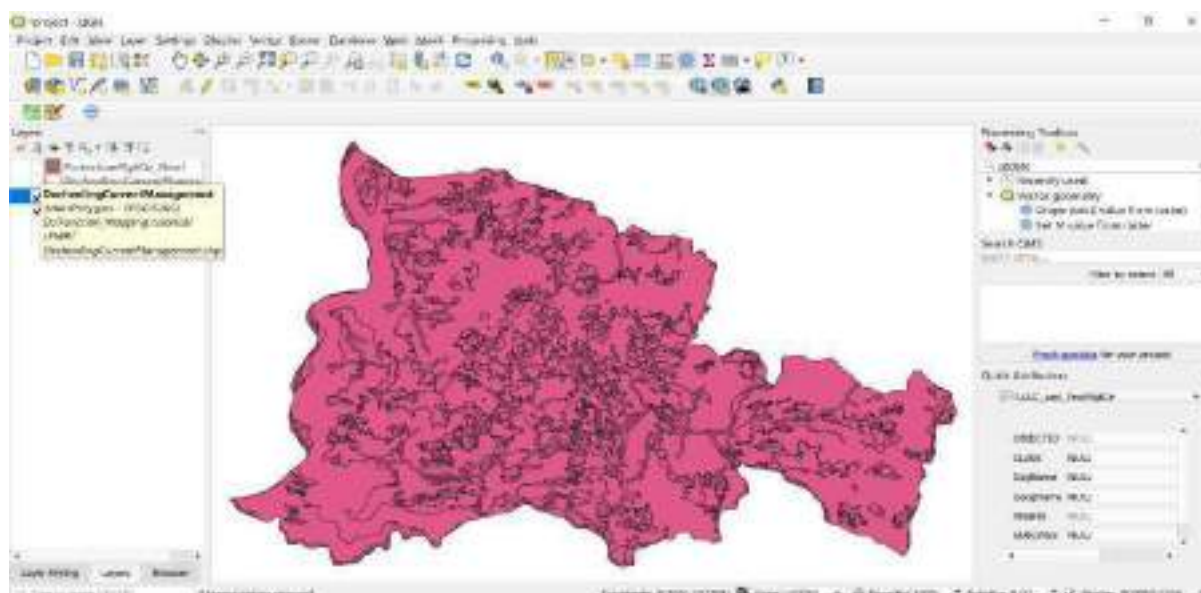
- *Type clip in processing toolbox*
- *Select Polygon clipping from SAGA Tools*
- *In Clip features: select LFMA boundary layer*
- *In input features: select LULC layer*
- *Output feature: Save the file with appropriate name in working directory*
- *Click Run*



Protected area needs to be updated in LULC

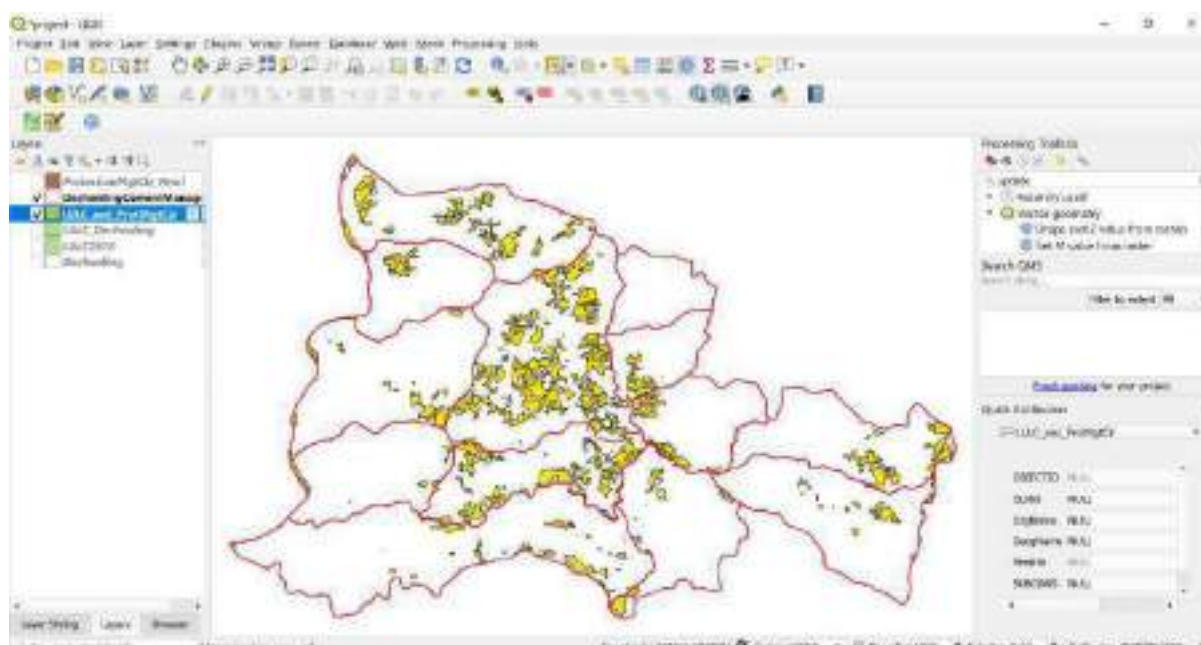
- *Type update in Processing Toolbox > select polygon update tool > double click to open the tool*
- *In Layer A: select LULC of LFMA*
- *In Layer B: select Protection Management Circle layers*
- *Updated polygons: Save the file with appropriate name in working directory*
- *Click Run*





Select only non-production area (Area other than forests and protected layer)

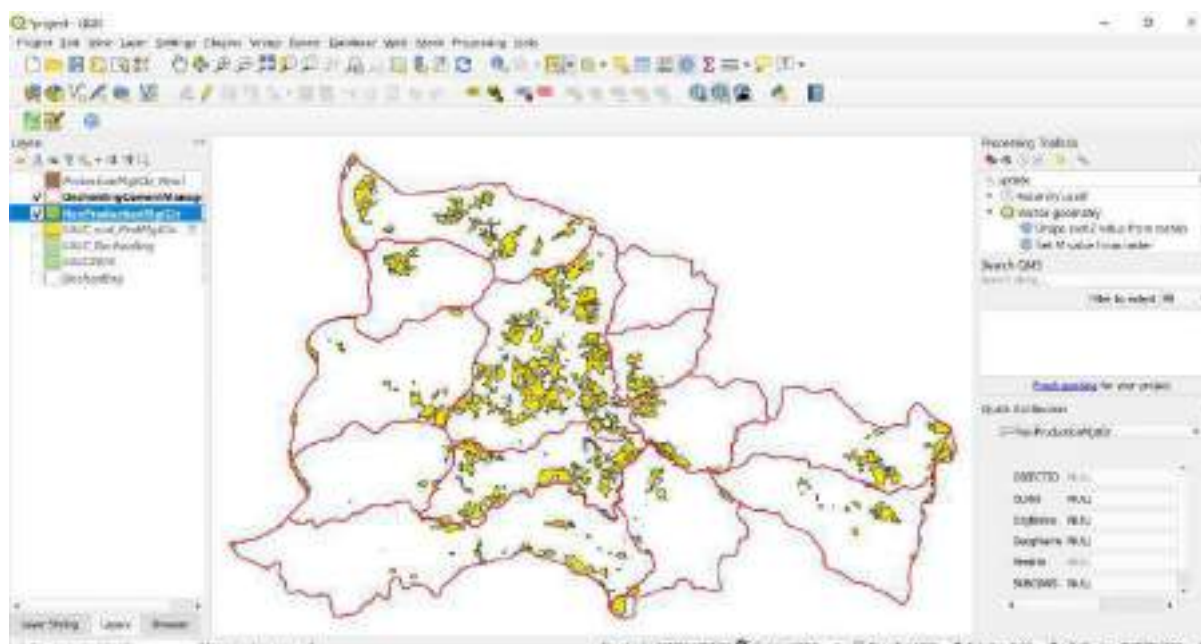
- Right click on LULC(LULC\_and\_PrtMgtCir) > Filter
- Enter expression following expression:  
"CLASS" = 'Built up' OR "CLASS" = 'Cultivated Agriculture' OR "CLASS" = 'Landslides' OR  
"CLASS" = 'Non Built up' OR "CLASS" = 'Shrubs' OR "CLASS" = 'Water Bodies'
- Click Ok



Export the filtered layer and save it as non-production layer

- Right click on filtered layer > Export > Save Features As
- Format: Select ESRI Shapefile
- File name: Save the file with appropriate name in working directory
- Click Ok





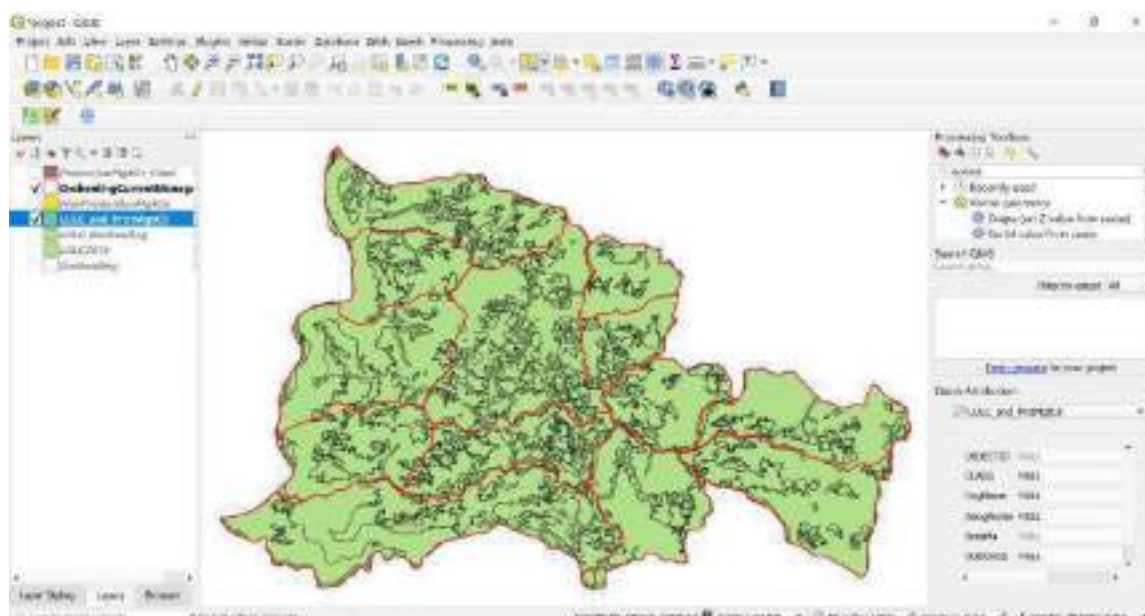
### Production Management Circle

The Production Management Circle comprises of forest area that can be brought into sustainable management of forest to meet the rural timber demand. Forest area left after identifying the Protection Management Circle and Non-Production Management Circle is considered as Production Management Circle. This management circle constitutes areas which are more stable and stocked with merchantable timbers of important species which can be allotted for rural use. The area would be harvested for rural timber supply.

### GIS Steps

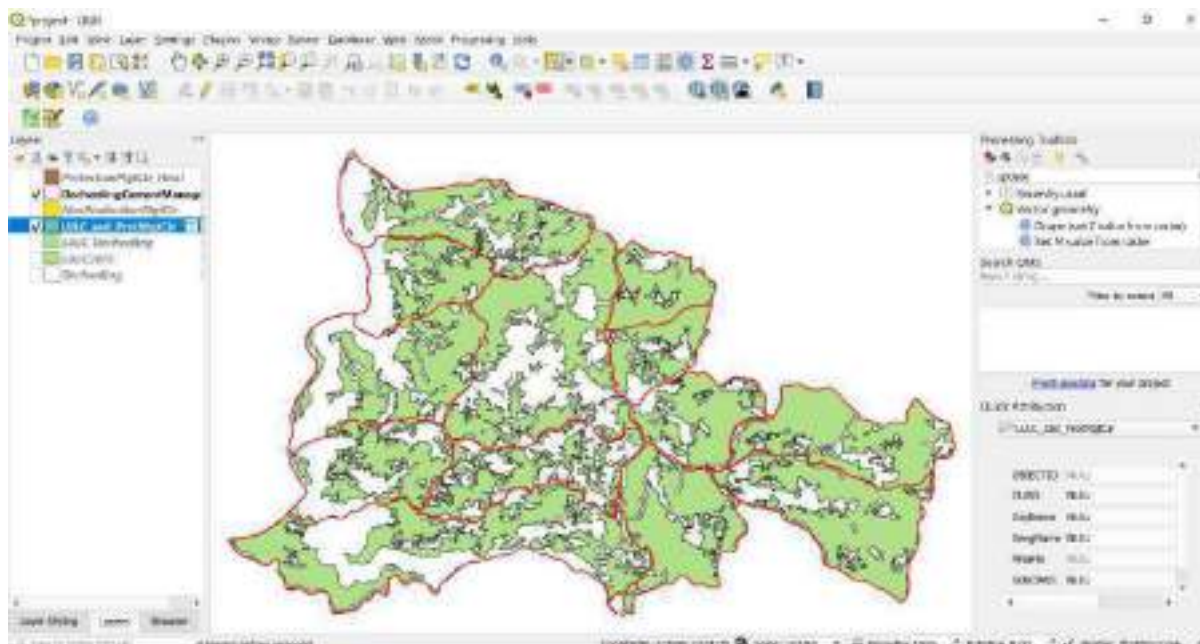
This GIS analysis step is demonstrated in QGIS version 3.12; therefore, it is advised to used QGIS version 3.12 and above.

- *Open QGIS*
- *Add LFMA boundary layer*
- *Add updated Land use and land cover (LULC\_and\_PrtMgtCir) layer*



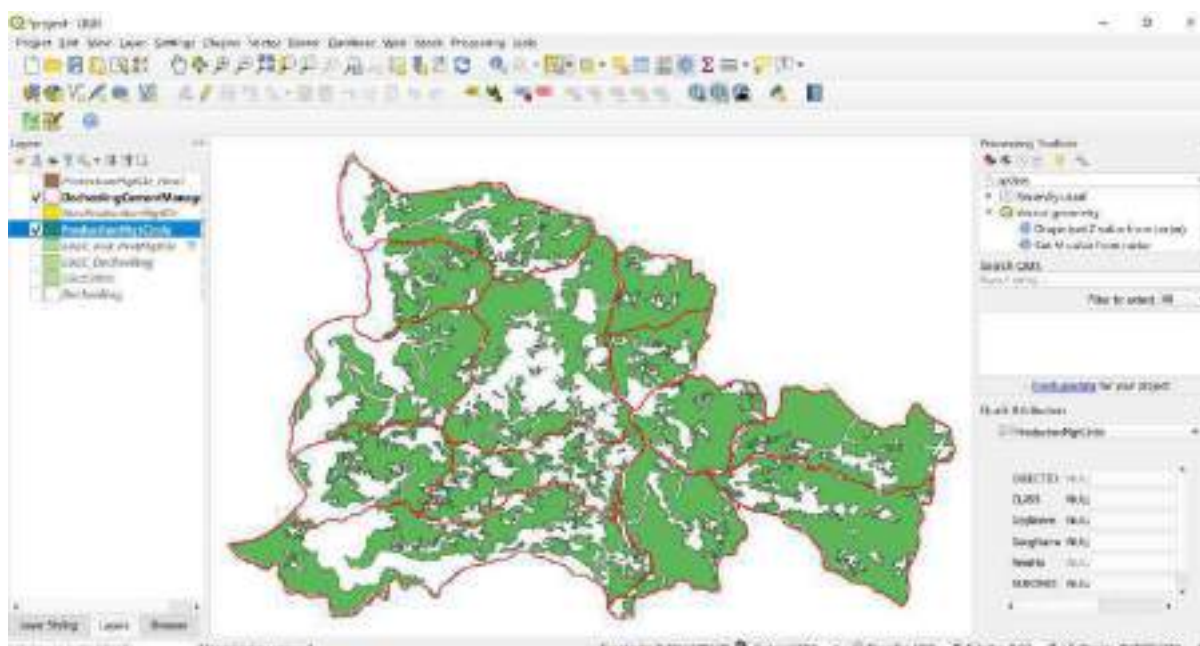
Select only forest area as Production Management Circle

- *Right updated LULC > Filter*
- *Enter expression following expression:*  
*"CLASS" = 'Forests'*
- *Click Ok*



Export the filtered layer and save it as Production Management Circle

- *Right click on filtered layer > Export > Save Features As*
- *Format: Select ESRI Shapefile*
- *File name: Save the file with appropriate name in working directory*



## **NWFP Overlapping Management Circle**

Non-Wood Forest Products (NWFPs) are important source of income for improvement of rural people's livelihoods. However, unregulated collection of NWFPs may not only exceed the production potential of NWFPs in the forest, but would also cause genetic erosion in the wild in near future. NWFPs in the Management area must be identified, assessed and harvesting as per guidelines prescribed in Volume V of the *Code*.

The Management Circle shall overlap with all other Management Circles, including Protection and Non-Production Management circles of the Local Forest Management Area. The overall objective of this Management Circle is to manage the NWFPs on sustainable basis, and ensure low impact through regulated collection.

The details on criteria, management restrictions and mapping can be referred to Section 1.9 Forest Function Mapping of this Volume of the *Code*.

### **3.3.3.2 Field Validation**

The objective of field validation is to verify whether the boundaries of Protection, Non-Production and Production Management Circles as determined through function mapping, prepared using GIS, correspond with field condition. The planner must prepare a base map reflecting all the functions prior to going to the field for field validation. The planner may set predetermined random geolocations within the Forest Management Area and conduct visits to those locations in the field using GPS for field validation. Preferably bird eye view points must be selected for better view and validation of the Management area. The intensity of field validation shall depend on the accuracy of Digital Elevation Model and the Land Use Land Cover Maps used. The planners should make necessary changes on the function maps (if any) based on the field validation exercise.

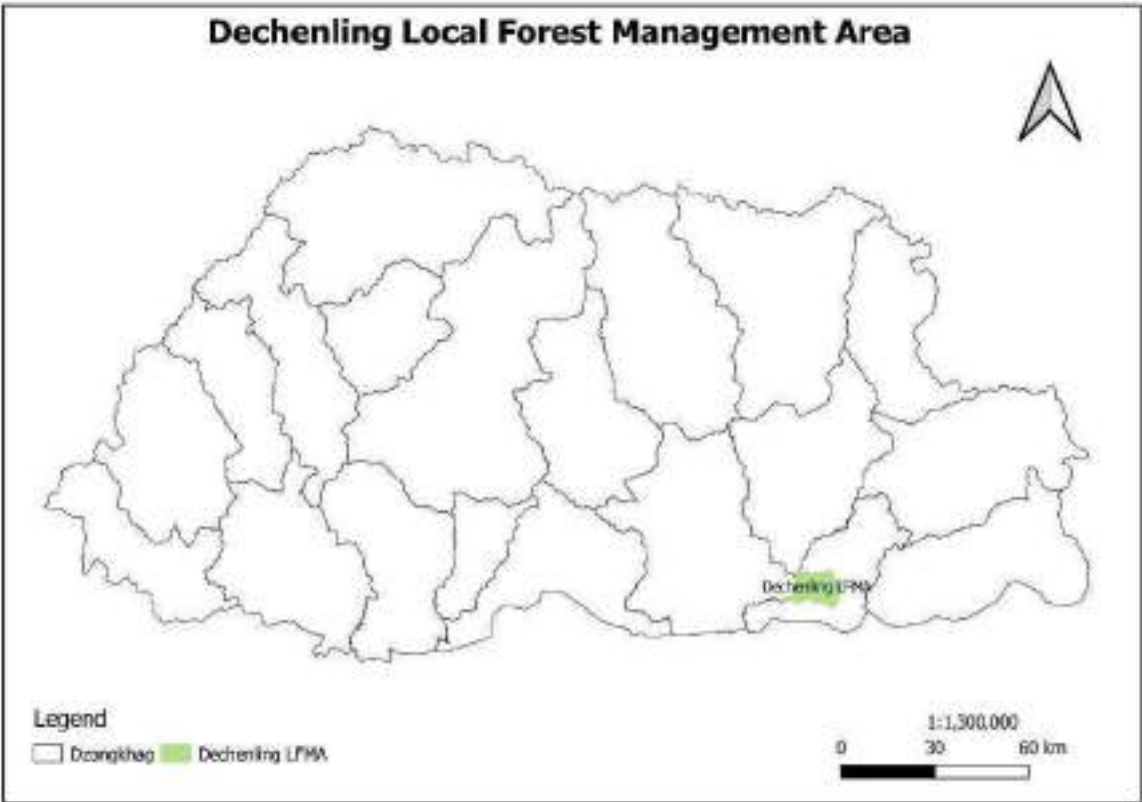
### **3.3.3.3 Preparation of Forest Management Maps**

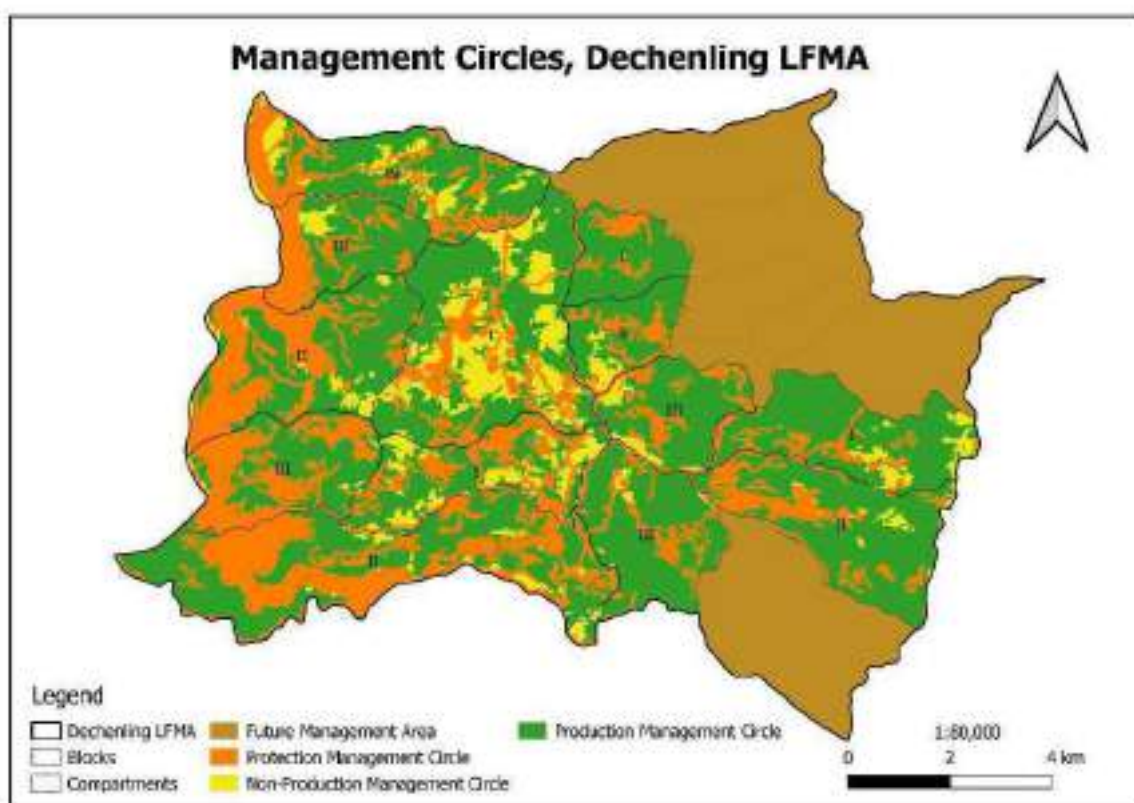
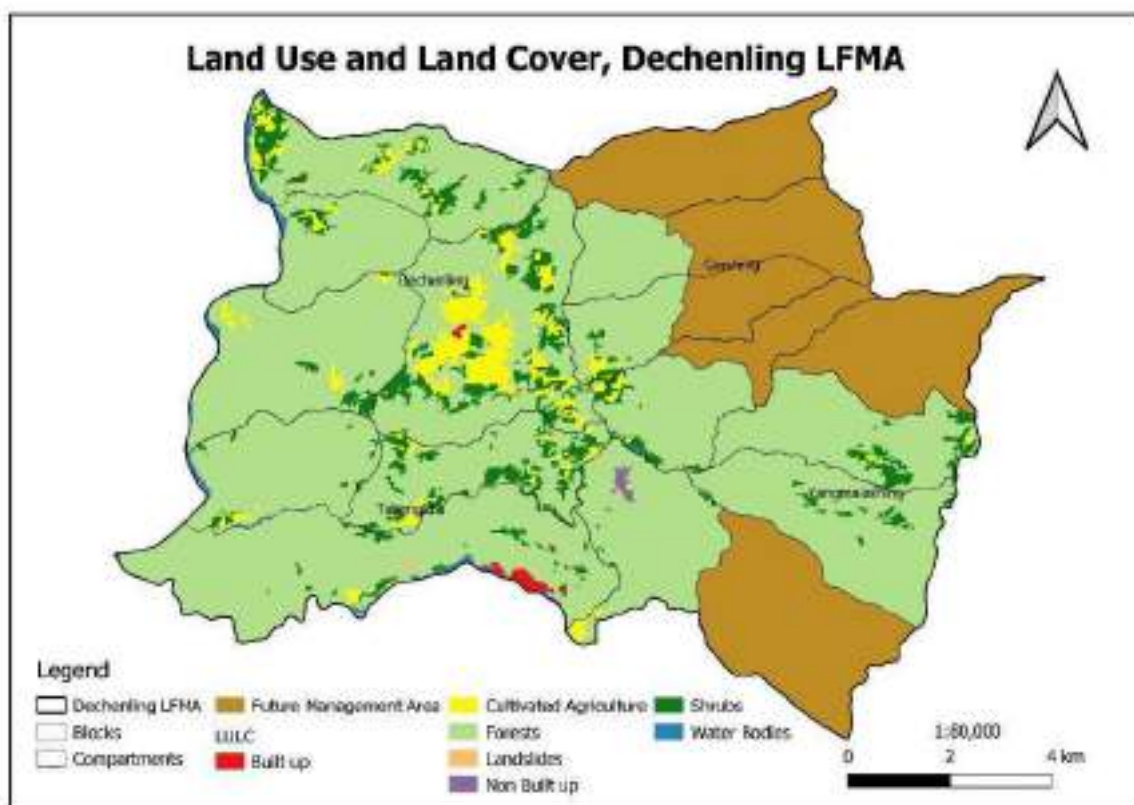
Upon completion of the forest function mapping and field truthing, the forest management maps should be prepared which shall guide the inventory crews and the planner to carry out forest resources assessment. The following maps must be prepared and attached to the Local Forest Management Plan for ready reference during implementation.

*Table 3.2 List of function maps and its components*

<b>Sl. No.</b>	<b>Name of the Map</b>	<b>Components to be Included</b>
1	Location Map	<ul style="list-style-type: none"> <li>• Location of Gewog</li> <li>• National and Gewog Boundary</li> </ul>
2	Overview Map	<ul style="list-style-type: none"> <li>• Map showing all existing Management Regimes in the Gewog</li> <li>• Road network</li> </ul>
3	Management Circle Map	<ul style="list-style-type: none"> <li>• Production Management Circle</li> <li>• Protection Management Circle</li> <li>• Non-production Management Circle</li> </ul>
4	Land Use and Land Cover Map	<ul style="list-style-type: none"> <li>• All Land Uses (forest and non-forest)</li> </ul>
5	Spatial Organization Map	<ul style="list-style-type: none"> <li>• Map showing Blocks and Compartments</li> </ul>







### 3.3.4 Forest Resources Assessment

Forest Resource Assessment (FRA) is the systematic assessment of quantity and quality of forest resources available for management by collecting relevant data and information. In order to determine the sustained yield for the forest, the forest manager need to know what resources currently exist and how fast do the

resources grow and what changes occur in response to management. The method of forest resource assessment may vary based on the management objectives.

**Note:** Forest Resource Assessment is done within Current Forest Management Area of each Gewog as determined under section 3.3.2.3 as a "Management Unit". Resource assessment within Future Management area is not required and will be deferred to the next planning period.

#### **3.3.4.1 Objectives**

The objective of the FRA is to provide, in fast and simple way, the information for each compartment on the following:

1. Growing stock
2. Forest type and conditions in the forest management area.
3. Current use of the forest by local people.
4. Management option and potential use for rural supply and NWFP extraction.
5. Required silvicultural measures in each compartment.

#### **3.3.4.2 Area of Assessment**

The resources assessment should be done for the current Forest Management Area as determined under section 3.3.2.3 as a "management unit". However, resource assessment within the Future Management Area is not required for the current plan and is to be deferred to next plan.

#### **3.3.4.3 Sampling Method**

The sampling grid is generated using the systematic sampling design and data for trees are collected using point sampling method while regeneration and sapling data area collected from fixed radius circular plots. This method is applied for all type for forest stand and stand age.

#### **3.3.4.4 Forest Inventory**

The stratified systematic sampling is used for the inventory of Local Forest Management Area inventory. The different forest types constitute the stratum for inventory design and data analysis. The point of location of prism swiping is considered as plot center and regeneration plot of 3.57 m radius circular plot laid and all type of regeneration data area collected (0.3-1.3 m height or less than 10 cm diameter).

##### **3.3.4.4.1 Objectives of Forest Inventory**

The objectives of the inventory may generally be stated as to provide essential information for preparation of local forest management plan. More specifically, the objectives of inventory are to:

1. provide a relatively accurate overview of the growing stock and regeneration potential of the natural forest in the area, according to major forest types;
2. give an overview of the general site characteristics of the natural forest, in terms of soils, non-tree vegetation and use by the local population; and
3. provide an indication of timber quality in the different forest types.

##### **3.3.4.4.2 Forest Inventory Design and Sampling plots**

#### **Inventory design**

LFMA (Local Forest Management Area) inventory shall adopt systematic sampling design as in case of NFI but at much finer spatial resolution. LFMA inventory should be designed to achieve estimates at 95% confidence interval and 10% margin of error/ sampling error. The systematic sample uses a fixed grid to assign plots in a regular pattern and its advantages are;

- Maximize the average distance between plots and therefore minimize spatial correlation on observations
- Increase statistical efficiency
- Can be representative in most cases and this is most common in forestry

### Sampling design

The systematic sampling design is used for forest management inventory. In this method, a sample grid is created at a predetermined sampling intervals or plot to plot distance. The sampling for LFMA inventory is designed to achieve results at 95% confidence interval at 10% standard error.

### Number of sample plots

*Table 3.3: CV% of forest type*

The sampling intensity for each LFMA is determined by the forest type of the particular LFMA which in turn is determined by the coefficient of variation. Higher the coefficient of variation, larger the sample size. The coefficient of variation for typical forest types of Bhutan (for plot area of 0.05 - 0.1 ha) is described in Table 1.26. The use of Land Use and Land Cover data, 2016 or any other update/latest land use and cover product is recommended for stratification of forest types and land use stratification.

The sample size is the function of coefficient of variation (Table 1.26) and percentage sampling error (10%) and level of confidence. The commonly used formula is :

Sl No.	Forest Type	CV%
1	Fir	50
2	Spruce	70
3	Blue Pine	105
4	Mixed Coniferous forest	70
5	Combined conifers	80
6	Oak (Quercus semecarpifolia)	65
7	Mixed broadleaf	85
8	Combined broadleaf	85
9	Combined all	85

$$n = \frac{t^2 \times CV\%^2}{SE^2} \quad (1)$$

Where,

n is number of sample plots or it is also called sample size

t is t value for 95% confidence interval from t-distribution table

CV% is coefficient of variation

SE is standard error or desired margin of error

**The coefficient of variation (CV)** is a statistical measure of the dispersion of data points in a data series around the mean expressed in percentage. The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from one another. It shows the extent of variability of data in a sample in relation to the mean of the population. The coefficient of variation is determined by Equation (2)(9).

$$CV\% = \frac{s}{\bar{x}} \times 100 \quad (2)$$

Where,

CV% of coefficient of variation in percentage

S is sample standard deviation

$\bar{x}$  is sample mean

For a sample with a mean of  $\bar{x} = 20$  and a standard deviation of  $s = 8$  we would estimate the coefficient of variation as  $CV\% = 0.40$  or 40 percent. This coefficient of variation can be used for determining the sample size for your inventory area.

The sample mean and standard deviation can be generated for basal area, tree count, tree height and tree volume. However, it is recommended to use the basal area to generate the sample mean and standard deviation to estimate CV%.

### Sample size Calculation

Let us consider the example of a LFMA of 9157 ha and estimate the sample size

**Step 1:** Define the total LFMA

In this case LFMA = 9157 ha

**Step 2:** Stratify the LFMA into different forest types using the latest available land use land cover/ forest type data. For example, let's assume the LFMA has four forest types of **Blue Pine, Broadleaf, Fir and Mixed Conifer forest** from 2016 land use and land cover data (Table 3.4).

Table 3.4: Forest Type of LFMA

Sl. No.	Forest Type	Area	Coefficient of variation (cv%)
1	Blue pine	2312.67	105
2	Broadleaf	370.52	85
3	Fir	1076.59	50
4	Mixed conifer	4732.14	85
	<b>Grand Total</b>	<b>8491.92</b>	

**Step 3:** Apply the CV% of each forest type to determine the weighted area by CV% of the forest type. This is estimated by the equation (3) and (4) and described in Table 3.5.

$$\text{Weighted Area by CV\%} = A_1CV_1 + A_2CV_2 + \dots + A_nCV_n \quad (3)$$

$$\text{Weighted CV\%} = \frac{A_1CV_1 + A_2CV_2 + \dots + A_nCV_n}{A_1 + A_2 + \dots + A_n} \quad (4)$$

Where,  $A_1, A_2, \dots, A_n$  is area of a particular forest type in ha

$CV_1, CV_2, \dots, CV_n$  is CV% of corresponding forest type

e.g. for current LFMA the weighted area by CV% is calculated as follow:



Table 3.5: Weight CV% for LFMA

Sl. No	Forest Type	CV%	Area (ha)	Weighted area
1	Blue pine forests	105	2312.67	2428.3035
2	Broadleaf Forest	85	370.52	314.942
3	Fir forest	50	1076.59	538.295
4	Mixed Conifer forests	85	4732.14	4022.319
	Sum		8491.92	7303.8595

Therefore,

$$\text{Weighted CV\%} = \frac{7303.8595}{8491.92} \times 100$$

$$= 86\%$$

**Step 4:** Applying the formula in *Equation 1* above, the number of plots or sample size calculated at confidence interval is 95% with corresponding t-value of 1.96 (rounded to 2), CV% of 86 as determined in step 3 and sampling error (used a synonymous with margin of error (MoE) and Standard Error) of 10%.

Therefore, number of plots is determined using equation 1 as follows;

$$n = \frac{2^2 \times 86^2}{10^2}$$

$$= 295.9 \text{ plots} \approx 296 \text{ plots}$$

**Step 5:** Allocate number of sample plots to each strata and validate the total number of plots for different strata using equation 5 and 6 (

Table 3.6).

$$\text{Weighted CV\% by strata} = \frac{\text{Weighted area of strata}}{\text{Total weighted area}} \quad (5)$$

$$\text{Plot by strata} = \text{Total number of plot} \times \text{Weighted CV\% by strata} \quad (6)$$

Table 3.6: Number of plots by strata in LFMA

Sl. No	Forest Types	CV %	Area (ha)	Weighted area	weighted CV by strata	No. of plots by strata
1	Broadleaf forest	85	370.52	314.942	0.043119942	12.75942767
2	Fir forest	50	1076.59	538.295	0.073700076	21.80825714
3	Blue pine forests	105	2312.67	2428.3035	0.332468539	98.37926627
4	Mixed Conifer	85	4732.14	4022.319	0.550711442	162.9585395
	<b>Total</b>		<b>8491.92</b>	<b>7303.8595</b>		<b>295.9054906 ≈ 296</b>



**Step 6:** Generate sampling grid area and determine the plot to plot distance using equation 7 and 8. The sampling grid is generated using the formula;

$$\text{Grid area} = \frac{\text{LFM forest area}}{\text{Number of plots}} \quad (7)$$

$$\text{Plot to plot distance} = \sqrt{\text{Grid area}} \quad (8)$$

For example, the grid area for LFMA is

$$\text{Grid Area} = \frac{8491.92}{296}$$

= 28.6889.189 ha, which is equivalent to 286889.189 m<sup>2</sup>

And the *Plot to plot distance* =  $\sqrt{286889.189 \text{ m}^2}$

= 535.62 meters.

But for the practical purpose, it is rounded to lower 50<sup>th</sup> value. Therefore, the final plot to plot distance is 500 m.

**Note:** The plot to plot distance is rounded to lower 50<sup>th</sup> value using the function = floor (estimated plot to plot distance, 50) in excel. In this case, = floor (535.62) = 500 m.

**Step 7:** Determine the new grid area based on plot to plot distance estimated in step 6 (Equation 9) in ha.

$$\text{Grid area} = \frac{(\text{plot to plot distance})^2}{10000} \quad (9)$$

$$\begin{aligned} \text{Grid area} &= \frac{500^2}{10000} \\ &= 25 \text{ ha} \end{aligned}$$

**Step 8.** Determine the final number of plots with new grid area estimated in step 7 using equation 10.

$$\text{No. of plots} = \frac{(\text{area of forest under LFMA})}{\text{Grid Area}} \quad (10)$$

For a) total LFMA

$$\text{No. of plots} = \frac{9157}{25}$$

= 366 (rounded to nearest whole number)

b) For forest area only

$$\text{No. of plots} = \frac{8491.92}{25} = 340$$

**Step 9:** Calculate no of plots by strata as per the no. of plots calculated in step 8 using equation

$$\text{Plot by strata} = \text{Total number of plot} \times \text{Weighted CV\% by strata}$$

Sl. No	Forest Types	CV %	Area (ha)	Weighted area	Weighted CV by strata	No. of plots by strata
1	Broadleaf forest	85	370.52	314.942	0.04311994	15
2	Fir forest	50	1076.59	538.295	0.07370008	25
3	Blue pine forests	105	2312.67	2428.3035	0.33246854	113
4	Mixed Conifer	85	4732.14	4022.319	0.55071144	187
	<b>Total</b>		<b>8491.92</b>	<b>7303.8595</b>		<b>340</b>

### Generate Sampling Grid

The regular sampling grid can be generated in ArcGIS, QGIS and any other GIS software. To generate the grid, you need to have physical boundary of the LFMA including clear boundaries for **Future management** and **Current management area** either in the .kml file or shape file, which shall be used for clipping the area such that only grid intersection falling inside the **Current Management Area** boundary is selected for further assessment.

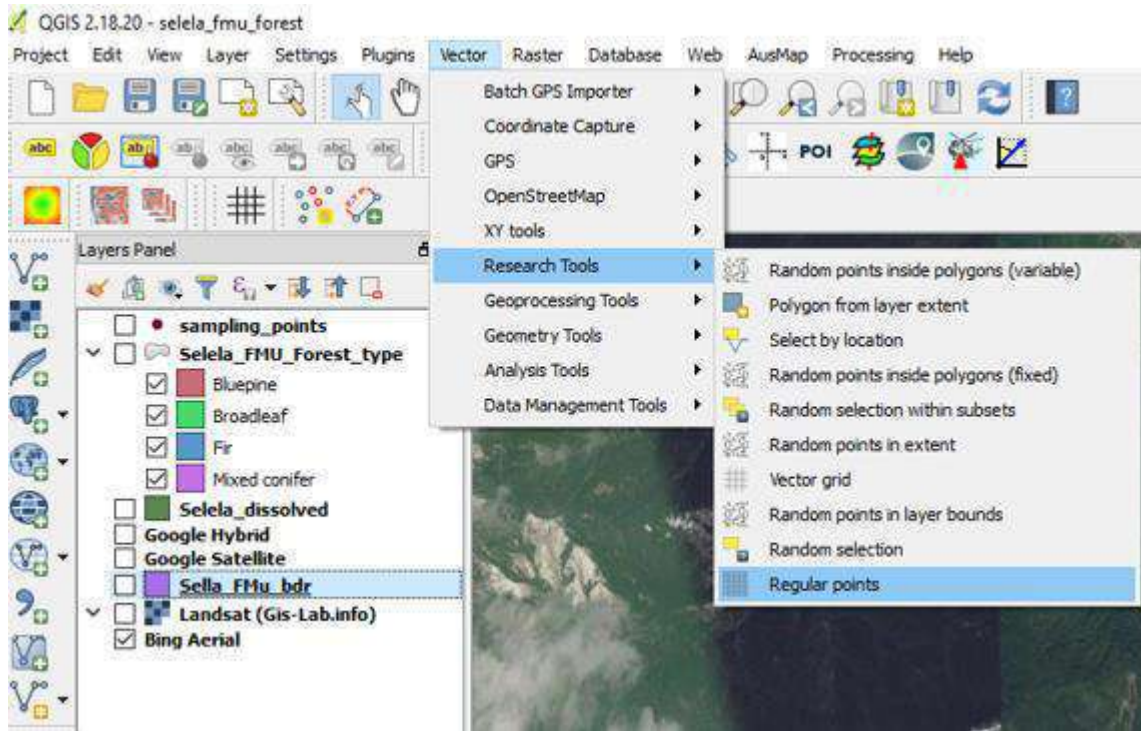
Note: In many cases, you shall need to confirm the coordinate system of the LFMA boundary. If it is in DrukRef, it has to be converted into WGS coordinate system. For each grid point, we then generate the northing and easting or coordinates for each point in degree minute second or decimal degrees as may be needed. If you are using QGIS, it is strongly recommended to use WGS coordinate system and coordinate in decimal degrees.

Another point to be noted here is that using the plot to plot distance (sampling grid), which in this example is 500 m, the sampling points or sample points shall be generated. Often the sampling points generated from GIS may not be exactly same as generated using equation 9 above. This is because in GIS we use regular plot distance (500 m) but the actual boundary of the LFMA is irregular, hence the slight variation between calculated plot number vis-à-vis the one generated from GIS. However, this is not a huge cause of concern, just ignore it.

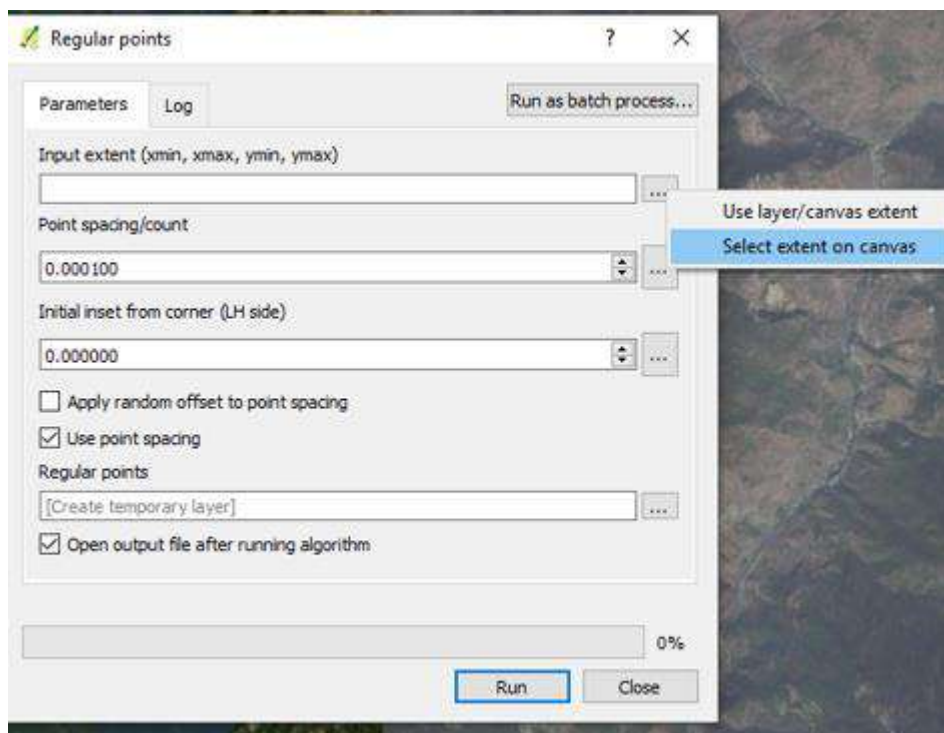
In QGIS, you can generate the systematic sampling points following the following step;

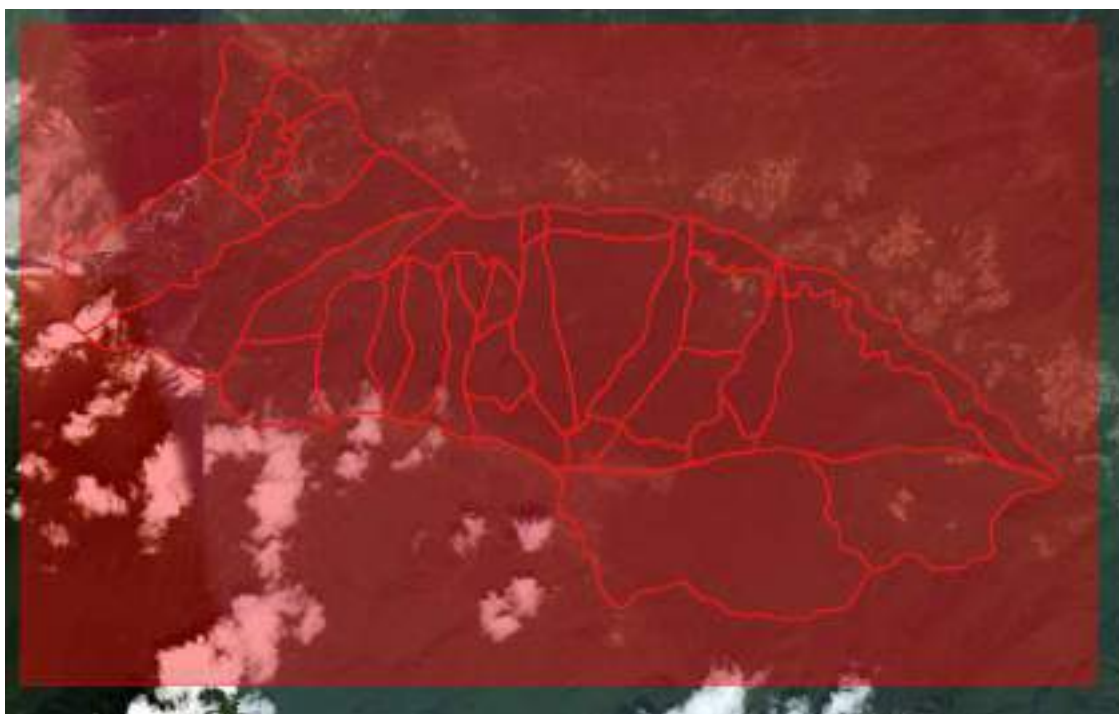
Load your forest boundary (LFMA boundary in this case) shape file or .kml file, which is a vector layer

Open Vector → Research Tools → Regular Points, a new window pops up.

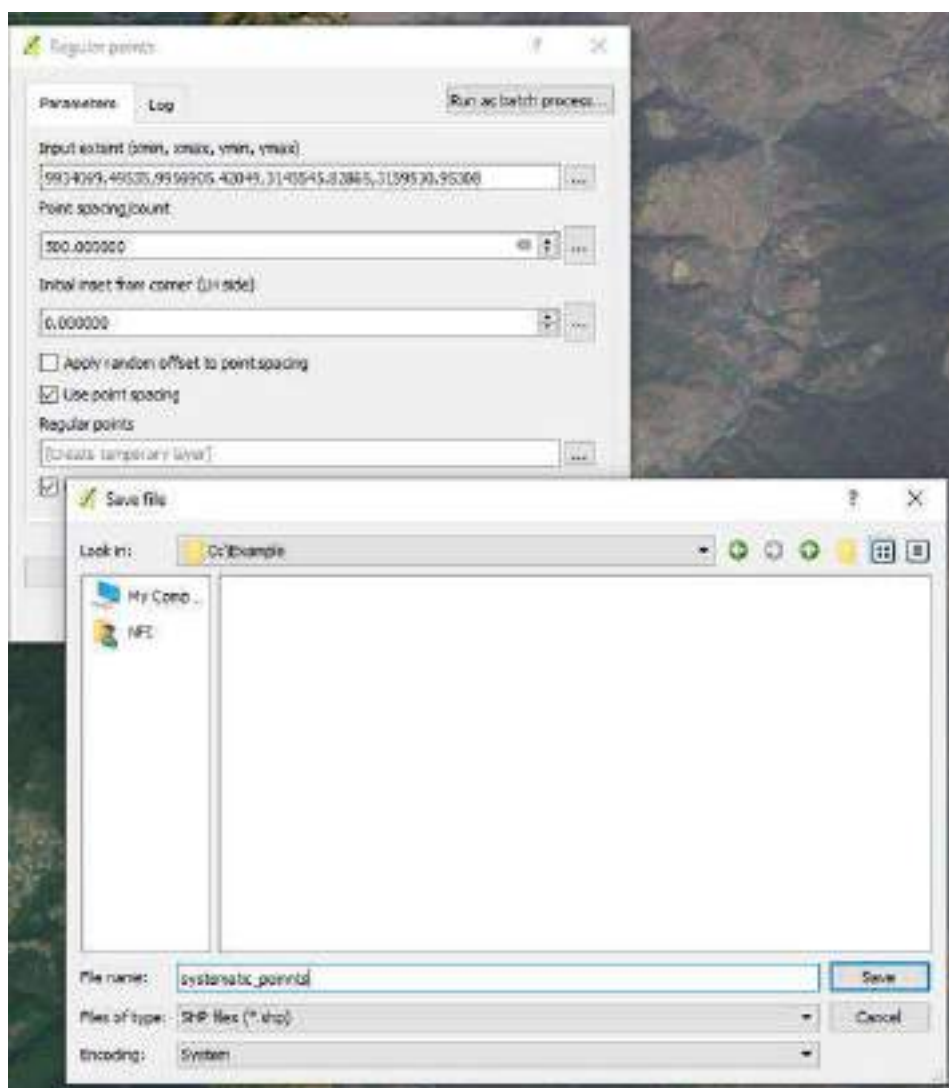


In the Input Extent, Select Extent on Canvas and select the extent of canvas by dragging the mouse covering whole LFMA boundary



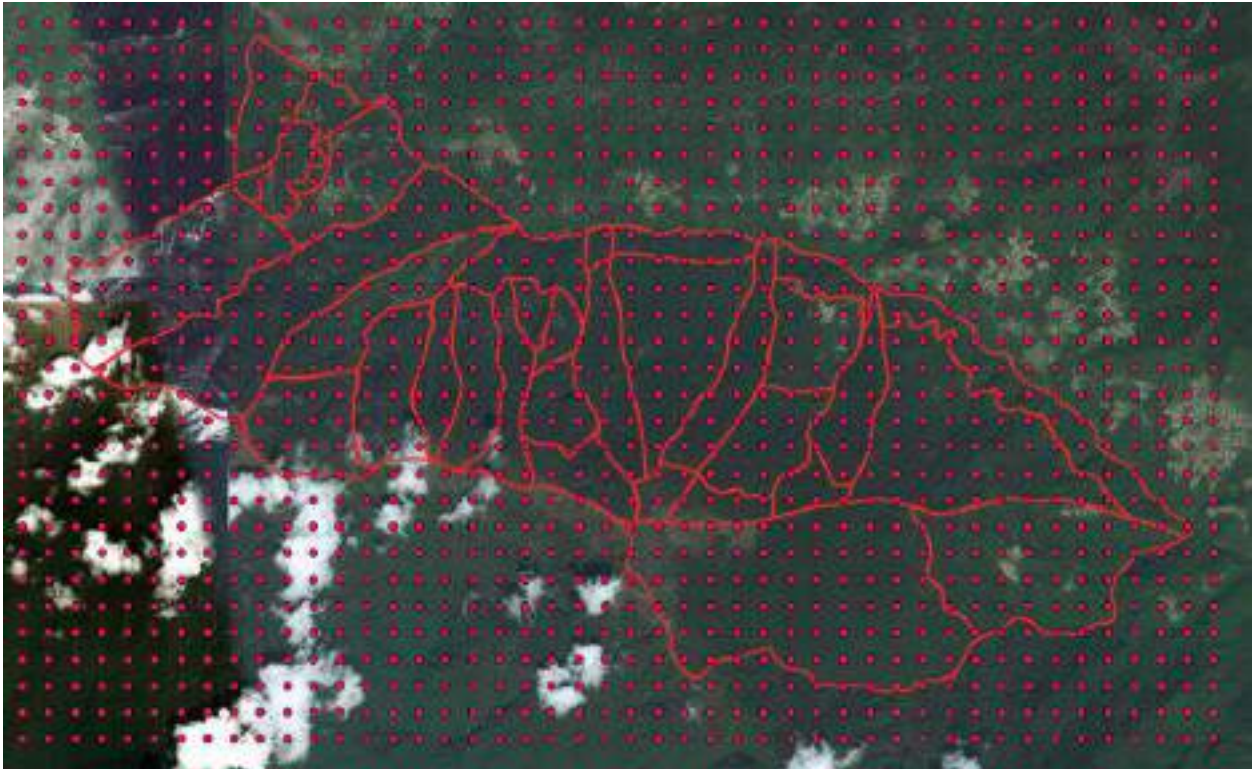


In the point spacing/count, type the plot to plot distance (e.g. 500 ) and save the file as systematic\_points or with any desired name and click on run. A systematic points shall be generated

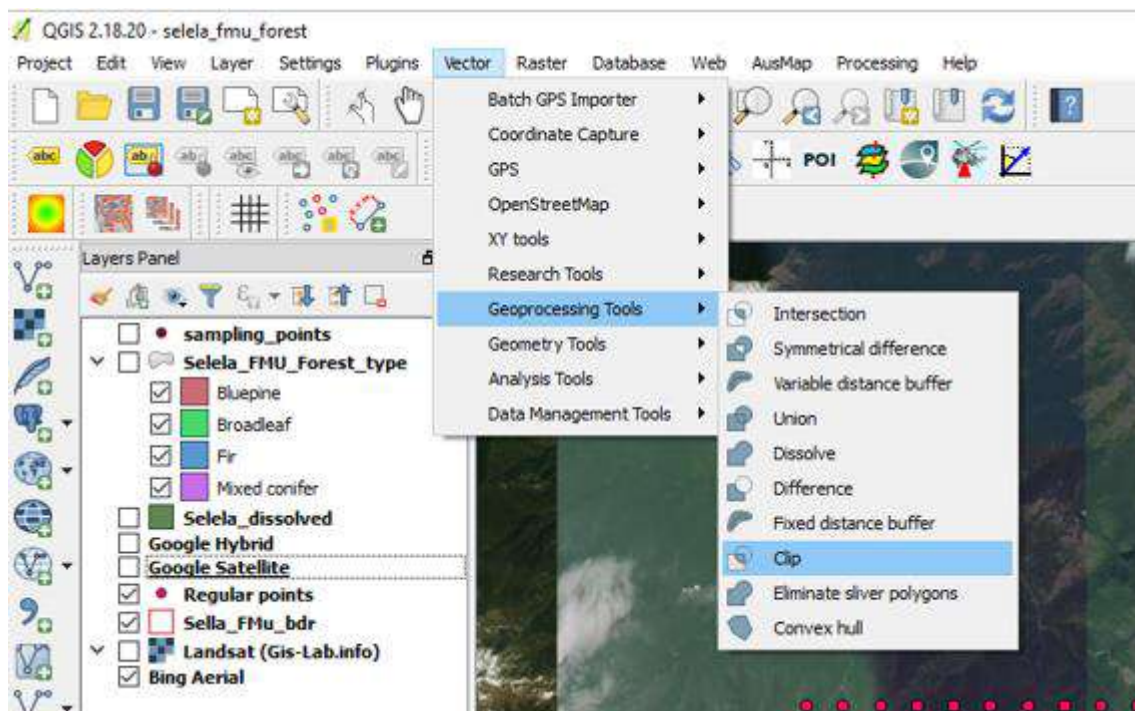




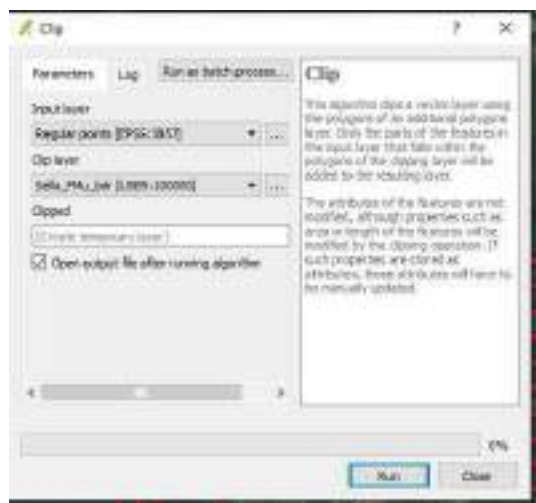
Systematic sample points shall be generated



Since we only want points falling inside the **Current Forest Management Area**, we need to clip the points using clip function in QGIS. Open **Vector** -> **Geoprocessing Tools** -> **Clip**



Select ‘**systematic\_points**’ as input layer and the **Current Forest Management Area** boundary as clip layer. Name the file as desired and save and run the algorithm



Go to the Attribute table for the sampling\_point.

Enable the edit mode.

Open the Field calculator and name the new column Plot\_ID

Set the **Output field type to :Text (string)** or as desired

Similarly generate coordinate for each sampling points

Export the sampling point as GPS exchange format for loading into GPS for locating the plots in the field

### **Forest Inventory Equipment**

The following equipment are required for the conduct of LFM forest inventory. Equipment shall be arranged by concerned office and they should ensure that each of them are functioning properly before moving to the field.

- Wedge Prism (with basal area factor of 2)
- GPS
- Altimeter
- Compass
- Smartphones with SW Maps installed (optional)
- Diameter Tape
- Measuring Tape
- Forest Inventory design map
- Base Map reflecting Blocks and Compartments.
- Data Sheets/Tally Sheets

### **Field Work**

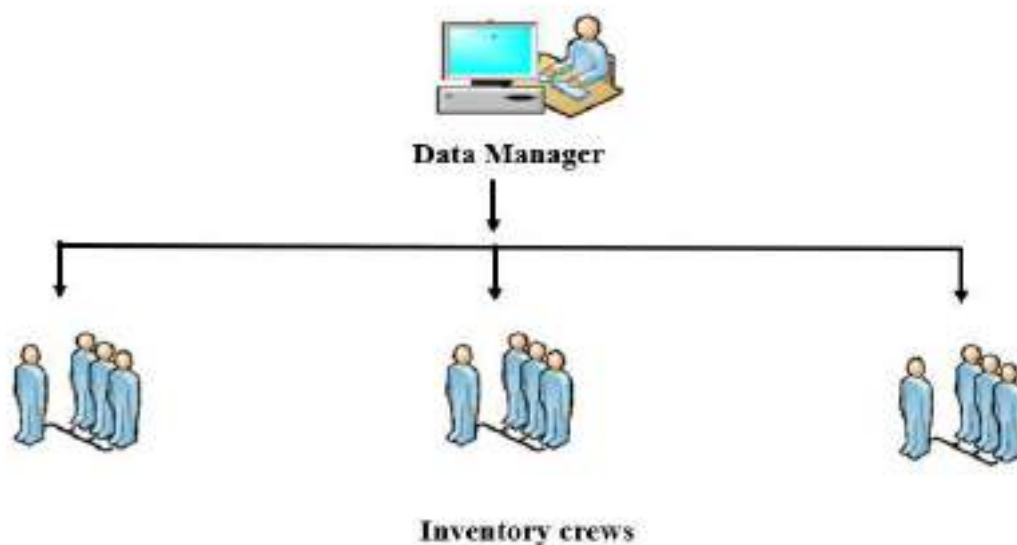
Field Work should involve mainly data collection from inventory plots. Specifically, it shall involve measurement and records of dbh of all trees which are above 10 cm dbh within a plot, besides, collecting information on regeneration and site conditions.

### **Formation of Inventory crew**

The Divisional Forest Offices shall be responsible for conducting the forest resource assessment for LFMA. The fieldwork may be coordinated by Range Officers for areas falling under his/her jurisdiction. For the



ease and fastness of the inventory work, the Range Officer concerned can form Inventory crews comprising of three to four members. The number of inventory crews shall depend on the number of inventory plots to be assessed within a Local Forest Management Area. The Data collected by each inventory crew shall be submitted to the Data Manager assigned by the Range Officer based at the Range Office.



*Figure 3.4 Inventory crew*

### **Navigation to Sample Plot**

Prior to navigation, it is crucial to upload all the Inventory Plots as waypoints into the GPS and SW map (optional). Once the inventory plots are uploaded into the GPS, the crew members can navigate to the plot center of every plot using GPS.

The open source SW map is very useful for navigation and can complement GPS in locating the plot center. In-ternet connectivity is important for using SW map for viewing the background google map and locating the plots. However, it is likely that the crews may not have access to internet in the field. Therefore, it is recom-mended to load the project area google map, plots and view the plot before moving to the plot at a location where there is a good internet connectivity. The offline maps thus generated works perfectly in absence of in-ternet connection in the field.

If your sample plot falls into an open area, or in a very dense and difficult place, do not change position because you feel this is not typical or assessment work is too difficult! If the plot is not accessible or inoperable, treat it as a zero plot and proceed to the next plot (mark the plot as inoperable). This is explained in subsequent chapters.

### **Data Collection**

There are three different tally sheets, one for conifer/mixed conifer forest, one for hardwood forests (temperate) and one for tropical forests. Depending on the forest type, appropriate tally sheet should be selected (Table 3.7 and Table 3.8). The actual assessment should always follow the same sequence as described in Table 3.9 This shall ensure that the measurements are not forgotten.

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Table 3.7 Example of a Tallysheet (Conifer)

Forest Resources Assessment Tally Sheet			Officer Date		Sheet No. Prism factor																			
Geog			Plot No.	accessible	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40																			
Block				inaccessible	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40																			
Compartment			Plot No.	accessible	41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74																			
				inaccessible	41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74																			

Species	1. Sample circle (r=3m)		2. Point sample with prism											
	0.3 - 1.3 m height	> 1.3m, < 10cm	10<20	20<30	30<40	40<50	50<60	60<70	70<80	80<90	size			
Chirpine			R											
			T											
			F											
Bluepine			R											
			T											
			F											
Hemlock			R											
			T											
			F											
Spruce			R											
			T											
			F											
Fir			R											
			T											
			F											
Other Conifers			R											
			T											
			F											
Oak			R											
			T											
			F											
Acer			R											
			T											
			F											
Betula			R											
			T											
			F											
Rhododendron			R											
			T											
			F											
Other Broadl.			R											
			T											
			F											

Table 3.8 Compartment description

Compartment Description									
Single choice only from 1-9 (the total number of records per box must be equal to the total number of accessible sample plots)									
Site condition									
1. Slope			2. Erosiveness			3. Soil Cover			
gentle (<25%)	moderate (25-50%)	steep (50-100%)	stable	moderate	unstable	high	moderate	low	
4. Forest Type									12. Wildlife
Hemlock	Fir	Spruce	Mixed Conifer	Blue Pine	Chirpine	Hardwood	Mixed H/C		
5. Age Class									
young/pole	immature	mature	old/over-mat.		6. Stand Type				
					plantation	natural	coppice		
7. Canopy Closure									
dense (>70%)	closed (40-70%)	open (10-40%)	unstocked (< 10%)		8. Condition				
					good	average	poor		
9. Silvicultural Measures									
planting	thinning	felling (Firewood)	felling (Timber)	no activity					
Multiple choice possible from 10-11 (the total number of records must not be equal to the total number of accessible plots)									
10. Forest Use	intensive	extensive			11. NWFP	abundant	sparse		
Grazing					Firewood				
Soskhing					Bamboo				
Lopping					Cane				
					Daphne				
13. Stand Description						14. Management Prescription			

Table 3.9 Sequence of steps for resource assessment

Step	Description	Where/When
1	Fill header of tally sheet	At 1st sample plot
2	Decide whether plot is accessible or inaccessible	For each sample plot
3	Regeneration sample (3m radius)	For each accessible plot
4	Prism sweep	For each accessible plot
5	Tabular description	For each accessible plot
6	Verbal stand description + management prescriptions	At the end of the assessment

The details of the sequence of steps for resource assessment are explained hereunder:

### Step 1: Fill Header

- a) Fill all the fields.
- b) Enter Sheet No.

Note: For each Compartment only one tally sheet is required. However, in case the space within a cell is not sufficient, a second tally sheet shall be attached. In this case the field “Sheet No.” should be filled as follows:

Sheet 1: 1/2

Sheet 2: 2/2

**Note:** this is very important; otherwise the 2nd sheet may be left out during data entry and analysis

- c) Enter the prism basal area factor. This factor is marked on the prism, default factor is 2.

### Step 2: Decide, whether plot is accessible or not.

A plot is considered as in-accessible, if the plot center is located on Steep slope which is difficult to access for any kind of silviculture measures.

Depending on its nature, encircle/strike through the number of the plot in the respective line and mark it also on your base map.

**Note:** It is very important that the number of plots, which were actually assessed, is indicated on the tally sheet, otherwise data analysis shall be wrong! (Note: during data analysis, the number of counted trees shall be divided by the number of sample plots).

*Table 3.10 Recording Plots according to accessibility*

Plot	accessible	<del>1</del> 2 3 4 5 6 7 8 9 10 11 12 <del>13</del> 14 15 16 17 18 19 20 21 22 23 24 25 26
No.	In-accessible	1 2 3 4 5 6 7 8 9 10 <del>11</del> <del>12</del> 13 14 15 16 17 18 19 20 21 22 23 24 25 26

**If a plot is inaccessible, then no measurements shall be taken. In that case, proceed to the next plot!**

### Step 3: Regeneration Sample

Within a circle of 3.57 meters radius, all trees above 30 cm height and below 10 cm in diameter are assessed. This refers only to live trees of timber species (e.g. *Lyonia* is not counted). The radius of the sample plot is measured with a 3.57 metres long stick. The radius is horizontal distance. If you have measured the slope distance using measuring tape, the correction factor must be used to convert slope distance into horizontal distance. Assessment is always done clockwise starting from North to avoid double counting or missing them all together. Coppice shoots are counted as single trees, if they sprout directly from the stock or root. Branches or other sprouts are not counted.

Recording: Mark each tree with a vertical line in the respective column and a dash as shown in the example below. When assessing the next sample plot just continue recording by using the same cells for the same species.

*Table 3.11 Recording Plots according to accessibility*

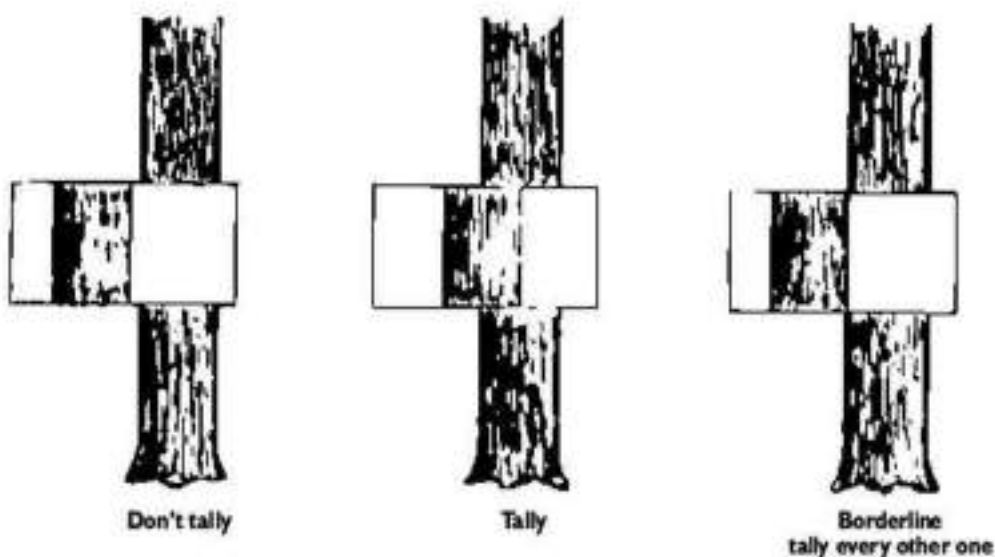
Species	1. Regeneration sample circle (r=3m)	
	0.3 - 1.3 m height	> 1.3m height < 10cm dbh
Bluepine		
Chirpine		

#### **Step 4: Prism Sweep**

Sample trees are identified with the help of a wedge prism. Whether a tree is a sample tree or not depends on its basal area and the distance to the plot centre (i.e. probability according to size). Large trees can be located further away than small trees. Dead trees are not counted. (Note: if there are dead trees, which can be used for firewood, this is considered in the box "NWFP").

From the sample point a 360° prism sweep is taken clockwise starting from the North for the ease of field work and to avoid double counting and missing any 'IN' trees. The prism needs to be held directly above the sample plot center. (Note: The person should be right in the centre of the sample point and not the prism).

As it depends on the distance and the dbh whether a tree is "IN" or "OUT", slope correction is necessary especially on steep areas. This is done by pointing with the prism (use the prism like you would be using a stick) to the tree at breast height (usually at 1.3 metres height). Then turn the prism 90° and check whether the tree is "IN" or "OUT" (Figure 3.5).



*Figure 3.5 Identification of sample trees with the wedge prism*

#### **How to treat borderline trees?**

Borderline trees are treated half and counted as half. For the ease of tally, generally adopted method in LFM is to count as follows: the 1<sup>st</sup> is "IN", the 2<sup>nd</sup> "OUT", the 3<sup>rd</sup> "IN" and so on. The counting continues throughout the Compartment for all sample points.

#### **What to do, if the tree is not visible or behind another tree?**

This problem can be solved in different ways:

- Move your position sideward from the sample point, until you can see the tree clearly or The easiest way is observe if the trees of same dbh or smaller further way from hidden tree. However, it is very important, that the distance to the tree is kept constant.

- Check whether the tree is "IN" on higher part of the stem. If it is "IN" or at borderline, then the tree is "IN". If the tree is almost in, then treat as a boundary tree. If it is clearly out, then it should be treated as "OUT".
- Remove shrub or objects, which obscure visibility.
- If you can't see the tree stem at all, then check the critical distance as a last resort.

Measure the dbh of the tree and multiply the dbh with 0.3535 (this is the critical distance factor for basal area factor 2). This gives you the critical horizontal distance in metres. If the horizontal distance to the tree is less than the critical distance, then the tree is "IN". E.g.: dbh = 49 cm, then the critical distance is  $49 \times 0.3535 = 17.3$  m, if the tree is 16.9 m away, then it is a sample tree.

For each "IN"-tree the following observations and measurements are taken and recorded:

- dbh-class (check with tape if you are in doubt, especially for larger dbh)
- Should the tree be extracted within the next 10 years for silvicultural reasons<sup>5</sup>? If yes, then it needs to be decided whether it can be used for timber (T) or only as firewood (F). Depending on the result, a dash must be marked in one of the following lines:
  - **R** (remain): trees that shall not be harvested;
  - **T** (timber): could be extracted and used as *drashing, cham, tsim, shingleps*, flagpoles, poles, posts and other construction purposes;
  - **F** (firewood): could be extracted and used for firewood, only.

**Note:** This is a very important element of the resource assessment, as this shall provide the information, on how many trees could be removed from the sub compartment and for what purpose it could be used based on the "production potential" of the forest. The decision whether a tree could be used shall be based entirely on silvicultural considerations, and should be done very carefully. Follow the prescriptions of the silvicultural guidelines. In case of doubt, mark the tree as remainder, especially if canopy closure is open.

Table 3.12 Recording sample trees (basal area sampling)

2. Point sample with prism <sup>*1</sup> : 100, 150									
	10<20	20<30	30<40	40<50	50<60	60<70	70<80	80<90	Size
<b>R</b>									95.125 <sup>*1</sup>
<b>T</b>									
<b>F</b>									

In case the dbh is larger than 90 cm then note the dbh in column "size" as shown in the example above. If there are more large trees than there is space in the cell, just note it somewhere on the tally sheet (indicate with \*1, as shown in Table 3.12 Recording sample trees (basal area sampling)).

### Step 5: Tabular Compartment Description (Back-Page of the Tally Sheet)

After completion of the sample plot assessment, the tables on the back-page (Compartment Description) need to be filled for each sample plot. The description refers to the immediate vicinity (approximately on tree length in radius) of the sample point. For the boxes 1-9, a single choice must be made (i.e. the total number of records must be equal to the total number of accessible plots). The different criteria are assessed based on "expert valuation"; some indicators are specified in Table 3.9. The boxes 10-12 must only be filled if required, multiple choices is possible.

Table 3.13 Tabular assessment of site and forest condition (1-8)

Criteria		Indicator	Remark
<b>1 Slope</b> <i>(Refers to the slope, where the plot centre is located)</i>	gentle	Slope < 25%	If the slope is > 100% then the plot is considered as "inoperable"
	moderate	Slope 25-50%	
	steep	Slope 50-100%	
<b>2 Soil Cover</b> <i>(Refers to the coverage of the soil with vegetation and is an indicator for surface runoff and water infiltration)</i>	good	Soil is covered by dense undergrowth (tree regeneration, herbs, shrubs, etc.), rain does not fall directly on soil	
	moderate	There is little shrubby vegetation or undergrowth, crown cover dense to closed	
	low	Very little vegetation, heavily browsed areas; rain falls directly on the ground, surface run off	
<b>3 Erosiveness</b> <i>(Refers to the risk of erosion if trees are removed)</i>	stable	Gentle to moderate slopes, good soil cover, erosion risk low	
	moderate	Moderate to steep areas, clayish soil, little ground vegetation	
	high	Waterlogged areas on moderate to steep slopes, already some signs of erosion, high risk for land slides	
<b>4 Forest type</b> <i>(Refers to the forest type within a tree length distance)</i>			For mixed Hardwood/Conifer the percentage of broadleaves or conifers should be at least 10%.
<b>5 Age class</b> <i>(Refers to the age of the forest, for natural uneven aged forests it refers to the development stage)</i>	young/pole	<u>Even-aged</u> : thicket and pole size, no timber size trees	Sometimes it may be difficult to determine the age class, as there might be a mix of different age classes. In this indicate the dominating age.
	immature	<u>Even-aged</u> : majority of trees immature <u>Uneven-aged</u> : development stage, no mature trees, few over-mature trees	
	mature	<u>Even-aged</u> : majority of trees have reached harvestable size <u>Uneven-aged</u> : consolidation phase, most of the trees have reached harvestable size	



	over-mature	<p><u>Even-aged</u>: majority of trees over-mature, some signs of die-back and decay, trees should be harvested as soon as possible</p> <p><u>Uneven-aged</u>: regeneration phase: over-mature trees with groups of regeneration and pole size trees in lower storey</p>	
<b>6 Stand Type</b> <i>(Refers to type of stand establishment)</i>	plantation	Trees have been planted	
	natural	Trees grown from natural regeneration of seeds	
	coppice	Trees grown from coppice shoots, only common in broadleaved forests	
<b>7 Canopy closure</b> <i>(Refers to the closure of the main canopy)</i>	dense	> 70%	
	closed	40-70%	
	open	10-40%	
	unstocked	< 10%	
<b>8 Condition</b> <i>(Refers to health, form, stocking density and distribution)</i>	good	<p>Mature and immature forests: trees of good form, no signs of decay or die-back, closed canopy;</p> <p>Young/pole age: commercial species are equally distributed throughout the area, closed</p>	
	average	No particularities	
	poor	<p>Over-mature forest with signs of decay and die back, lack of natural regeneration, shrubs/bamboo dominate under-storey.</p> <p>Young/pole: dense, non-commercial species dominate</p>	

## 9. Silvicultural measure

There are broadly five main silviculture measures identified for LFMP. They are **Planting**, **Thinning**, **Felling (Firewood)**, **Felling (Timber)** and **No Activity**. For each sample plot decide what silvicultural operation is required. If trees are marked for removal, specify the type of operation, i.e. “**Felling (firewood)**” or “**Felling (Timber)**”. If the plot needs stand improvement silviculture measures specify the type of operation i.e., “**Planting**” or “**Thinning**”. Elaborate. If the plot does not require any kind of silviculture operation specify the operation as “No activity”. Mark only one option per plot. Multiple choices are not possible. Total number of records must be equal to the total number of accessible plots.

**Note:** The filling of these boxes allows the calculation of the approximate area where the operation shall be carried out.

## 10. Forest Use and 11. NWFP

The occurrence of NWFP and their current use is assessed by visually evaluating the forest in the immediate surrounding of the sample point. If you observe the availability of any NWFP, record type and mark, whether it occurs in abundance or you can only see a few or a single specimen (sparse). Firewood in this context refers to the availability of deadwood, which can be collected. Evaluate the intensity of grazing, soksing and lopping and mark it in the respective column. If there is none, then don't mark. There is an empty row, where you can enter an additional use.

**Table 3.8 Recording of NWFP, firewood and other forest use**

NWFP	abundant	sparse	Forest Use	intensive	extensive
Firewood			Grazing		
Bamboo			Shoksing		
Cane			Lopping		
Daphne					
Ferns					

## 12. Wildlife

If you observe any sign of endangered or totally protected wildlife, while walking along the inventory plots, indicate wildlife species on tally sheet.

Table 3.9 Example for wildlife recording

Wildlife
Snow Leopard
Black Bear

## Step 6: Stand Description and Management Prescription (back-page of tally sheet)

This is done once the last plot has been assessed. It provides guidance for the assessment for stand description and providing management prescription.

*Box 3.1 Guide for stand description and management prescription (13-14)*

### 13. Stand Description

The description refers to the whole compartment and includes observations, which are observed while walking along the inventory plots through the compartment.

In this box one has to briefly describe stand condition of the whole compartment. It shall include: age class, forest type, canopy closure, condition, type, age or forest type distribution, health condition, etc. Significant differences in stand composition and peculiarities should be additionally indicated on the draft compartment map. For the formulation of the stand description the tabular description may serve as a valuable aide. Emphasis has to be given to any spatial differences in stand condition, which cannot be depicted from the tabular description.

### 14. Management Prescription:

In this box, the potential uses shall be described and, if only a part of the compartment is usable, the location needs to be specified. Also, reference should be made to the accessibility (i.e. distance from road or village). Need for protection measures, e.g. control of grazing, etc. should be specified.

### 3.3.5 Data Analysis

#### 3.3.5.1 Requirements

The entire data analysis must be carried out in pre-designed excel sheets. Therefore, the planner should have adequate knowledge on use of Microsoft excel program.

#### 3.3.5.2 Data Entry and Print-out of Compartment Register

Data analysis is done by simply transferring the data recorded in the tally sheet into an EXCEL spreadsheet. There are three different spreadsheets, one for conifer/mixed conifer zone (Compartment register-conifer.xls), one for the hardwood zone (Compartment register-hardwood.xls) and one for tropical forests (Compartment register tropical.xls). Once data are entered, the spreadsheet shall automatically carry out all the calculations and fill the Compartment sheet, which can be printed out.

The screenshot displays the 'compartment register -hardwood.xls' spreadsheet. The interface includes a standard Excel menu bar (File, Home, Insert, Page Layout, Formulas, Data, Review, View, Help) and a toolbar. The active cell is A36. The spreadsheet is divided into several sections:

- Data Entry and Analysis:** A section at the top with instructions and input fields for 'Date', 'Time', 'Location', 'Area', 'No. of sample plots', 'Operator', 'Status', 'Area', 'Production', and 'Production'.
- Notes:** A yellow box containing instructions for data entry and calculations.
- Input Data:** A table with columns for 'No.', 'Name', 'Status', 'Area', 'Production', and 'Production'.
- Output Data:** A large table with columns for 'No.', 'Name', 'Status', 'Area', 'Production', and 'Production'.

The output data table is a large grid with rows for different forest types (e.g., Conifer, Mixed Conifer, Hardwood, Mixed Hardwood) and columns for various attributes (e.g., No., Name, Status, Area, Production, Production).

Figure 3.6 Example of a Compartment register –Hardwood (Data Entry)

Compartment Record																											
Geog	Shari		Block	Jangsa		Block No	1		Comp.No	I																	
Areas in ha																											
Non Production		50.0		Protection		30.0		In-accessible		7.5		Net Production		62.5													
Forest Composition and Description																											
<div><div>Number of trees/ha by diameter class (dbh&gt;10 cm)</div><div><div>■ Beilschmiedia spp.</div><div>■ Litsea spp.</div><div>■ Quercus spp.</div><div>■ Other Broadleave</div><div>■ Cinnamomum spp.</div><div>■ Michelia spp.</div><div>■ Schima spp.</div><div>■ Conifer spp.</div><div>■ Exbucklandia</div><div>■ Persea spp.</div><div>■ Walnut</div></div></div>										Stand data																	
										Bas. Area (m2/ha)		6.8															
										Tot. Vol. (m3/ha)		44.7															
										Vconifer %																	
Forest Type		%		Stand Type		%		NWFP+firew.		A		S															
Hemlock				Plantation				Type		%		%															
Fir				Natural		100		Firewood		88		16															
Spruce				Coppice				Bamboo																			
Mixed Conifer				Canopy		%		Cane																			
Blue Pine				Dense				Daphne																			
Chir Pine				Closed		88																					
Hardwood		100		Open		12																					
Mixed H/C				Unstocked				Forest Use		I		E															
Age Class		%		Condition		%		Type		%		%															
Young				Good		40		Grazing		92		8.00															
Immature				Average		60		Shokshing																			
Mature		92		Poor				Lopping																			
Overmature		8		Site Characteristics																							
Slope		%		Erosiveness		%		Soil Cover		%																	
Gentle		92		Stable		80		High		12																	
Moderate		8		Moderate		12		Moderate		88																	
Steep		4		Unstable		8		Low																			
Species		Height		N/ha per diameter class										Total (> 10cm)													
		0.3<1.3 m		<10		10<20		20<30		30<40		40<50		50<60		60<70		70<80		80<90		90+		N/ha		%	
Beilschmiedia spp.						59		21		7		3		2		1		1		1				94		57	
Cinnamomum spp.																											
Exbucklandia																											
Litsea spp.																											
Michelia spp.																											
Persea spp.						45		24		1														71		43	
Quercus spp.																											
Schima spp.																											
Walnut																											
Other Broadleave																											
Conifer spp.																											
Total						104		46		7		3		2		1		1		1				164		100	
Future Management & Monitoring of Activities																											
Production Potential (N, Volume)					No of trees removed each year										Total	%											
Product size	N total	N/ha	%	(m3)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028													
>50	Drashing	86	1	33	265																						
	Firewood	68	1		176																						
30-49	Cham	198	3	24	213																						
	Firewood	156	2		113																						
20-29	Tsim	509	8	36	159																						
	Firewood	1019	16		324																						
10-19	Poles, etc.	1415	23	7	88																						
	Firewood																										
Silvicultural Measures					Area in ha implemented per year										Total	%											
Measure	Area (ha)	in %			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028													
Planting	66.0	44																									
Thinning	66.0	44																									
Felling (firewood)	6.0	4																									
Felling (timber)	12.0	8																									
No activity																											
Assessment carried out by			Tashi										Year:		2019												

Figure 3.7: Example of results sheet- hardwood

### 3.3.5.3 Steps for Data entry and analysis

Data entry and analysis should be done as follows (note: it is very important that the database structure is always the same for each Gewog.)

1. Create a new folder with the name of the forest management area, e.g.: Kawang
2. Under this folder create a new sub-folder with the name “Gewog name + compartment register”, e.g. “Kawang Compartment Register”
3. Within the sub-folder “compartment register”, create for each compartment again a sub-folder with the number and name of the compartment, e.g. “Dompola-1”
4. Select the corresponding spreadsheet (Compartment register-conifer.xls, Compdata-hardwood.xls or Compartment register-tropical.xls) and copy it into sub-folder (e.g. “Dompola-1”). - Open Compdata-?.xls and rename it with the name of the compartment, e.g. “Dampola-1”
5. Each "compartment" spreadsheet consists of the two sheets: "data entry" and "results"
6. Open sheet "data entry"
7. Transfer data from the tally sheet in the blue marked cells.
8. During data entry, check on plausibility. The total number in the following boxes must be equal to the total number of accessible sample plots:
  - Forest Type
  - Age Class
  - Type
  - Canopy –
  - Condition
  - Soil Cover
  - Steepness
  - Erosiveness
  - Silviculture measures
9. For the other boxes (Forest uses and NWFP) it may be less or more (multiple choice)
10. Stand Description and Management Prescription has to be directly entered in the sheet "Results".

Once all data are entered, then the Compartment Record (= "Result" sheet) can be printed. Make at least one back-up copy on hard drive. For future reference, the original tally sheets and the field map must be kept for the entire planning period.

### 3.3.5.4 Calculation of Results

The calculation of the results is done based on an EXCEL spreadsheet named “Summary Sheet.xls”. The capacity of the summary sheet is limited to 20 Blocks and 100 compartments. In case the forest management area consists of more Blocks or/and compartments, then the spreadsheet needs to be changed in consultation with FRMD. For the calculation of results, the data from the compartment register should be transferred into the summary sheet. This can be done by two persons; one should read the data and the other one should enter it into the spreadsheet.

Dzongkhag	Paro	Geog	Shari
Basal Area Factor	2		
Block			
No	Name		
1	Jangsa		
2	Kudophu		
3	Bjishinggang		
4	Zega		
5	Brekha		
6	Zonglela		
7	Betekha		
8	Korilla		

	Summary data																		
Block No	Compartment		Area (ha)						BA/ha	Volume/ha	Vconifer %	No of accessible sample plots	Forest Type (%)						
	Block Name	Comp No	Non-Production	Protection	Inaccessible	Net Production	Hemlock	Fir					Spruce	Mixed C	Bluepine	Chirpine	Hardwood	Mixed HC	
1	Jangsa	I	45.3	3.2	17.0	17.8	144.2	88	21		5		43	19		5	29		
1	Jangsa	II		53.3	7.4	23.3	18.2	175.3	73	19			5	95					
1	Jangsa	III	62.4	57.1	3.3	17.2	17.7	143.3	88	21		5		43	19		5	29	
1	Jangsa	IV	48.3	31.7	1.6	18.7	9.0	69.2	81	23					65		9	26	
2	Kudophu	I		48.0	20.1	30.1	33.9	304.0	73	15				47	53				
2	Kudophu	II		25.0	7.4	54.6	10.3	71.9	73	22					41		5	55	
2	Kudophu	III		25.0	8.4	61.6	5.5	39.2	98	22					95				
2	Kudophu	IV		33.2	12.2	18.2	13.9	107.9	98	15				20	80				
2	Kudophu	V		42.0	13.2	16.8	16.1	159.9	71	14				21	79				
2	Kudophu	VI		30.0	6.4	13.8	26.1	230.8	64	17				47			6	47	
3	Bjashingang	I		23.0	12.0	18.0	14.3	132.7	100	15		73		27					
3	Bjashingang	II		54.0	16.0	24.0	16.5	166.0	98	15	5	67	13						
3	Bjashingang	III		26.0	8.4	61.6	28.5	247.1	100.0	22		5	9	86					
3	Bjashingang	IV		27.0	28.0	42.0	32.1	318.7	94.0	15	7	20	73						
3	Bjashingang	V		20.0	12.0	48.0	24.1	239.0	94	20	20	25	56						
4	Zega	I		15.0	11.4	29.2	24.0	202.4	96	18		11	6	61	11			11	
4	Zega	II		25.0	9.6	30.4	22.1	175.7	91	19				68			11	21	
4	Zega	III		14.3	13.2	33.8	14.8	154.5	97	18		28	28	44					
4	Zega	IV		20.0	19.9	42.3	8.8	101.6	100	17				94	6				
4	Zega	V		8.0	2.2	53.3	23.8	175.3	88	24			4	38	27		4	38	
5	Brekha	I		45.3	3.2	17.0	17.8	144.2	88	21		5		43	19		5	29	

Figure 3.8: Summary Sheet

## Steps

1. Open folder "Gewog name", e.g.: "Kawang" (i.e. it is the same folder, where the compartment register is kept)
2. Copy "Summary Sheet.xls" into this folder & Rename copied "Summary Sheet.xls" in "Gewog name + Summary Sheet", e.g. "Kawang summary sheet.xls"
3. open the spreadsheet and De-activate Macros and Select sheet "Data Input" which is the sheet at the utmost left (the EXCEL file consists of a number of individual sheets)
4. Enter name of Dzongkhag and Gewog in blue cells
5. Enter Basal area factor (i.e. 2) in blue cell.
6. List all Blocks and Compartments .
7. Transfer all data from compartment register into the blue cells of the box: "summary data".
8. Always save spreadsheet after entering data of one Compartment.

Once all data are entered, re-check all entries! Make at least one back-up copy on a hard drive. The calculation of results is done by the spreadsheet automatically.

**Note:** The soft copies of Tallysheets, Compartment registers and summary sheets are available at FRMD. Therefore, the planner can collect the sheets from FRMD whenever required.

## 3.3.6 Preparation of Forest Management Plan, Approval and Implementation

### 3.3.6.1 Preparation of Local Forest Management Plan

The management plan should be prepared by trained forest officers and reviewed by the concerned CFO. To ensure same standard, quality and compatibility of the plans and to minimize the effort of writing, a template has been developed. This provides – as far as possible – standard formulations. The writer only has to add forest management area specific information in predefined places.

The use of a template may shorten approval procedures considerably, as all the plans shall be of the same format and all calculations are done in exactly the same way. This makes an intensive technical check redundant. For the preparation of the plan, FRMD shall provide technical assistance.

#### Planning period

The plan period for the Local Forest Management Plan shall be for 10 years.

#### Plan layout

The layout of the plan is as per Figure 3.9. This is the minimum requirement of the plan. However, the planner can include additional sections and information if deemed necessary. The softcopies of the Plan layout is available at FRMD.



<b>Table of Content</b>	<b>Page</b>
<b>1 AUTHORITY FOR PREPARATION, REVISION AND APPROVAL .....</b>	<b>1</b>
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## Annexes

1. Compiled Results by Compartment
2. Compartment Register
3. Overview Map
4. Forest Management Circle Map
5. Spatial Organization Map of Blocks and Compartments

Figure 3.9: Plan Layout

### 3.3.6.2 Planning Schedule

*Table 3.14 Planning Schedule*

Activity	Components	Approximate Man days
Reconnaissance Survey	<ul style="list-style-type: none"> <li>• General survey of Gewog Area</li> <li>• Collection of data on roads, rivers, drinking water sources, religious sites, future management areas, etc.</li> <li>• Public Consultation</li> </ul>	10 days
Compartmentalization and Forest Function Mapping	<ul style="list-style-type: none"> <li>• Preparation of Blocks and Compartments</li> <li>• Preparation of Map using GIS tools</li> <li>• Field truthing</li> </ul>	30 days
Forest Resource Assessment	<ul style="list-style-type: none"> <li>• Inventory</li> <li>• Data Collection</li> </ul>	6-10 Plots/Crew/Day
Data Compilation and Analysis	<ul style="list-style-type: none"> <li>• Data Entry</li> <li>• Analysis</li> </ul>	15 days
Plan Writing	<ul style="list-style-type: none"> <li>• Plan Writing</li> <li>• Map Preparation</li> <li>• Divisional Level Review</li> <li>• Submission</li> </ul>	15 days
Review and Approval	<ul style="list-style-type: none"> <li>• Review of Plan at FRMD</li> <li>• Approval from Department and the Ministry</li> </ul>	30 days
Printing	<ul style="list-style-type: none"> <li>• Printing</li> </ul>	10 days

**Note:** The above schedule and the mandays indicated are tentative and are only estimates. The actual requirement of mandays and planning schedule may vary depending on the area extend of Local Forest Management area, topographic features and other factors within the locality.

### 3.4 Review and Approval

Following administrative protocols should be followed for review and approval of the Local Forest Management Plan.

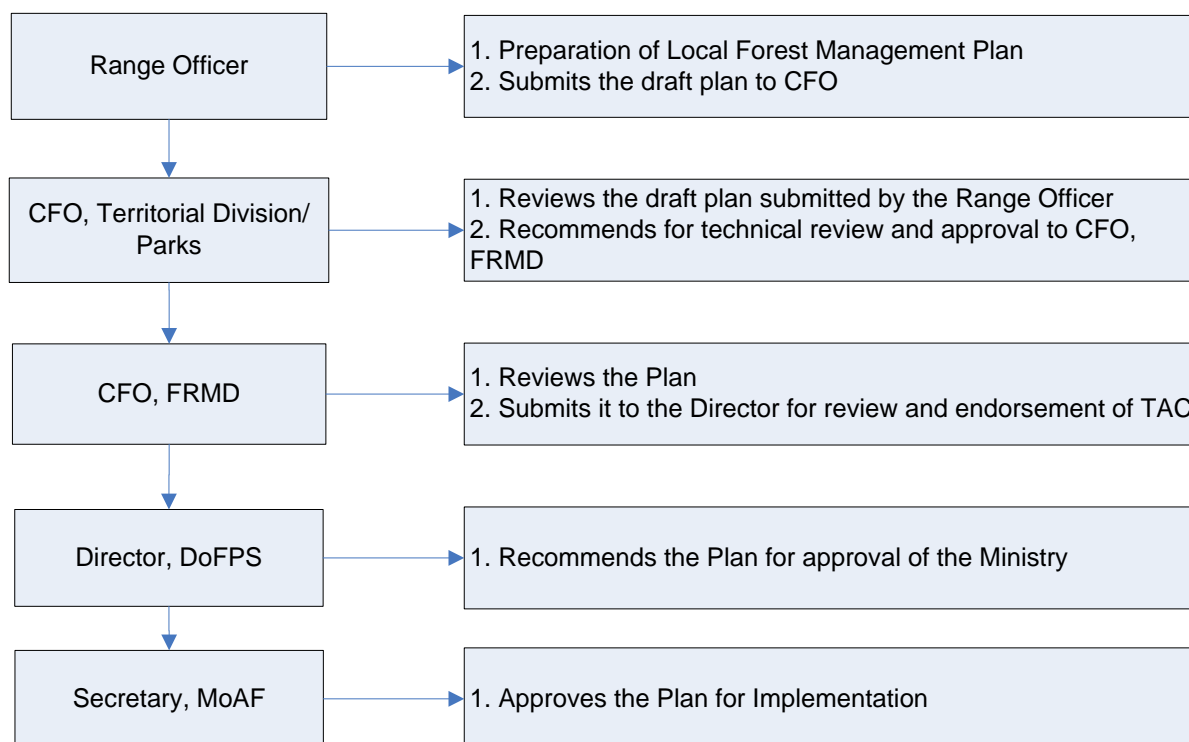


Figure 3.10 Review and approval procedure

#### 3.4.1 Provision for amendment and plan revision

The approved Plan may be revised during the implementation period if major changes occur in the area of LFMA and in the event of major disasters.

The Head, Department of Forests and Park Services, can authorize revision based on proposal for amendment from the respective divisions.

### 3.5 Implementation

Once the plan is approved by the Department and the Ministry, the approved plan should be handed over to concerned Divisional Forest Office/ Parks for implementation. The Division and Park shall implement the plan as per the plan prescriptions. The timber allotment from the Local Forest Management area shall be restricted within the AAC prescribed in the plan.

#### 3.5.1 Silviculture system

Single tree selection system shall be applied for extraction of timber from Local Forest Management Area. The details guidelines for Single Tree Selection Silviculture system is prescribed under section “Implementation Framework < Silviculture Implementation Guidelines” of Chapter 1: Forest Management Units of this volume.

### 3.6 Monitoring

Monitoring is the continuous/periodic review undertaken by management at every level of implementation of an activity to ensure that input deliveries, work schedules, targeted output and other required actions are proceeding according to the plan.

Regular Monitoring should be carried out by the concerned Range Officer. Periodic monitoring of Local Forest Management Area should be carried out by the concerned CFO of the division, preferably during the month of January of every year. The monitoring report must be submitted to the Department latest by 28<sup>th</sup> February every year. *FRMD should conduct mid-term and final monitoring of the LFMP.*

### **3.6.1 Objectives**

The main objectives of the monitoring are:

1. To ensure that the allocation of rural timbers is within the AAC prescribed.
2. To ensure that reforestation/ afforestation and thinning activities are carried out as per the plan prescription and requirements.

### **3.6.2 Annual Monitoring Process**

The Local Forest Management Plans shall be monitored on an annual basis. The Annual Monitoring report must consist of following components:

1. Dully filled annual Monitoring Form.
2. Observations
3. Recommendations
4. Annexures:
  - i. Report sheet of the tree marking book.
  - ii. Monitoring sheet of the tree marking book.

## **Annual Monitoring Form**

*Table 3.15 Annual Monitoring Form*

<b>Indica- tor No.</b>	<b>Indicator</b>	<b>Definition</b>	<b>Progress/ Achievement</b>	<b>Corrective Measures/ Remarks</b>
1	Annual Timber Volume Re-removed	This indicator constitutes the volume of timber prescribed for removal annually (AAC)	Quantity as per Tree Marking book**and the monitoring report (m3)***	
2	Annual Removal of Firewood	This indicator constitutes the volume of firewood allotted/ removed annually (AAC)	Quantity as per marking book and monitoring report (m3)	
3	Plantation Creation	Plantation creation in the management area (in hectares)	Plantation Area in Hectare	
4	Thinning	Area of forest within the management area in which thinning is carried out	Thinning Area in Hectare	

**Note:** The tree marking book\*\* and the monitoring reports\*\* are to be maintained in excel based predesigned format as explained in the following pages. Both the report sheet and Monitoring sheet must be printed and attached with the annual monitoring report of the Local Forest Management Area as annexures.

## **Observations**

The annual monitoring team should list down the observations from the field and should include (but not limited to) the following:

- Field observations to be reflected by the concerned field CFO.
- This section shall give only general observation regarding the implementation of the plan.
- It shall include both positive as well as negative observations.

## **Recommendations**

Based on the observation in the field and the prescriptions of the management plan, the annual monitoring team should recommend certain corrective measures. The recommendations should be precise and in alignment with the prescription of the management plan.

## **Annexures**

The Monitoring sheet and the Report sheet of the tree marking book must be attached to the annual monitoring report as annexures.

### **3.7 Record Keeping**

#### **3.7.1 Tree Marking Book**

Tree marking book is a excel based predesigned and automated sheet where the marking officer concerned shall enter information of marked trees based on its multiple use (Construction, Renovation, Other Construction, Other purposes. etc). The tree marking book has following salient features:

1. The location where the tree is marked shall be specified
2. The purpose (i.e. construction, renovation, etc.) is recorded
3. The volume of the marked tree shall be calculated based on a volume table
4. The use of the tree is specified (e.g. drashing)
5. The data shall also be recorded in electronic format

Recording the location of the harvested trees helps that a specific area is not over-cut (not more trees shall be allotted than the overall production potential or “silvicultural AAC” of a specific compartment). Specifying the purpose allows calculation of the production data as required for the annual statistics. The calculation of the actual volume is necessary in order to control the keeping of the fixed AAC. To keep it also in an electronic format considerably facilitates the calculation of the total harvested volume and the monitoring of the already harvested trees versus the production potential of a specific compartment.

The “tree marking book.xls” consists of 7 individual sheets:

1. Construction;
2. Renovation;
3. Other construction;
4. Other purpose;
5. Firewood;
6. Report;
7. Monitoring.

“Construction, Renovation, Other Constr., Other Purpose and Firewood” contain the entries from the tree marking book, here the specifications of the marked tree are entered. The “Report” sheet automatically calculates the total number and standing volume of marked trees and compares it with the AAC (annual allowable cut). The “Monitoring” sheet provides an overview of the current production potential. It subtracts the harvested trees from the production potential on compartment level.

Data entry from the hardcopies of the tree marking books of the various ranges/beats within the forest management area into the electronic format is done as follows:

Select the sheet depending on the purpose of wood allocation (i.e. “Construction, Renovation, Other Constr., Other Purpose, Firewood”). The following screen shall appear. Enter data as shown in the example and use always the same format as described below.

*Table 3.16 Tree marking book (construction)*

Tree Marking Book (Construction)																		
Year	Date	Location	Species	Dbh	Standing Volume in m3								Standing Volume in m3					
					Drashing		Shing.		Chams		Tsims		Poles (10-19cm)		Posts (10-19cm)		< 10 cm (Dangchu)	
					Vol	No	Vol	No	Vol	No	Vol	No	Vol	No	Vol	No	Vol	No
2019	1/6	Jangsa-1	Hemlock	50	10	5	10	3	24	10	25	90	13	30	12	34		35
2019	2/6	Jangsa-1	Hemlock	60	15	6	8	24	12	17	23	12	60	112	40	78		34
2019	10/10	Jangsa-2	Bluepine	70	8	10	15	16										

Year: Format: 2005

Date: Format: 14/4

**Location:** Name of the compartment: Format Jangsa-1; it is very important to write the compartment name correctly; otherwise the computer cannot calculate the monitoring sheet! The location always refers to the compartment of the forest management area.

**Species:** common name

**Dbh:** enter the DBH and corresponding standing volume in m<sup>3</sup> from the volume table; decide on the type of product and enter volume in respective column. For Dangchung size trees (i.e. dbh less than 10 cm) only the total number needs to be entered. It is not necessary to measure the dbh of the individual Dangchung size trees and its corresponding volume. Enter the number of trees marked in the No. column of the respective product.

### Reporting sheet:

The “Reporting sheet” gives the overall allotment of rural timbers (product wise) against the AAC of the Local Forest Management Area. Select sheet “Report” - Enter year, name of Forest Management Area and AAC in the blue cells at the top of the sheet. The computer shall automatically up-date the report. - Enter “balance from last year” in the AAC table, e.g. -/+50 (this means, that the AAC of the years before have been either over-used or under-used for a total of 50 m3). The report can be printed in hard copies.

### Monitoring sheet

The “monitoring sheet” is the most important tool for the range/beat officer to identify the location (i.e. compartment) from where trees for a specific purpose can be allotted. It shows for each compartment the production potential, the amount of already harvested trees and the remaining stock.

The first step after installation of the spreadsheet “tree marking book.xls” into the computer, the production potential of all compartments needs to be entered. This has only to be done once at the beginning of the planning period, as described in the following:

- Open the sheet “Monitoring”
- Enter the name of the compartment, format: Jangsa-1 (Note: it is very important to use exactly the same spelling as used in the data input sheets).
- Enter the production potential by compartment in the shaded column “Pro”. This information can be derived from the compartment record sheets (i.e. compartment register) or from the sheet “Production N” of the respective “Summary Sheet.xls”.
- The computer shall do the rest.



Table 3.17 Recording of “monitoring” sheet

Monitoring sheet for the extraction of trees from individual compartment																				
Sub-comp.	Timber												Firewood							
	Drashing			Chams			Tsims			Poles			50+ cm			30-49 cm			20-29 cm	
	Pro	Use	Bal	Pro	Use	Bal	Pro	Use	Bal	Pro	Use	Bal	Pro	Use	Bal	Pro	Use	Bal	Pro	Use
		0	0		0	0		0	0		0	0		0	0		0	0		0
		0	0		0	0		0	0		0	0		0	0		0	0		0
		0	0		0	0		0	0		0	0		0	0		0	0		0
		0	0		0	0		0	0		0	0		0	0		0	0		0

Explanation of the columns:

Pro: contains the production potential as determined by the forest resources assessment

Use: the number of trees already harvested.

Bal: the number of trees still available in the compartment for harvesting.

### 3.7.2 Gewog Register

In addition to the hardcopy, the Gewog registers should be kept in electronic format. This considerably reduces the time requirement for checkup, whether an applicant is eligible for timber allotment (refer to “search for past allotments in the sub-chapter below).

For each Gewog, a separate register is kept. A new Gewog register is opened for every new management period. This is done as follows:

- Copy “Gewog register.xls” in Gewog directory e.g. “Kawang” - Rename copied “Gewog register.xls” in e.g. “Kawang register.xls”

The spreadsheet combines all the 4 different registers. The same information is entered as in the current hardcopy. The spreadsheet itself comprises of 5 sheets: •Construction; •Renovation; •Other construction; •Other purpose; •Annual reports.

In the first four sheets, the same information is entered as in the already existing hardcopy registers. It is important, that the “Year” is entered in the correct way, e.g. “2005” for every line, otherwise the annual report shall not be calculated correctly.

The sheet “annual report” provides a summary of the number of allotted for the selected year. The data of this “report” should correspond with the data of the “report” from the “Tree marking book.xls”.

### 3.7.3 Data Management and Documentation

All data and documents produced as part of the management plan preparation should be well documented. These implies to both spatial and non-spatial data to be maintained in soft and hard copies. The entire shapefiles and the data collected for the plan preparation should be submitted to FRMD along with the draft plan..

### **3.8 Bibliography**

- BHUTAN, ROYAL GOVERNMENT OF (1995) Forest and Nature Conservation Act of Bhutan, 1995. Thimphu.
- BHUTAN, ROYAL GOVERNMENT OF (2017) Forest and Nature Conservation Rules of Bhutan (Revised), 2017. Thimphu.
- BHUTAN, ROYAL GOVERNMENT OF (2004) Forest Management Code of Bhutan, Forest Resources Development Division, Department of Forests.
- BHUTAN, ROYAL GOVERNMENT OF (2004) Community Forestry Manual for Bhutan, Part I – IV, Social Forestry Division, Department of Forests.
- LAUMANS,P.(1994) Guidelines for Forest management Inventory, UNDP/FAO Forest Resources Management and Institutional Development Project, Department of Forestry, Ministry of Agriculture.
- SCHINDELE, W. and DHITAL, D.B. (1997) Guidelines for the Preparation of a Forest Function Map and definition of Management Prescriptions/Restrictions. Bhutan-German Sustainable RNR Development Project. Working Paper No. 11. Ministry of Agriculture, Royal Government of Bhutan.
- SCHINDELE, W.; 1996: Guidelines for a Reconnaissance Forest Inventory. 2nd Draft. Mission Report on Forest Resources Assessment and Forest Management within the Scope of the Bhutan-German Integrated Forest Management Project. BG-IFMP, Working Paper No. 6.
- SCHINDELE, W.; 1996: Angle-Count Sampling and the Use of the Relascope. Mission Report on Forest Resources Assessment and Forest Management within the Scope of the Bhutan-German Integrated Forest Management Project. BG-IFMP, Technical Paper No. 4.
- SCHINDELE, W.; Forest Resources Potential Assessment of Bhutan. Bhutan-German Sustainable RNR Development Project. Working Paper, Ministry of Agriculture, Royal Government of Bhutan.
- Management Plans of all FMUs in the country, Forest Resources Management Division, Department of Forests and Park Services.





## 4. Private Forestry

**Author:**

Tashi Wangchuk, Dy. Chief Forestry Officer, SFED

**Contributors:**

1. Karma Jigme Temphe, Chief Forestry Officer, SFED
2. Sithar Wangdi, Dy. Chief Forestry Officer, SFED



## **4. Private Forestry**

### **4.1 Management Context**

Establishment of Private Forestry aims to facilitate raising forestry crop on registered land to accrue ecological, social and economic benefits. Private Forest shall constitute planting of tree and any other forest crop including those species listed in Schedule I, or growing on private registered land.

The land category where the private forests are established shall be guided by the relevant laws of the country. In case, any private land owner wishes to establish a private forest, the field office shall render all possible technical support in the preparation and management of the forest.

### **4.2 Resource Inventory & Data Processing**

#### **4.2.1 Stand Map**

Stand map should be prepared as and when the private forest owner(s) seek support from the Department.

#### **4.2.2 Use the most appropriate of the following methods**

**Total Enumeration:** If the private forest is less than 1 ha, you should conduct a full count of all of the trees that are pole-size (20 – 40 cm dbh) and timber size (larger than 40 cm dbh).

#### **4.2.3 Sample plots**

If the total enumeration is not possible for practical reasons such as difficult terrains, area of the plantation and/or other circumstances, sampling may be best method to estimate the forest and tree parameters of the forest.

Sampling intensity of 2 % is recommended for assessment of the private forest for planning purpose. For example, if your stand is 1 ha (10,000 m<sup>2</sup>), measure 2 sample plots of 10m x 10m (100 m<sup>2</sup> each). Lay transect as deemed appropriate and the sample plots can be laid along the transect based on professional judgement. Calculate the number of trees in the two categories: pole-size (20 – 40 cm dbh) and timber size (larger than 40 cm dbh).

#### **4.2.4 Management Prescriptions**

The Field offices should provide appropriate recommendations for the management of the private forest.

### **4.3 Management Planning**

Respective field offices shall assist the owner in developing Private Forest Management Plan (PFMP). While preparing management plan, keep the following:

- Prepare the management plan in consultation with the owner to be consistent with his/her requirements and capabilities.
- Make the management prescriptions easily understandable by avoiding technical terms.
- Help the owner maximize production from his/her private forest.

#### **4.3.1 Stand Description**

The description must include the following information:

- Species, age, quality of natural regeneration, and estimated stand area in ha
- Include the year of establishment for plantations.
- Other information, if appropriate, such as: tree height, quality, distribution pattern, existence of NWFPs, ground cover, aspect, slope gradient, traditional and present use, and soil description, should be included.

#### **4.3.2 Plantation Works**

Forestry field offices should provide technical support with regard to plantations within private forest areas if the owner needs.

#### **4.3.3 Thinning**

Forestry field offices should provide technical support with regard to thinning if required. In case areas prone to land slide and erosion, field offices may recommend phase wise thinning.

#### **4.3.4 Harvesting**

If the private forest consists predominantly of mature trees, the field offices should advise the owner to follow one of the following options:

- Harvest the most mature ones on a single tree basis. This method is appropriate in mixed stands where not all the species are mature.
- Harvest most of the trees except a small number of the best quality seed trees. This method may be appropriate in conifer forests with good potential for natural regeneration. The remaining seed trees can be harvested once the new stand is well established.
- Harvest all trees at once (clear cut). This method may be appropriate in evenaged and monospecific stand which does not have the potential to regenerate naturally, or if the owner wants to promote other species.

#### **4.3.5 Management of NWFPs and fodder trees**

The management prescriptions for NWFP and fodder trees shall vary considerably in different regions. The field office should provide appropriate recommendations to ensure sustainability and maximize production. Social Forestry and Extension Division may provide technical support if the private forest owner(s) needs.



## 5. List of Contributors

### 1. Former taskforce members for the FMCB (2014)

Sl. No	Name	Designation	Office
1	Ratu Wangchuk	Dy. Chief Forestry Officer	NCD
2	Kinley Dorji	Dy. Chief Forestry Officer	SFED
3	Tshewang Dorji	Sr. Forestry Officer	UWICER
4	Kezang Dema	Dy. Chief Forestry Officer	NCD
5	Sonam Choden	Dy. Chief Forestry Officer	SFED
6	Tshering Dorji	Sr. Forestry Officer	FPED
7	Dimple Thapa	Chief Forestry Officer	Tsirang Division

### 2. FMCB Internal Review Workshop (22-27th December 2019)

Sl. No	Name	Designation	Office
1	Pasang Wangchen Norbu	Specialist/Advisor	DoFPS
2	Norbu Wangdi (PhD)	Chief Forestry Officer	FRMD
3	Arun Rai	Principle Forestry Officer	FRMD
4	Dawa Zangpo	Dy. Chief Forestry Officer	FRMD
5	Tashi Norbu Waiba	Dy. Chief Forestry Officer	FRMD
6	Lhab Tshering	Sr. Forestry Officer	FRMD

### 3. Second Consultation Workshop, DoFPS Conference Hall (3rd January 2020)

Sl. No	Name	Designation	Office
1	Lobzang Dorji	Director	DoFPS
2	Pasang Wangchen Norbu	Specialist/Advisor	DoFPS
3	Kinley Tshering	Chief Forestry Officer	FPED
4	Kaka Tshering (PhD)	Principle Forestry Officer	UWICER
5	Sigyel Delma	Chief Forestry Officer	WMD
6	Norbu Wangdi (PhD)	Chief Forestry Officer	FRMD
7	Sonam Wangdi	Chief Forestry Officer	NCD
8	K.J Tempel	Chief Forestry Officer	SFED
9	Arun Rai	Principle Forestry Officer	FRMD
10	Dorji Wangdi	Dy. Chief Forestry Officer	FRMD
11	Yonten Phuntsho	Dy. Chief Forestry Officer	FRMD
12	Dawa Zangpo	Dy. Chief Forestry Officer	FRMD
13	Tashi Norbu Waiba	Dy. Chief Forestry Officer	FRMD
14	Kinley Dem	Dy. Chief Forestry Officer	FRMD
15	Tashi Wangchuk	Dy. Chief Forestry Officer	SFED
16	Kezang Dema	Dy. Chief Forestry Officer	NCD

**4. Writeshop in Phuentsholing (3-7th February 2020)**

Sl . No	Name	Designation	Office
1	Pasang Wangchen Norbu	Specialist/Advisor	DoFPS
2	Arun Rai	Principle Forestry Officer	FRMD
3	Dorji Wangdi	Dy. Chief Forestry Officer	FRMD
4	Yonten Phuntsho	Dy. Chief Forestry Officer	FRMD
5	Dawa Zangpo	Dy. Chief Forestry Officer	FRMD
6	Tashi Norbu Waiba	Dy. Chief Forestry Officer	FRMD
7	Kinley Dem	Dy. Chief Forestry Officer	FRMD
8	Tashi Wangchuk	Dy. Chief Forestry Officer	SFED
9	Sither Wangdi	Sr. Forestry Officer	SFED
10	Jigme Tenzin (PhD)	Dy. Chief Forestry Officer	WMD
11	Jamyang Phuntsho	Principle Meteorological Officer	WMD
12	Ram Bdr Mongar	Sr. Forestry Officer	FPED
13	Tashi Yangchen	Forestry Officer	FPED
14	Tshering Pem	Sr. Forestry Officer	NCD
15	Namgay Bidha	Sr. Forestry Officer	NCD
16	Thinley Choden	Dy. Chief Forestry Officer	UWICER
17	Karma Thukten	Sr. Research Officer	UWICER

**5. Consultation with Chief Forestry Officer (8-10th February 2020)**

Sl . No	Name	Designation	Office
1	Lobzang Dorji	Director	DoFPS
2	Pasang Wangchen Norbu	Specialist/Advisor	DoFPS
3	Shacha Dorji	Director	UWICER
4	Kinley Tshering	Chief Forestry Officer	FPED
5	Norbu Wangdi (PhD)	Chief Forestry Officer	FRMD
6	Sonam Wangdi	Chief Forestry Officer	NCD
7	Tempa Tshering (PhD)	Chief Forestry Officer	BTC
8	Sonam Tobgay	Chief Forestry Officer	JKSNR
9	Pema Wangda	Chief Forestry Officer	Gedu Division
10	Lhendup Tharchen	Chief Forestry Officer	Paro Division
11	Thinley Wangdi	Chief Forestry Officer	Samtse Division
12	Arun Rai	Principle Forestry Officer	FRMD
13	Dorji Wangdi	Dy. Chief Forestry Officer	FRMD
14	Yonten Phuntsho	Dy. Chief Forestry Officer	FRMD
15	Dawa Zangpo	Dy. Chief Forestry Officer	FRMD
16	Tashi Norbu Waiba	Dy. Chief Forestry Officer	FRMD
17	Kinley Dem	Dy. Chief Forestry Officer	FRMD
18	Tashi Wangchuk	Dy. Chief Forestry Officer	SFED

19	Sither Wangdi	Sr. Forestry Officer	SFED
20	Jigme Tenzin (PhD)	Dy. Chief Forestry Officer	WMD
21	Jamyang Phuntsho	Principle Meteorological Officer	WMD
22	Ram Bdr Mongar	Sr. Forestry Officer	FPED
23	Tashi Yangchen	Forestry Officer	FPED
24	Tshering Pem	Sr. Forestry Officer	NCD
25	Namgay Bidha	Sr. Forestry Officer	NCD
26	Thinley Choden	Dy. Chief Forestry Officer	UWICER
27	Karma Thukten	Sr. Research Officer	UWICER

#### **6. Writeshop in Punakha (25-30th July, 2020)**

Sl. No	Name	Designation	Office
1	Pasang Wangchen Norbu	Specialist/Advisor	DoFPS
2	Norbu Wangdi (PhD)	Chief Forestry Officer	FRMD
3	Arun Rai	Principle Forestry Officer	FRMD
4	Dorji Wangdi	Dy. Chief Forestry Officer	FRMD
5	Kinley Dem	Dy. Chief Forestry Officer	FRMD
6	Saran Pradhan	Dy. Chief Forestry Officer	FRMD
7	Sither Wangdi	Sr. Forestry Officer	SFED
8	Jigme Tenzin (PhD)	Dy. Chief Forestry Officer	WMD
9	Kuenzang Om	Sr. Agriculture Officer	WMD
10	Tshering Pem	Sr. Forestry Officer	NCD
11	Namgay Bidha	Sr. Forestry Officer	NCD
12	Thinley Choden	Dy. Chief Forestry Officer	UWICER

#### **7. Finalization workshop in Thimphu (12-24th October 2020)**

Sl. No	Name	Designation	Office
1	Passang Wangchen Norbu	Specialist/ Advisor	DoFPS
2	Norbu Wangdi (PhD)	Chef Forestry Officer	FRMD
3	Kinley Dem	Dy. Chief Forestry Officer	FRMD
4	Tashi Norbu Waiba	Dy. Chief Forestry Officer	FRMD
5	Sither Wangdi	Sr. Forestry Officer	SFED
6	T.B Rai	Sr. Forest Ranger I	SFED
7	Tashi Wangchuk	Dy. Chief Forestry Officer	SFED
8	Sonam Choden	Dy. Chief Forestry Officer	SFED
9	Jigme Tenzin (PhD)	Dy. Chief Forestry Officer	WMD
10	Tshering Pem	Forestry Officer	NCD
11	R.B Mongar	Forestry Officer	FPED
12	Sherab	Specialist	UWICER
13	Sangay	Dy. Chief Forestry Officer	UWICER

<b>14</b>	Tshewang Dorji	Sr. Forest Ranger I	SFED
<b>15</b>	Ugyen Tshering	Sr. Forestry Officer	SFED
<b>16</b>	Arun Rai	Principle Forestry Officer	FRMD
<b>17</b>	Dorji Wangdi	Dy. Chief Forestry Officer	FRMD
<b>18</b>	Dawa Zangpo	Dy. Chief Forestry Officer	FRMD
<b>19</b>	Jamyang Choden	Forestry Officer	FRMD