QGIS based decision-support system for creating Forest Working Plans

Dr. Ankur Awadhiya, IFS

Indira Gandhi National Forest Academy
Dehradun

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सत्यमेव जयते

FOREWORD

While going through manuscript of write up titled **"QGIS based decision- support system for creating Forest Working Plans"** of Dr Ankur Awadhiya, IFS Probationer, following thoughts emerged.

Forester in India is no stranger to forest administration and management. He and several of his fellow foresters move through the forest areas on regular basis for protection and for collecting the information that allows the Department to manage forests for environment and community. Since long time, they have used a combination of maps and compass to orient themselves and guide their activities. But as the realm of computer technology advances and the need for convenient, systematic forest data collection increases, new tools have emerged that are becoming more accessible to the forestry community. A suite of technology tools, collectively referred to as geospatial technologies, can dramatically simplify evaluation, planning, and management of timber and wildlife resources. Geospatial technologies are used to collect, characterize, summarize, analyze, visualize and display spatial data.

Educational advances have developed in parallel with technological advances. As a growing number of forestry graduates are trained in geospatial technologies, forestry departments and government benefit from their skills. Introduction of geographical information systems(GIS) in the forestry sector of India has been also influencing the social transformations taking place amid the tension between local aspects of social and organisational life of Forest Departments that are dealing with forest management and pressures of change that are coming through challenges of development, livelihoods and ecological securities as well as with introduction of new technologies like GIS.

Recognizing these trends, Indira Gandhi National Forest Academy has been in the process of outfitting its Officers Trainees with state-of-the-art data collection and organization tools including GPS, GIS, handheld computers and compatible software. In combination with digital imagery, these tools have the potential to increase the pace and accuracy of forest management activities. GIS technology profoundly and positively impacts the way foresters would manage their land resources and timber & NTFP resources. I am glad that Dr Ankur Awadhiya, IFS Probationer (MP, 2014) in Professional Course at IGNFA has documented his training and learning on the subject of QGIS based decision support system for Working Plans. His work is praiseworthy and commendable. I would also like to complement our faculty member Sri Uttam Kumar Sharma, IFS (MP, 1999) with his guidance and facilitations for this work.

Remote sensing and other geospatial tools are to be applied to plan for large number of forest blocks for administration and management including working forest diversions/ leases, and to assist office and field users to improve the efficiency of required monitoring. GIS has now made it possible to incorporate spatial components of forest, wildlife, communities and that of multi-objective planning of forest working plans being becoming subject of many demands.

While one will continue to use traditional forest management tools and techniques, these new spatially advanced tools incorporated into their daily activities would enhance analytical, monitoring abilities and efficiency to current demands on development. Where applied, these tools are changing the way we approach field forestry. We make decisions based on better data, in a more timely manner, with increased accuracy, resulting in improved outcomes.

I am sure that the efforts of Dr Ankur Awadhiya through this document for application of QGIS as a tool in forest management as well as participatory forest management under Working Plan explained in simple manner as a part of his elective paper contribution would be well received.

Dehradun
The 01 April, 2016.

(Vinod Kumar)

Ph.: 0135 - 2754647 (O), 0135-2757314 (Fax)

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Indira Gandhi National Forest Academy

सत्यमेव जयते

भारत सरकार, पर्यावरण एवं वन मंत्रालय
Government of India, Ministry of Environment & Forests

PREFACE

The Working Plan exercise is the most important and integral part of the training of the probationers of the Indian Forest Service. The importance of this exercise can be appraised by the sheer amount of time that we devote to it: the preparation, field surveys, measurements, data collection and analysis, and preparation of the report take around three weeks of meticulous and demanding labour. Also, this exercise exhorts the probationers to make full use of all their learnings in all the courses undertaken so far, to be able to decide in what best way we can regenerate the forest. Since large volumes of data need to be processed simultaneously and lots of mathematical calculations involved, the need for an assistive decision support system was long being felt, especially since we now have adequate computational resources that can help us perform the job effectively and efficiently with better understanding.

During the working plan exercise for the 2014 batch of probationers, I observed Ankur using GIS platform to collate, analyse and present his data. I found the results impressive. We discussed it further and decided that he should elaborate on his work, and try to develop a decision support system based on GIS for the working plan exercise. This system would take in user requirements, say regarding ranges of slopes, canopy density, distance from habitation, presence of wildlife, etc., and discern the compartments in the working plan area that match those requirements. These compartments would then be included in a given working circle. I encouraged Ankur to create the system in the form of a manual that would be used in training the future batches of probationers.

The workflow that has been developed in this manual fully serves the purpose. Besides, it also presents the information visually in the form of maps that permit quick and easy interpretation of information, which is extremely important in preparation of working plan. I am confident that this manual will be found useful in the hands of the users.

Uttam Kumar Sharma, IFS
Associate Professor, Indira Gandhi National Forest Academy
21/03/2016

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AUTHOR'S PREFACE

The working plan is a sacrosanct document that has to be consulted before performing almost any operation in a forest. This is why utmost importance is given to its preparation, and the creation of a working plan demands meticulous processing and analysis of vast amounts of data.

The IFS probationers at the Indira Gandhi National Forest Academy, Dehradun get exposed to the process of creation of working plans in a multi-day field exercise. The exercise requires a congregation of field data through numerous cruises to dense forest areas aimed at getting an understanding of the terrain characteristics, heights and girths of trees, incidence of fire and diseases, canopy cover of the forest and biodiversity, including signs of presence of wildlife, at several locations in the forest. The exercise also involves a collection of socio-economic data from nearby villages to understand the requirements of local villagers for effective participatory management, and the scope and impact of biotic pressure created by their livestock in the forest areas.

After a mountain of data gets collected, we begin the exercise of analysing and interpreting it to create meaningful information. Several factors needs to be considered concomitantly to decide, for instance whether a certain parcel of the forest should be worked or not, and if yes, how should it be worked, what would the yield be, and how would it be regulated. Thus, several working circles get created; some are exclusive, while others are overlapping or partially overlapping.

While participating in the activities of the exercise, I felt that many actions can be performed with greater precision and reduced drudgery if we could create a decision management system. This system would allow an examination of several factors at the same time, using SQL-like queries on a tabulated form of field data. Besides, if the system could project the results on a map, the interpretation and management of working circles would become easy. For instance, a map showing fire-prone areas and areas suffering from extreme levels of biotic pressure should ease the allotment of compartments into the forest protection (overlapping) working circle with great precision and confidence.

While discussing this idea with Sh. Uttam Kumar Sharma, IFS and faculty incharge for the working plan exercise, he encouraged me to create such a system in the form of a module, to be used for training and research purposes. I have employed the QGIS platform to design a decision-support system for the creation of working plans. The use of this free and open-source platform ensures that the procedure can be used inexpensively at the field situations in states, without the need for proprietary softwares.

The target audience for this book is very wide, since the procedure is useful not only for the creation of working plans, but can also be used, with appropriate modifications, in the areas of general administration and research. Thus, the audience might comprise field staff such as beat officers, foresters, range officers, patwaris, students of civil engineering and geography, probationary officers of the Indian Forest Service, the Indian Police Service and

the Indian Administrative Service, civil service aspirants, media personnel and people with a general interest in this field.

It is hoped that the book will be found useful by the users. I shall be extremely delighted to receive any comments from the users, who may contact me at mp572@ifs.nic.in.

Before closing, I take the opportunity to express my heartfelt gratitude towards Dr. Rajiv Sinha of IIT Kanpur who first exposed me to the field of remote sensing and GIS. Our faculty Sh. Uttam Kumar Sharma, IFS at the Indira Gandhi National Forest Academy, Dehradun motivated me to develop this module to be used in training the future batches of IFS probationers at the academy. It was through his prodding that the book in its current form got developed. And he so delightedly agreed to write a preface to the manuscript. Thank you Sir. Another faculty, Sh. Deepak Mishra, IFS, also took keen interest in the preparation of this document, and guided me through numerous fruitful discussions with him. I am extremely grateful to him for sharing his knowledge and time. Sh. Vinod Kumar, IFS and the Director of the Indira Gandhi National Forest Academy, Dehradun was kind enough to draft a foreword for the manuscript. He also took personal interest in getting it published. Thank you so much Sir. I also wish to thank the staff of geomatics lab at the Indira Gandhi National Forest Academy, Dehradun who were extremely helpful in my quest of understanding the RS-GIS proprietary softwares, and Sh. K. Kannan, IFS and course director 2014 batch at the Indira Gandhi National Forest Academy, Dehradun for his

guidance and motivation.

Dr. Ankur Awadhiya

04 April 2016, Dehradun

ABOUT THE AUTHOR

Dr. Ankur Awadhiya (b. 1987) is an IFS officer of 2014 batch borne on the Madhya Pradesh cadre. He has been trained as an engineer, and received his B. Tech in Biological Sciences and Bioengineering in 2009 from IIT Kanpur. He earned his Ph.D from IIT Kanpur in 2015, where his doctoral research was titled "Studies in Agarose-based bioplastic material". He got exposed to the field of remote sensing during his IIT days, where he presented a talk on the application of remote sensing in human health, and has since continued taking interest in the field. He developed expertise during his probation days at the Indira Gandhi National Forest Academy, Dehradun. Besides academics, he maintains a passion towards photography, painting, movie-making, and creative literary pursuits.

DEDICATION

To Ushi

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Chapter 1

Introduction

1.1 What is a Working Plan?

The working plan is a sacrosanct technical document for the scientific management of forests for a 10 year duration. It contains detailed information regarding forest types, plants, animals, soil conditions, water resources, historical and suggested management practices, growth and yield statistics, and other such data.

1.2 What is a Working Circle?

A working circle is defined as "a forest area, forming the whole or part of the working plan area, organised with a particular object and under one silvicultural system and one set of working plan prescriptions".

In other words, a working circle is an area of similar, uniform crop that may form part or whole of the working plan area. It has similar management objectives, and so is managed under one silvicultural system and one set of prescriptions.

1.3 What is GIS?

GIS or Geographic Information System is a system consisting of hardware (equipment), software (code) and humanware (people) that is designed to capture, store, manipulate, analyse, manage and present different kinds of geographical data.

Modern GIS technologies handle data in digital form. The data is represented in the form of layered stacks that are inter-connected and can be queried.

We get data for GIS from various sources, including

1. satellite data
2. photographs
3. scanned copies of maps
4. data from old documents
5. toposheets
6. GPS coordinates

7. field surveys

8. transacts and description forms

9. cruises, etc.

For handling geographical data, several platforms, including ArcGIS, QGIS, Grass and Erdas may be employed.

1.4 What is QGIS?

Quantum GIS or QGIS is a cross-platform, FOSS (free and open-source software) GIS application that is licensed under GNU General Public License. It is an official project of the Open Source Geospatial Foundation (OSGeo), and can be accessed at: http://www.qgis.org

In this module, we shall employ QGIS as a platform for handling geographical data to be used as an aid to decision making.

Chapter 2

Basic operations in QGIS

2.1 The window

When we launch the QGIS application, we are presented with a window depicted in figure 2.1.

This window is divided into 5 parts:

1. Map canvas: This is the largest vacant space, where the map itself gets rendered.

2. Browser panel: This panel, to the left, permits easy navigation in the database. Files can be loaded from the browser panel by double clicking the file or by dragging them onto the map canvas.

3. Layer list: The layer list on the left displays the layers available at any point of time. Ticking the checkbox next to a layer switches its

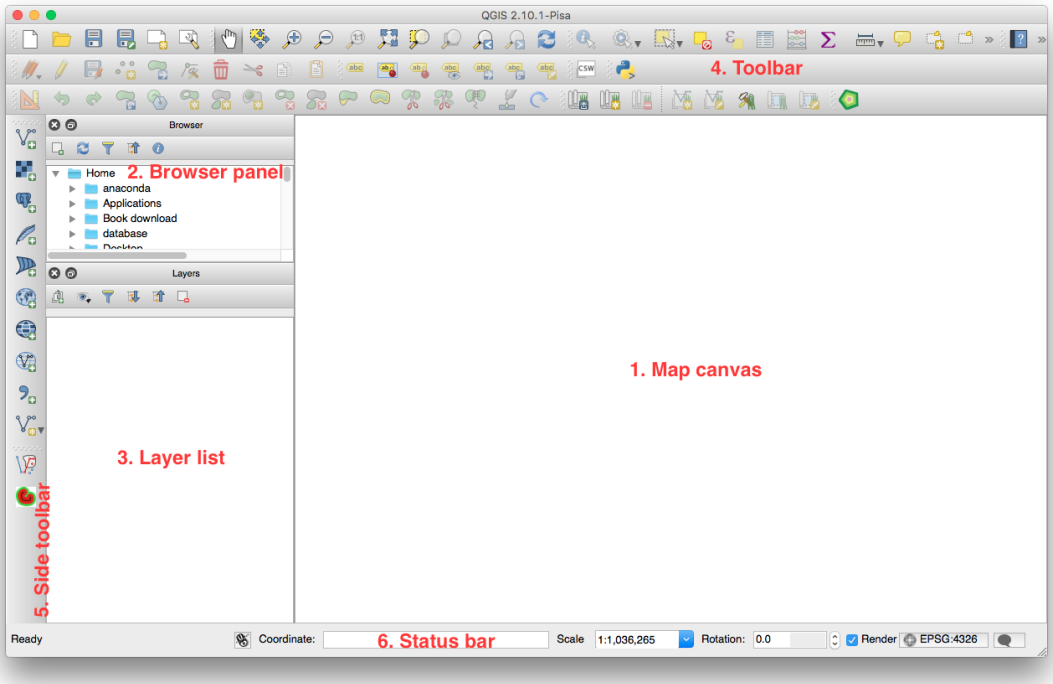


Figure 2.1: The basic interface of QGIS

visibility on or off.

4. Toolbar: The toolbar on the top houses the most often used tools. The interface of the toolbar can be customised via View → Toolbars menu.

5. Side toolbar: The side toolbar on the left can similarly be customised. By default, it houses the "add layer" tools.

6. Status bar: The status bar at the bottom depicts the information about the current map, besides facilitating the user to adjust the map scale and locate the coordinates of the mouse cursor on the map.

2.2 Digitising a map

To digitise the map of a region, here the forest estate, we execute the following operations:

1. Launch QGIS.

2. Click Layer → Add Layer → Add Raster Layer (Figure 2.2).

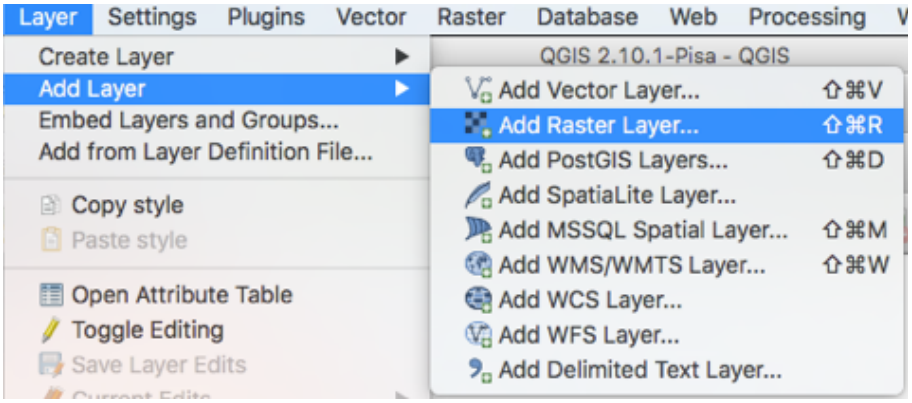


Figure 2.2: Adding a map as a raster layer

3. Select the file harbouring a scanned copy of the map to load it in the map canvas.

4. Georeference the map file:

   - Install Georeferencer GDAL plugin from Plugins → Manage and Install Plugins... Search for 'georeferencer' (Figure 2.3).
   - The plugin gets installed in the 'Raster' menu of toolbar. Launch it through Raster → Georeferencer → Geroreferencer... (Figure 2.4).

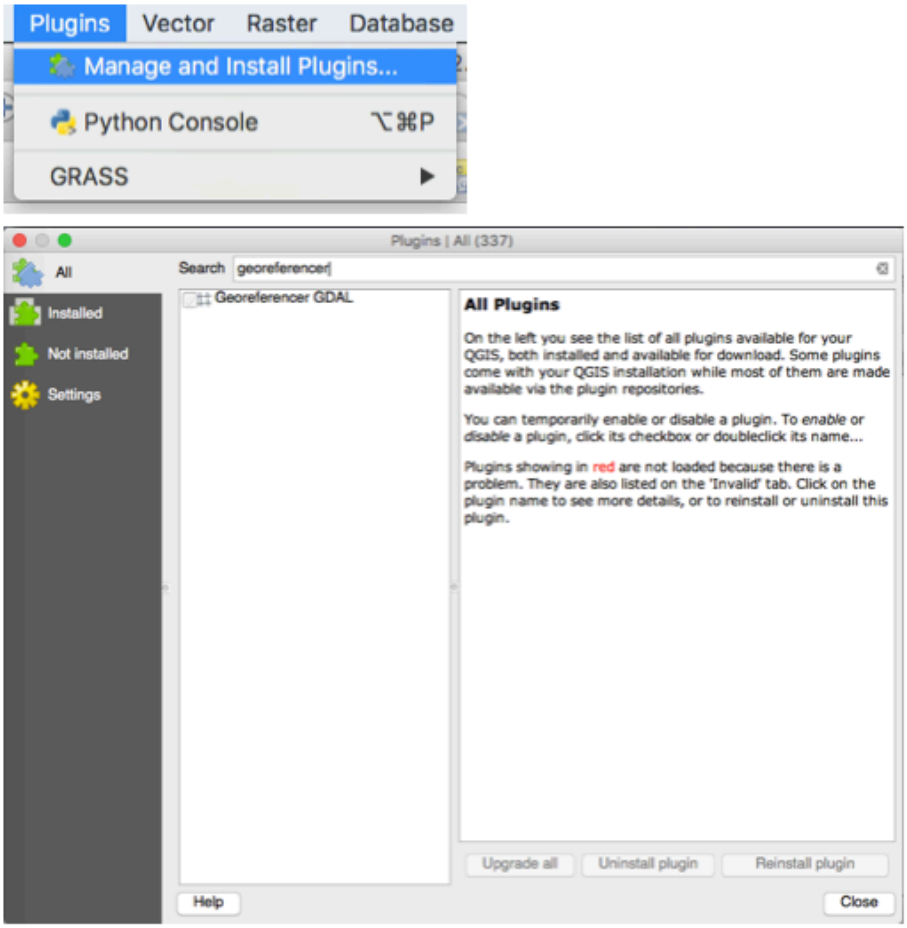


Figure 2.3: Installation of Georeferencer GDAL plugin

- Open the scanned copy of the map from File → Open Raster...
- Zoom to four corners of the map using zoom tool and set GCPs using "Add point" tool.
- Enter map coordinates.
- After all four corners are done, set transformation settings by Settings → Transformation Settings...

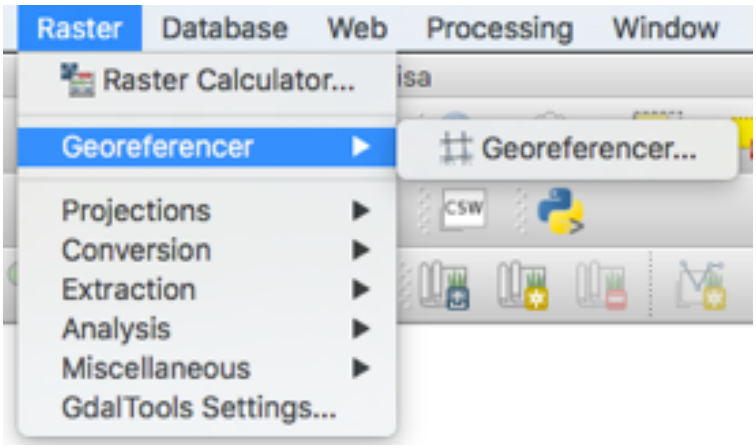


Figure 2.4: Lauching of Georeferencer GDAL plugin

- Set transformation type as "Thin Plate Spline", target SRS as WGS 84 / UTM zone 44N and give a filename to output raster file. Select "Load in QGIS when done".
- Press OK and close the window. The georeferenced file gets loaded into QGIS map canvas, with coordinates displayed in the status bar at the bottom.

5. Create new shapefile layer through Layer → Create Layer → New Shapefile Layer...

6. Select type as Polygon, file encoding as UTF-8, CRS as WGS 84 / UTM zone 44N and add attributes.

7. Save the layer.

8. Begin digitisation by toggling editing mode and adding feature. Left

click along boundaries to be digitised. End by a right click (Figure 2.5).

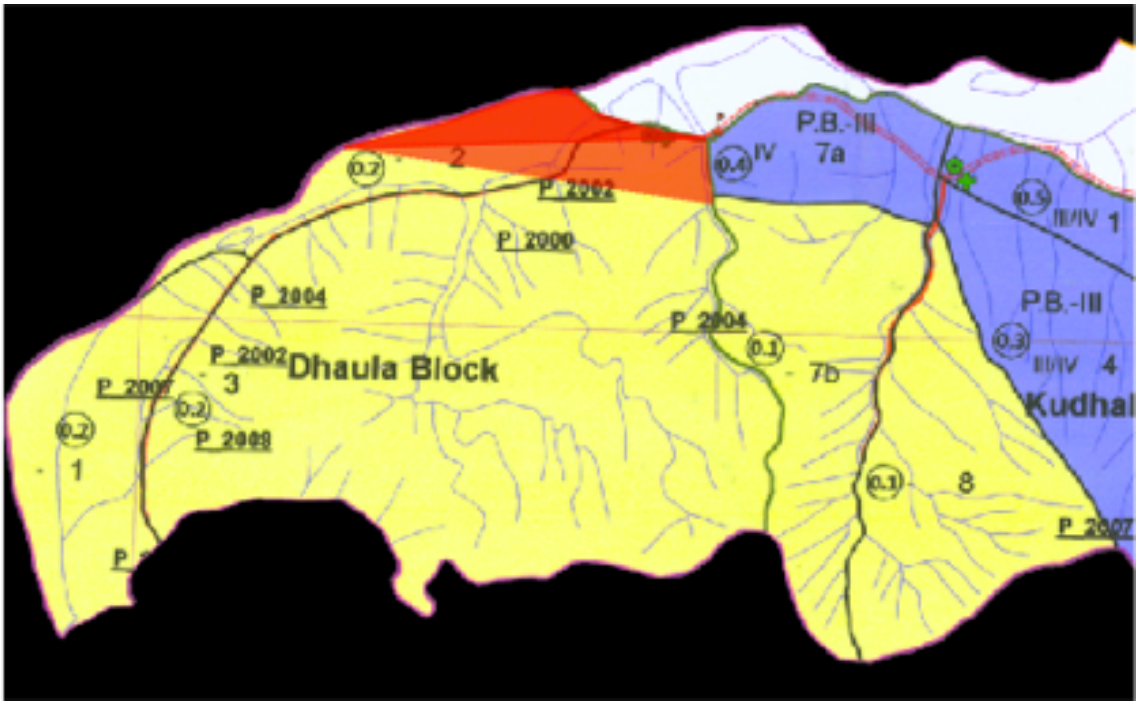


Figure 2.5: Adding features during digitisation

9. If required, the boundary can be adjusted with the node tool.

10. After digitisation of the outer boundary is done, increase the transparency of the layer by double-clicking it's name to open layer properties and increasing transparency.

11. Now digitise the inner boundaries by selecting the outer boundary with selection tool and splitting it with the split tool.

12. Start from outside boundary, and click along inner boundaries. End by right clicking outside the outer boundary, and complete the process of digitisation (Figure 2.6).

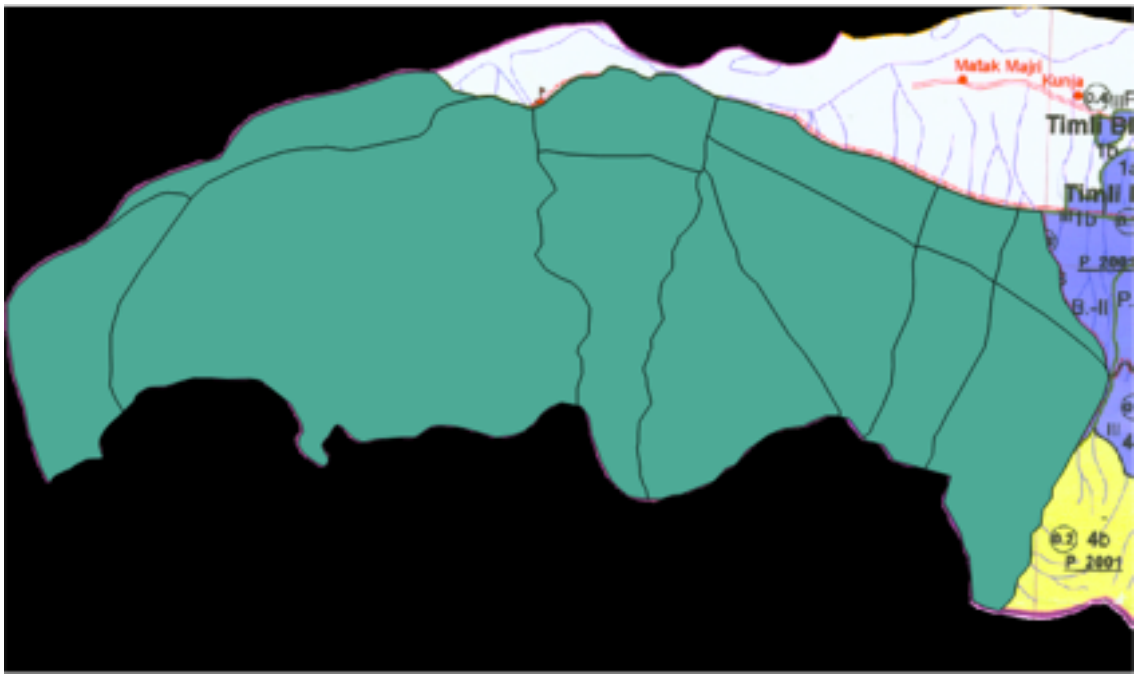


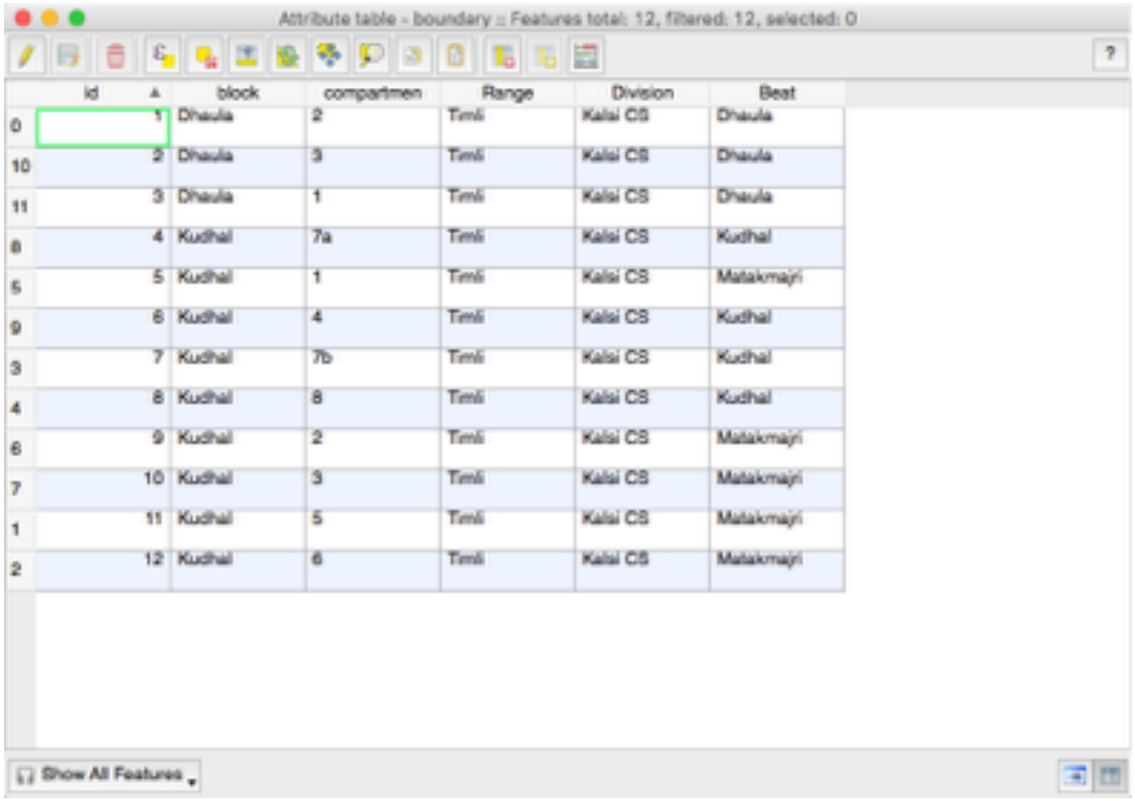
Figure 2.6: Finishing digitisation

2.3 Filling attributes

The attributes can be filled in by opening the attribute table and filling details after toggling edit mode (Figure 2.7).

We fill in the following attributes:

1. Range



	id	block	compartmen	Range	Division	Beat
0	1	Dhaula	2	Tmli	Kalsi CS	Dhaula
10	2	Dhaula	3	Tmli	Kalsi CS	Dhaula
11	3	Dhaula	1	Tmli	Kalsi CS	Dhaula
8	4	Kudhal	7a	Tmli	Kalsi CS	Kudhal
5	5	Kudhal	1	Tmli	Kalsi CS	Matakmajri
9	6	Kudhal	4	Tmli	Kalsi CS	Kudhal
3	7	Kudhal	7b	Tmli	Kalsi CS	Kudhal
4	8	Kudhal	8	Tmli	Kalsi CS	Kudhal
6	9	Kudhal	2	Tmli	Kalsi CS	Matakmajri
7	10	Kudhal	3	Tmli	Kalsi CS	Matakmajri
1	11	Kudhal	5	Tmli	Kalsi CS	Matakmajri
2	12	Kudhal	6	Tmli	Kalsi CS	Matakmajri

Figure 2.7: Adding attributes to attribute table

2. Block

3. Beat

4. Compartment

5. Area (in Ha): From the divisional area statement.

6. Slope: From the compartment description form. We can categorise slope into gentle, moderate, steep and very steep.

7. Canopy density: From the compartment description form.

8. Stems per hectare: From the enumeration results.

9. Crop density: From computations.

10. ND curve shape: Discerned from ND curves of compartments. We can categorise these into Inverse J or not Inverse J.

11. Plantation area: Discerned from the compartment description form.

12. Fire susceptibility: From the compartment description form. We can categorise fire susceptibility into most susceptible, very susceptible and less susceptible.

13. Wildlife presence: From the compartment description form. The presence can be categorised into high, medium and low.

14. Road: The access to roads can be discerned from the compartment description form or a map of the division. We can categorise the access as True and False.

15. Picturesque locations: The availability of picturesque locations useful for the purpose of tourism can be discerned from the compartment description form. We can categorise it into True and False.

16. Extremely sensitive: The area cannot be used for tourism purpose if it is extremely sensitive, or has endangered species that could be wiped off through huge anthropogenic activity such as tourism. The sensitiveness

can be discerned during cruising and from the compartment description form. We can categorise it into True and False.

2.4 Merging attributes

To add details from another table, we perform the following steps:

1. Save the table as a .csv file, and open it by double-clicking its name in the browser panel.

2. Select file layer properties by double-clicking the name of the layer in the layers panel. Goto Joins and press +. Set Join layer, Join field and Target field (Figure 2.8).

3. Click OK and OK. The attributes get joined. Check the attribute table to confirm joining.

4. Now we have a digitised map with attributes filled in.

The merging operation shall be used to incorporate Simpson index, Shannon index, growing stocks, etc. to the attribute table of compartments. This bypasses the requirement of making several manual entries in the attribute table.

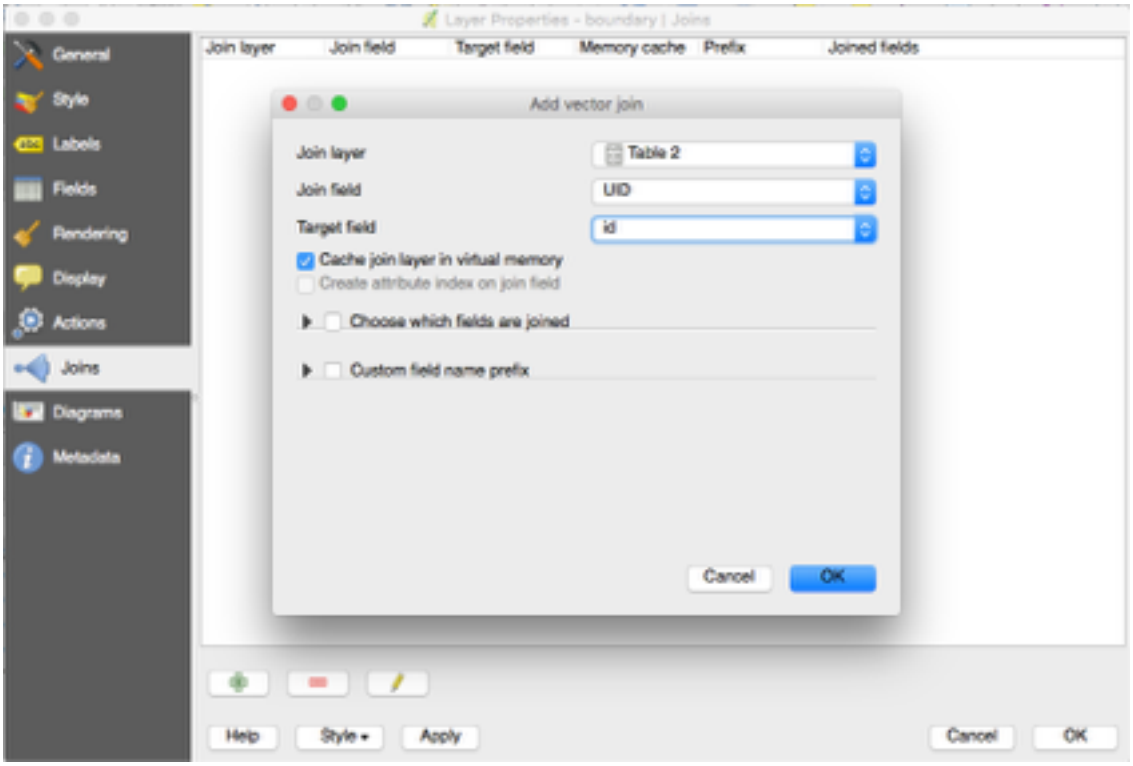


Figure 2.8: Setting joining attributes

2.5 Querying

Querying on the QGIS platform works like SQL (Structured Query Language, a standard for database manipulation). To perform querying, we execute the following operations:

1. Click "Select features using an expression" tool, aka the Query tool (Figure 2.9).

2. This opens the query field, as depicted in figure 2.10.

3. Insert the SQL query and press select. The objects matching the prop-

Figure 2.9: The Query tool

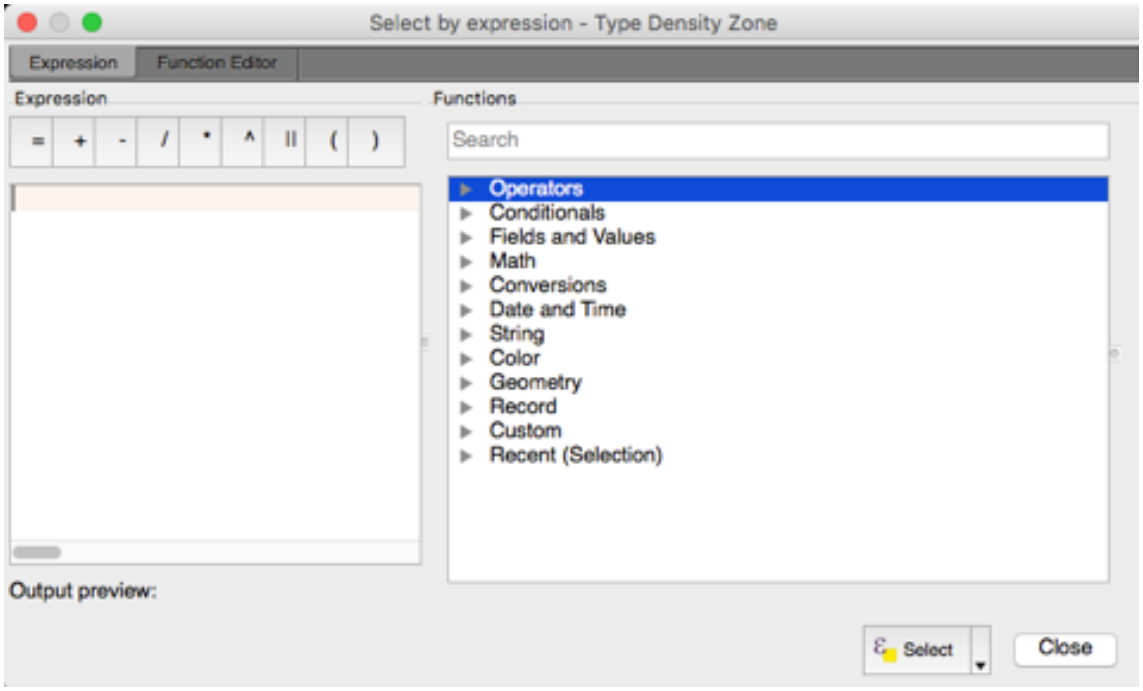


Figure 2.10: The Query field

erties get selected (Figure 2.11). We shall observe examples of SQL queries in later chapters.

2.6 Exporting selection to a new layer

The data that gets selected through query operation needs to be exported to a new layer to permit its usage as information, and for further manipulation.

Figure 2.11: Selection of features following querying operation

To export the selection to a new layer, we execute the following operations:

1. Right-click the layer's name in the layers panel and click "Save As..." A new window opens (Figure 2.12).

2. Give the new file a name and select "Save only selected features". Press OK. The new shapefile gets saved in the system.

3. It is a good practice to confirm the properties of the new layer by opening its attribute table.

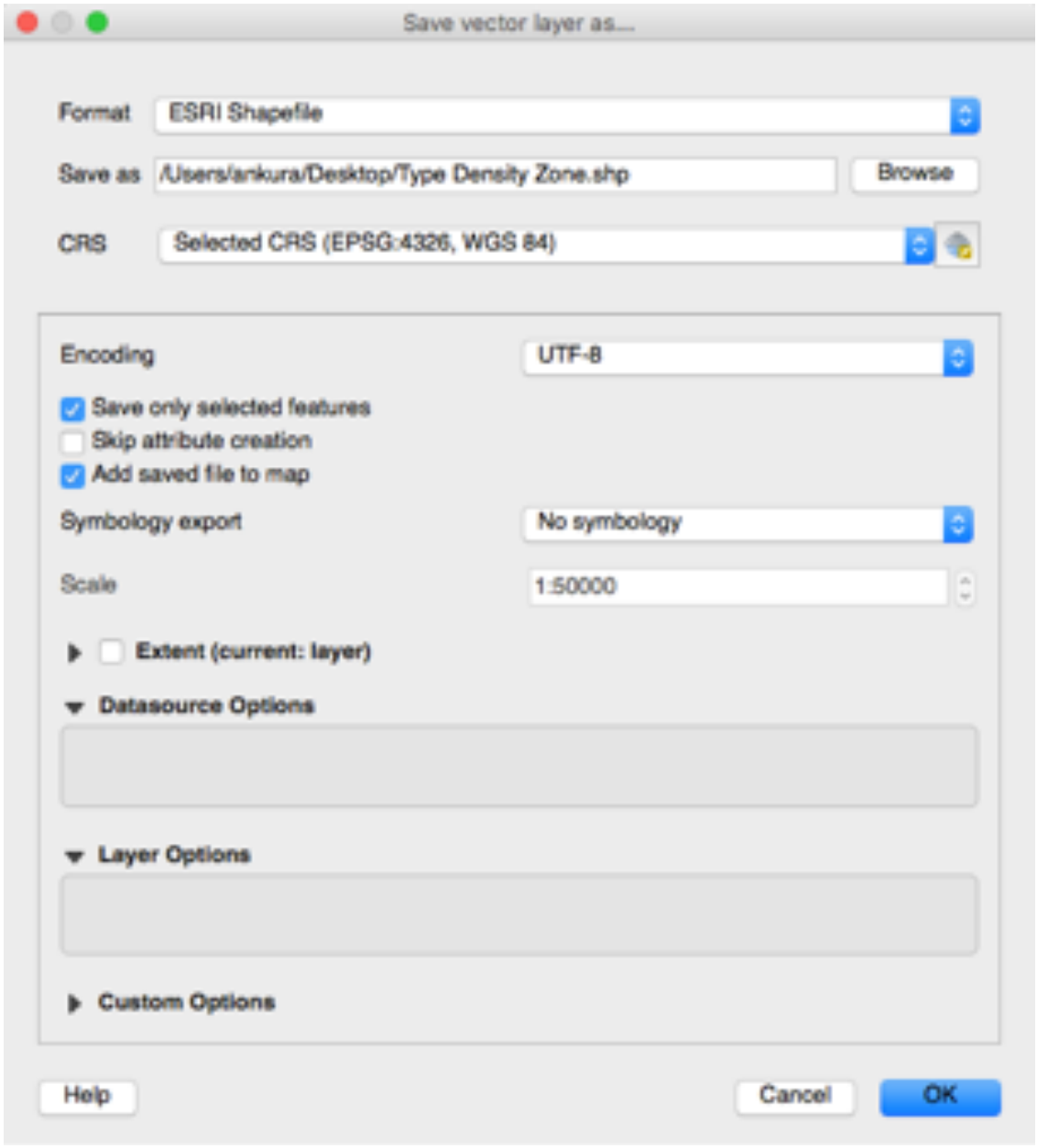


Figure 2.12: Exporting the selection to a new layer

2.7 Creating buffers

To create circular buffers of a given diameter, say 1500 m around some point features, say villages, we execute the following operations:

1. Select buffer tool from Vector → Geoprocessing Tools → Buffer(s)..., as depicted in figure 2.13.

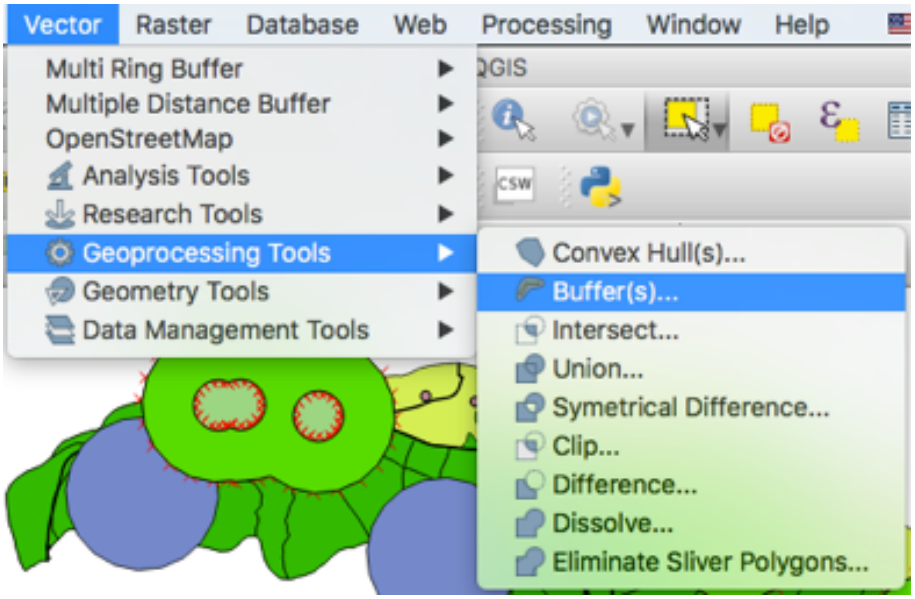


Figure 2.13: The buffer tool

2. Input the parameters as depicted in figure 2.14: Input vector layer is Village, buffer distance is 1500 (m). Select "Dissolve buffer results" and give a filename for the output shapefile. Press OK.

3. The application generates circular buffers of 1500 m around the villages, as depicted in figure 2.15.

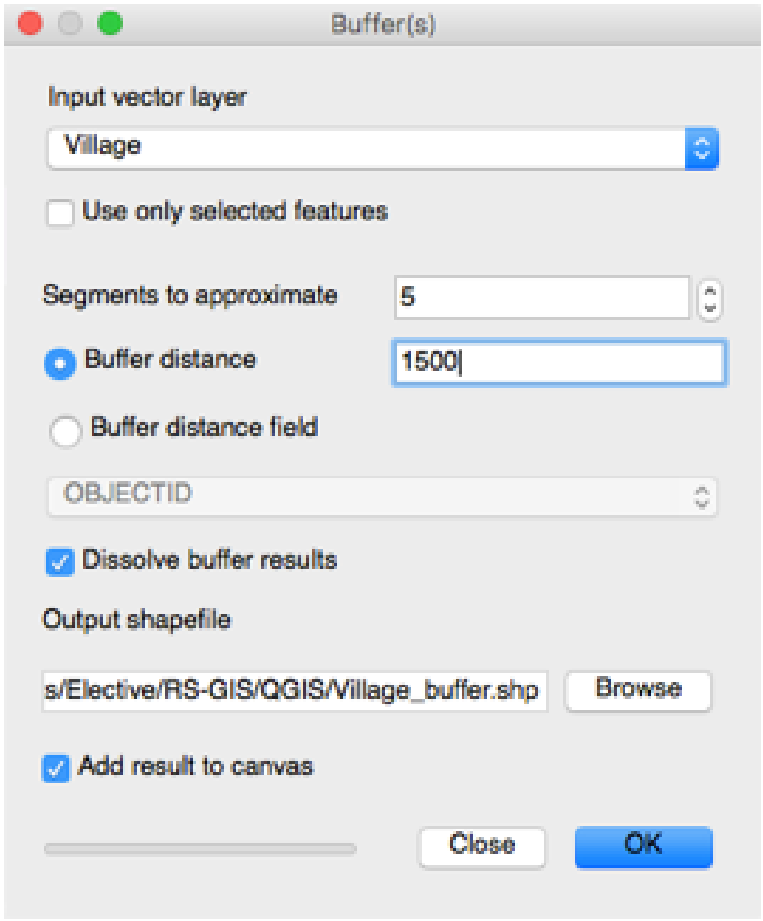


Figure 2.14: Parameters for the creation of buffer zone around villages

2.8 Generating maps

To generate a map from a layer or a set of layers, we execute the following operations:

1. Bring the requisite map to the map canvas by toggling the visibility of layers in the layers panel.

2. Click Project → New Print Composer → OK.

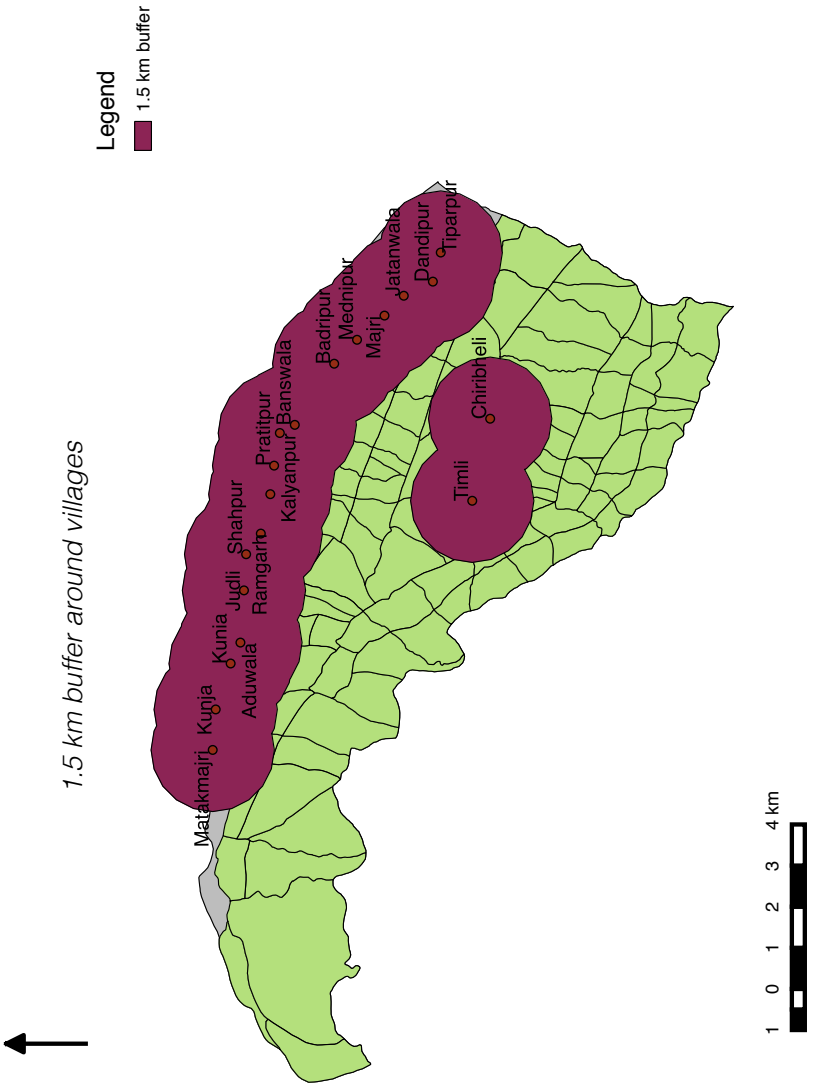


Figure 2.15: 1.5 km buffer around villages

3. A new print composer window opens (Figure 2.16).

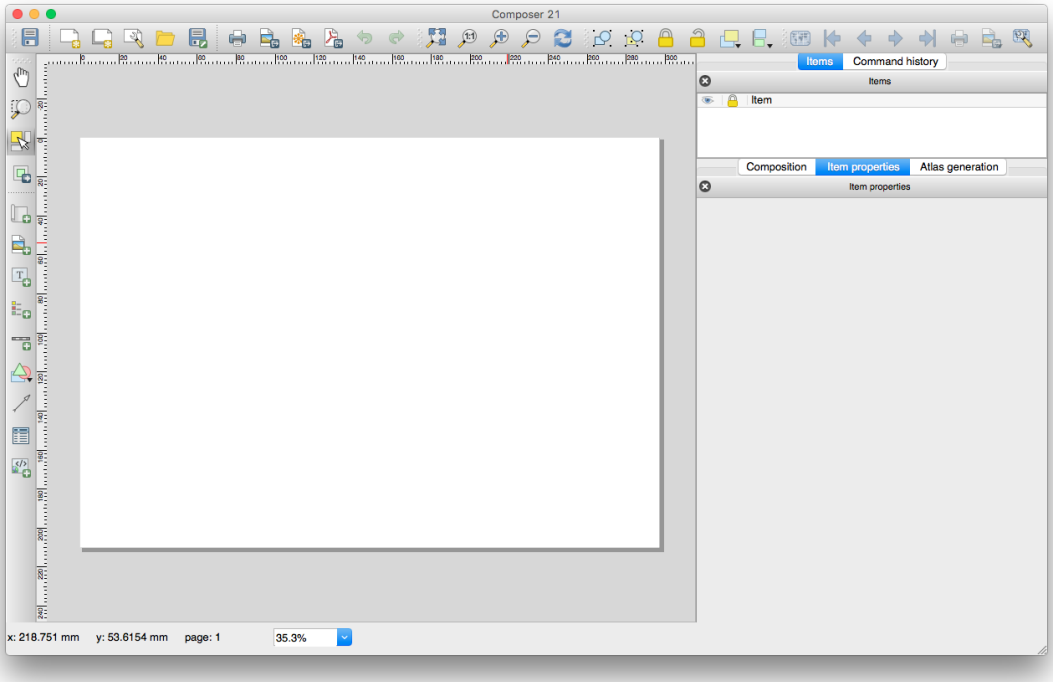


Figure 2.16: The print composer window

4. Add the map, title, legend, North arrow and scale using tools on the left panel. To edit a feature, click on it, and the editing options open on the right panel (Figure 2.17).

5. After you are satisfied, give print command (Composer → Print) and save the map as a PDF file.

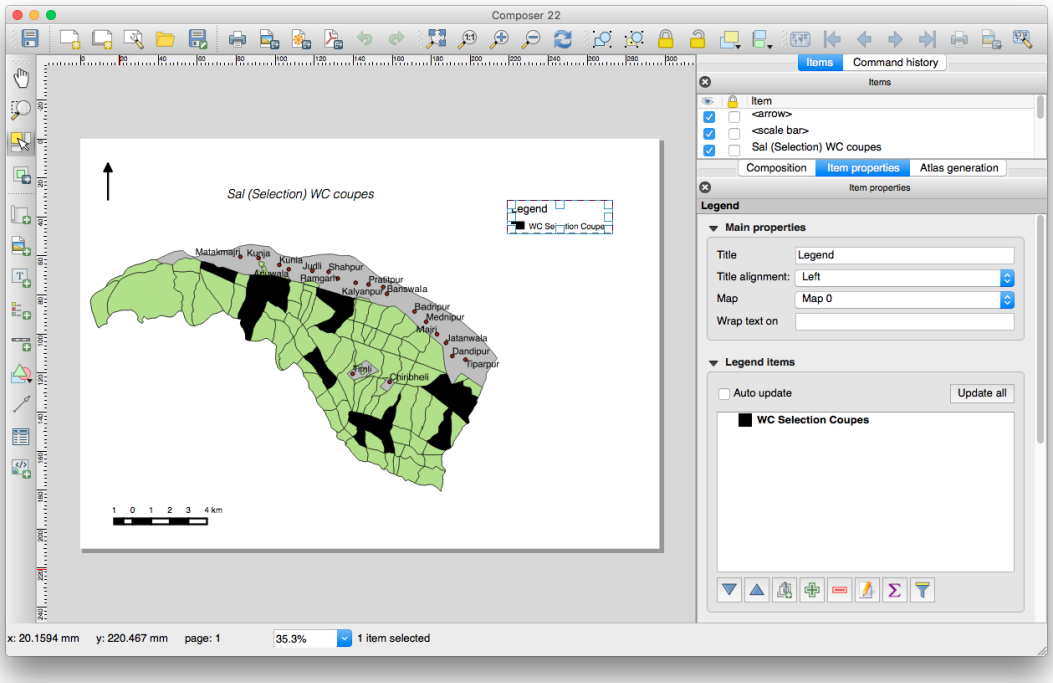


Figure 2.17: The final print composer window open for editing

Chapter 3

The Conservation and Improvement Working Circle

3.1 Introduction

This working circle incorporates those areas where felling is extremely difficult or non-remunerative. Such areas may include blanks and thinly forested regions, or those with steep slopes where not only is felling difficult and hazardous, but the loss of canopy cover would also lead to heavy erosion and disturbance to soil and moisture conservation.

This should be the first working circle to be discerned because it is easy to allocate these areas, for we shall not be doing any felling in this circle. These areas are sensitive and should not be touched, but for protection, conservation and improvement purposes.

3.2 Special objects of management

The aim of this working circle is to conserve, improve and extend the cover of forests for several purposes, such as wildlife conservation and regulation of water flow in the area.

The blank and degraded areas need to be re-forested with native species for meeting the fuel, fodder, NTFP needs of the local community, and the needs of the wildlife.

At the same time, those areas that have a substantial cover of weeds like lantana and parthenium, and exotic species that might have been planted earlier, would be cleared, and these species removed and uprooted in the interest of improving biodiversity of the area.

3.3 Discernment of compartments

The exact criteria to be used for the discernment of compartments is at the discretion of the working plan officer. To illustrate, here we shall use two criteria to identify the compartments that shall be included in this working circle:

1. The canopy density should be extremely low. This is a proxy for tree cover. If trees are very less, working of the area shall prove unremunerative. In this case, we can use CD < 0.4 as the criterion.

   To select such compartments, we give the following query:

"Canopy density" < 0.4

Figure 3.1 depicts such compartments.

2. The slope should be steep or very steep. Under such a condition, any felling will lead to large amounts of soil erosion and disturbance to water flow, resulting in the formation of gullies, raus and ravines.

   To select such compartments, we give the following query:

   "Slope" = 'steep' OR "Slope" = 'very_steep'

   Figure 3.2 depicts such compartments.

If some region has low canopy and low slope, some felling can be performed, aided by assisted natural regeneration or artificial regeneration / planting. Similarly, if a region has high canopy cover and high slope, some felling might be performed, taking care that enough trees remain to provide tree cover and soil binding. Thus, only such areas that satisfy both the criteria of the previous paragraph shall be included in this working circle.

To select these compartments, we give the following query:

"Canopy density" < 0.4 AND ("Slope" = 'steep' OR "Slope" = 'very_steep')

and export the selection to a new layer. Note the use of AND and OR boolean operators, and use of parentheses. We could also utilise other parameters / variables to add or remove some compartments in this working circle. For instance, some contiguous compartments might be included. Or, compartments that are to be worked under some new scientific / experimental principles might be excluded. This layer is then used to generate a map.

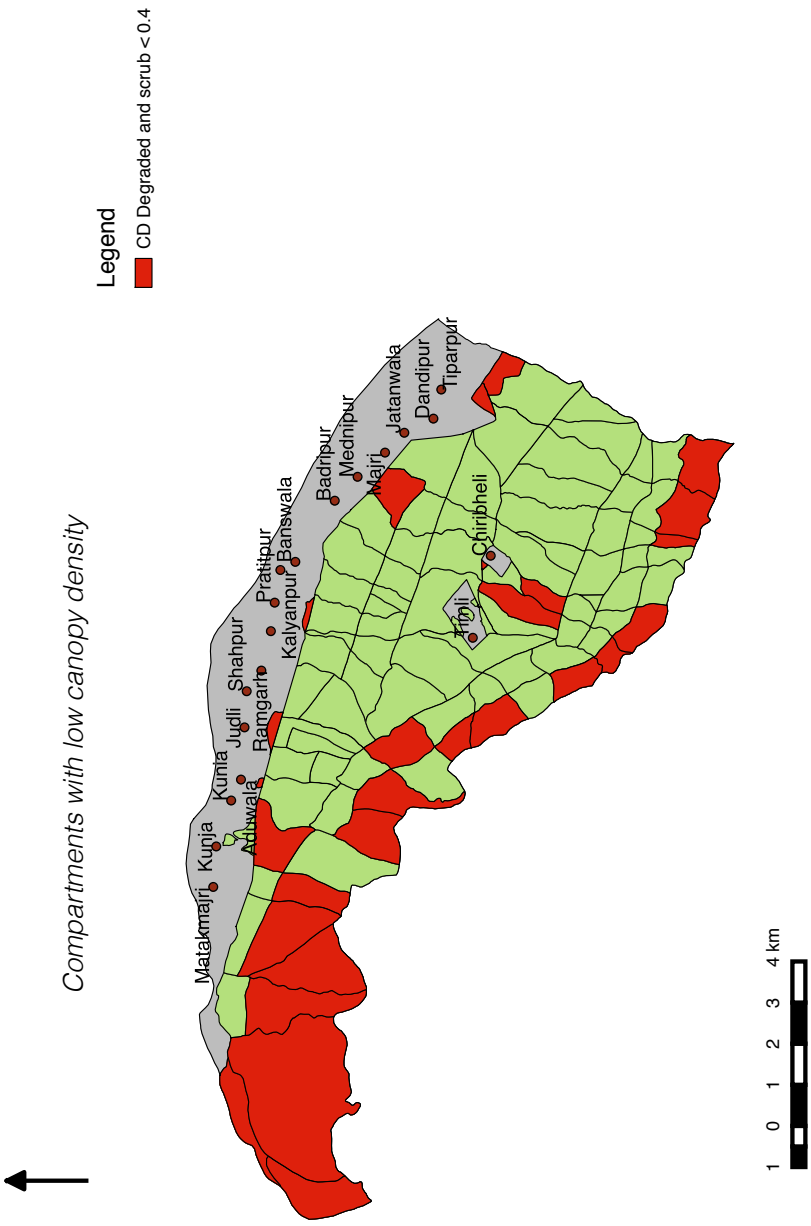


Figure 3.1: Map depicting compartments with CD < 0.4.

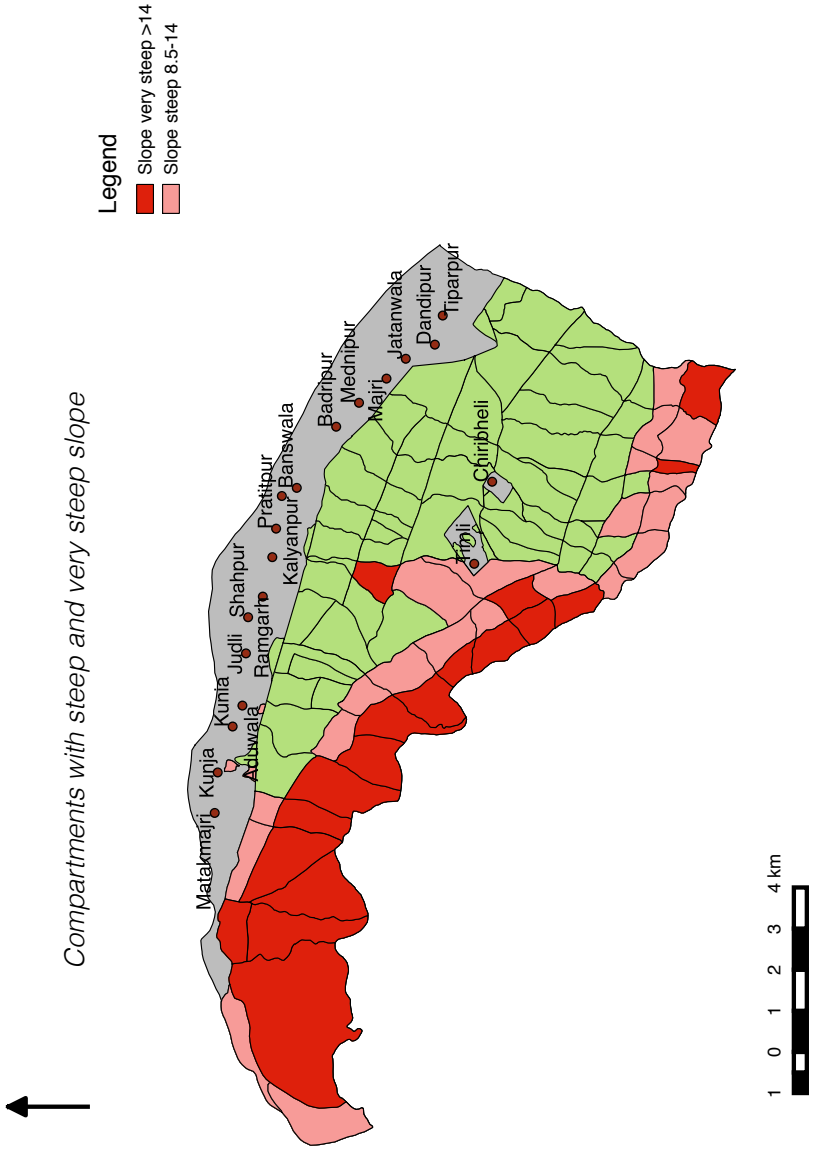


Figure 3.2: Map depicting compartments with steep and very steep slope.

Figure 3.3 depicts the final result of one such exercise.

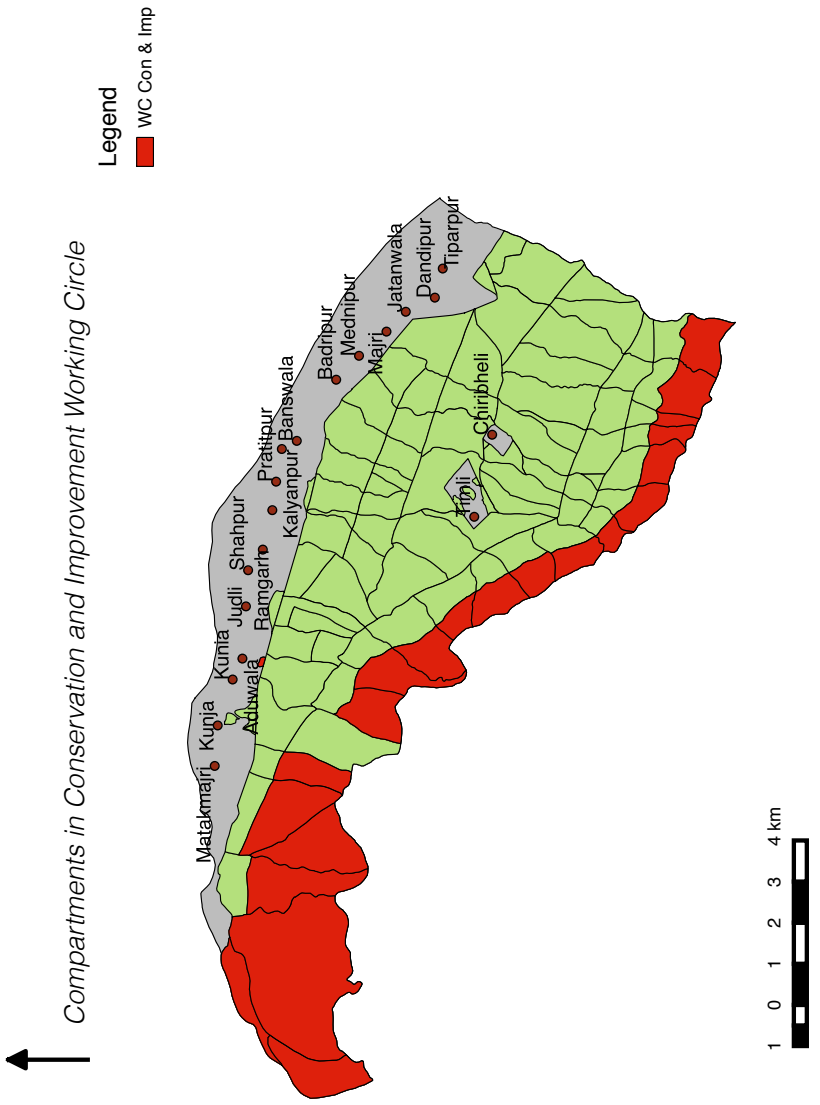


Figure 3.3: Map depicting compartments in Conservation and Improvement Working Circle.

Chapter 4

The Sal (IISS) Working Circle

4.1 Introduction

This working circle incorporates those areas that are suitable for regenerative felling. Such areas include regions that are fairly forested, especially those that have previously been worked under this system. Systematic working of the region ensures soil and moisture conservation even after felling operations.

4.2 Special objects of management

This working circle aims at natural regeneration of the forest areas by three ways:

1. nursing the existing regeneration where it exists

2. assisted natural regeneration in deficient areas

3. gap planting where necessary.

In addition, where the young crop exists, it strives to assist their vigorous growth by creating space for them through opening of the canopy.

Further, it tries to maintain and nurture the existing ecosystem for conservation purposes, and, where possible, extract the maximum sustained yield of large timber.

4.3 Discernment of compartments

Since the exclusive working circles should cover all the compartments under analysis, those compartments that have not been included in the Conservation & Improvement Working Circle should be included in one of the remaining exclusive working circles.

The exact criteria to be used for the discernment of compartments for the current working circle are at the discretion of the working plan officer. However, to illustrate, we shall use the following criteria to identify the compartments that shall be included in the Sal (IISS) working circle:

1. The area should not have an Inverse-J ND curve, for we would prefer to incorporate those compartments in Sal (Selection) Working Circle.

2. The area should have sufficient number of stems per hectare. In case the number of stems is insufficient, we would prefer to manage those compartments as Sal (Selection) Working Circle.

The exact structure of the working circle is again at the discretion of the working plan officer. However, to illustrate, let us consider three floating periodic blocks:

1. PB1: This comprises compartments with crops that are mature, and require working and regeneration. We could take crop diameter as a proxy for maturity, for it represents the RMS average diameter of different stems. To illustrate, let us consider 35 cm as a cut-off. Besides, we could also consider the number of stems per hectare to decide the viability of the operation. Let us take 200 stems per hectare as a cut-off. Thus, to find out the compartments satisfying these criteria, we could execute the following query operation:

   "ND curve shape" != 'Inv_ J' AND "CD" >= 35 AND "Stems" >= 200

   The result, when put to a new layer, is depicted in figure 4.1.

2. PB2: This comprises compartments with crops that have regenerated, but are not yet mature for felling, and so require thinning and protection. Taking crop diameter as a proxy for maturity, let us consider crops with CD between 23 and 35 cm. Besides, we could also consider the number of stems per hectare to decide whether or not to put a compartment for artificial regeneration, if, say, the stand density is very less. Let us take a cut-off of 200 stems per hectare for illustration. If the number of stems is less than this figure, we shall put that compartment for regeneration. To find out the compartments satisfying the

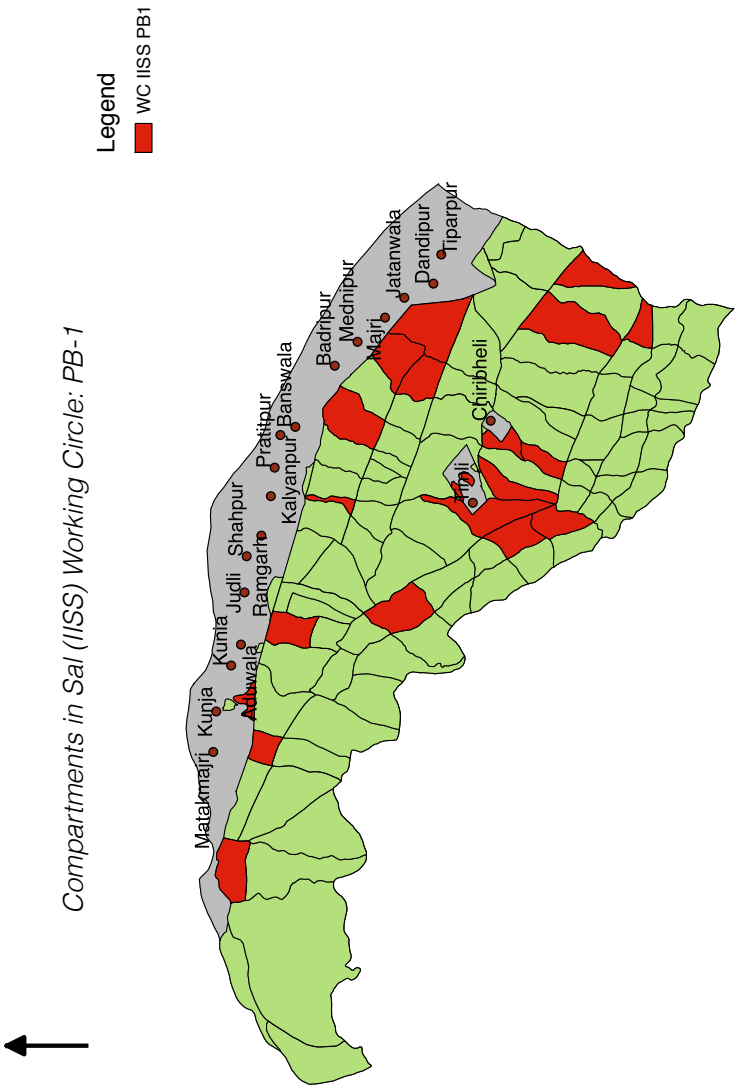


Figure 4.1: Map depicting compartments in the Sal (IISS) Working Circle: PB1

criteria for this PB, we could execute the following query operation:

"ND curve shape" != 'Inv_ J' AND "CD" >= 23 AND "CD" < 35 AND "Stems" >= 200

The result, when put to a new layer, is depicted in figure 4.2.

3. PB3: This region comprises compartments with recently regenerated crops. Thus, the crop diameter would be small, say less than 23 cm. These crops require tending, ANR and protection. To find out the compartments to be included in this PB, we could execute the following query operation:

   "ND curve shape" != 'Inv_ J' AND "CD" < 23

   The result, when put to a new layer, is depicted in figure 4.3.

The remaining compartments could be included into any of these periodic blocks depending on local exigencies such as contiguity, or into Sal (Selection) Working Circle (Chapter 5), or into any other exclusive working circle as desired by the working plan officer.

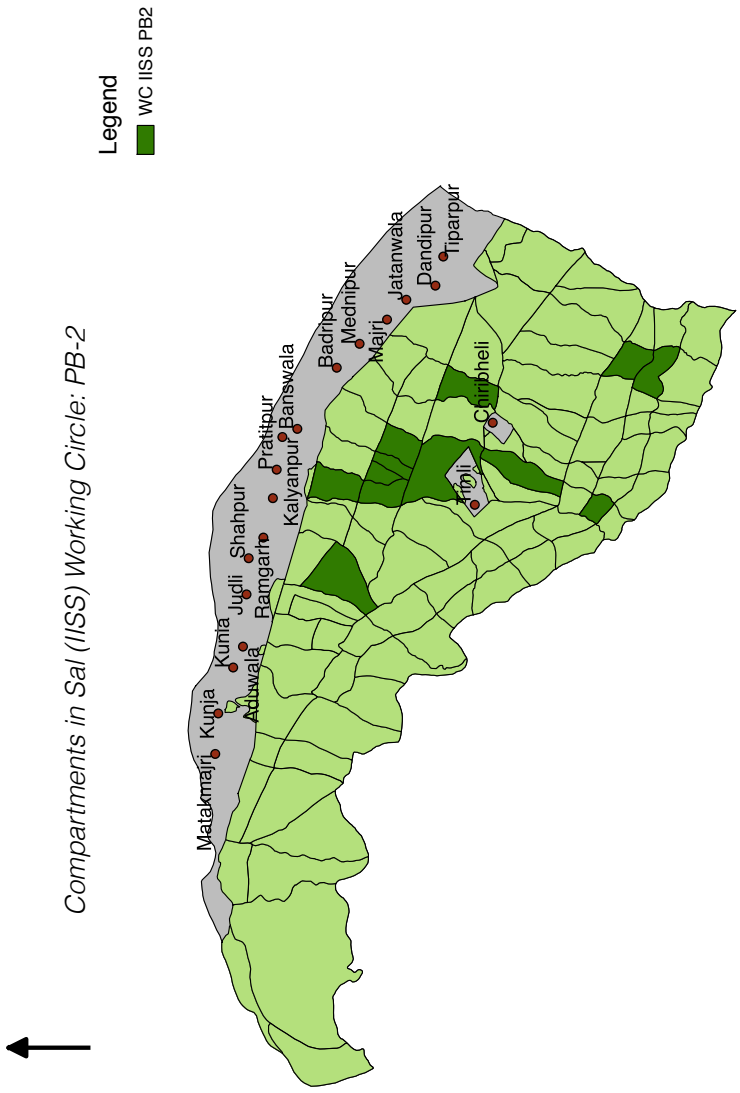


Figure 4.2: Map depicting compartments in the Sal (IISS) Working Circle: PB2

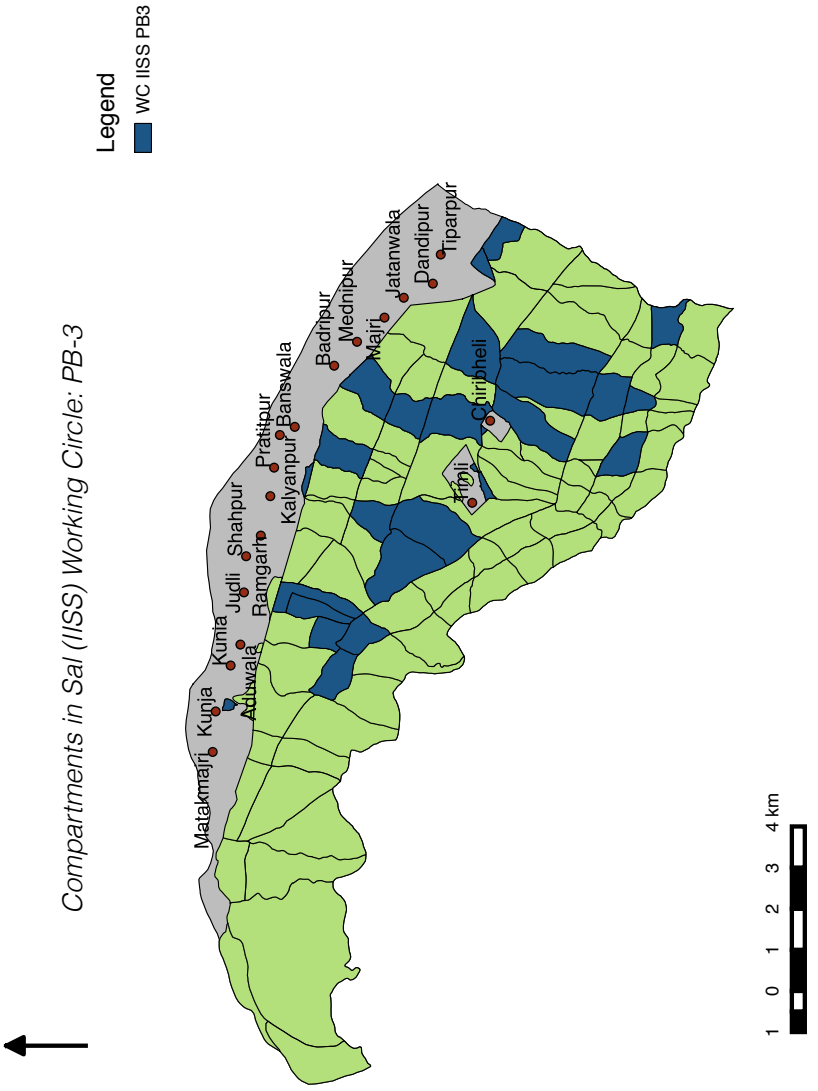


Figure 4.3: Map depicting compartments in the Sal (IISS) Working Circle: PB3

Chapter 5

The Sal (Selection) Working Circle

5.1 Introduction

Sal (Selection) Working Circle also includes areas suitable for regenerative felling. The choice of compartments to be included in this working circle depends on the history of management of the compartments, or on the special objects of management. In the selection management of forests, all age classes are represented in forest; hence it is closer to a natural forest. Systematic working of the region ensures soil and moisture conservation even though felling operations are undertaken in this working circle.

5.2 Special objects of management

This working circle aims at natural regeneration of the forest areas by three ways:

1. nursing the existing regeneration where it exists
2. assisted natural regeneration in deficient areas
3. gap planting where necessary

In addition, where the young crop exists, it strives to assist their vigorous growth by creating space for them through opening of canopy.

Moreover, it also aims to attain the normal forest by obtaining normal distribution of various age classes.

Further, it tries to maintain and nurture the existing ecosystem for conservation purposes, and, where possible, extract the maximum sustained yield of large timber.

5.3 Discernment of compartments

Since this working circle is an exclusive working circle, we could include all compartments that have not been included in the previous working circles in this working circle. However, a more rigorous approach would entail engendering certain criteria to be used for determining the compartments to be included in this working circle.

The exact criteria to be used for the discernment of compartments for the current working circle are at the discretion of the working plan officer; nevertheless, to illustrate, we shall use the following criteria to identify the compartments that shall be included in the Sal (Selection) Working Circle:

1. The area should have an Inverse-J ND curve.

To find out the compartments to be included in this PB with the above criteria, we could execute the following query operation:

"ND curve shape" = 'Inv_J'

Besides, those compartments that remain after allotment to other exclusive working circles could be included into this working circle depending on local exigencies.

The result, when put to a new layer, is depicted in figure 5.1.

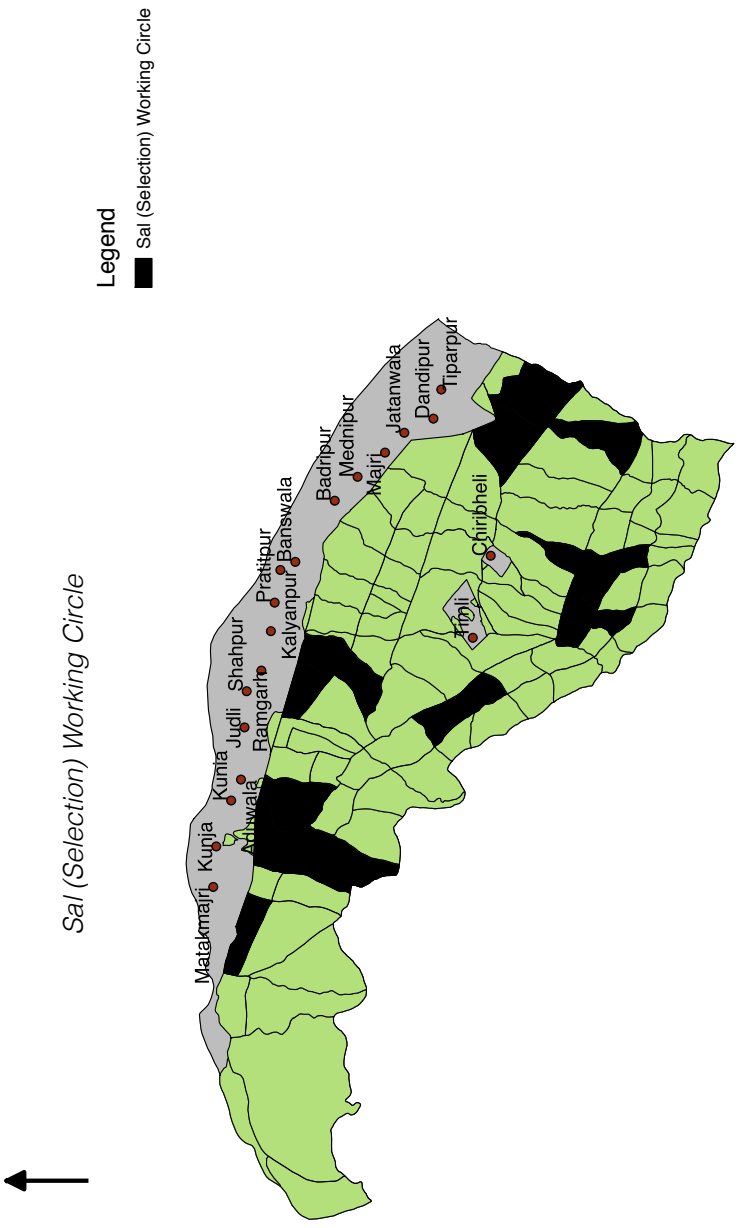


Figure 5.1: Map depicting compartments in the Sal (Selection) Working Circle

Chapter 6

The Plantation (Overlapping) Working Circle

6.1 Introduction

The Plantation (Overlapping) Working Circle includes all existing plantations that need to be cared for, and also those open areas that are considered fit for plantation following the plantation policy of the government. Generally these open areas are poorly stocked, degraded, blanks or regions deficient in regeneration. Often, they are heavily infested with weeds. Thus, these areas have immense potential for improving biodiversity and meeting local demands, if only they can be adequately managed. Being an overlapping working circle, this working circle also includes compartments that have already been incorporated into the exclusive working circles.

6.2 Special objects of management

This working circle aims at improving the stocking of the existing forest with Sal, its associates and other indigenous miscellaneous species.

In addition, it tries to raise mixed plantations to enrich biodiversity, and to obtain a suitable habitat for wildlife, while also assisting soil and water conservation.

Besides, the existing plantations are protected and improved by suitable tending and cultural operations.

Through well-stocked and diversified forests, the demands for fuel wood, fodder and non timber forest produce of the local people are also met.

In addition, there is an urge to maximise output by introducing improved technologies like root-trainers, clonal techniques etc. in plantation works.

This working circle also attempts to increase the tree cover by involving government and non-government organisations, private parties, and several other such groups, through raising plantations in civil and private areas.

6.3 Discernment of compartments

This working circle is a non-exclusive working circle, so we can include compartments that have already been included in the previous working circles.

The exact criteria to be used for the discernment of compartments for the current working circle are at the discretion of the working plan officer; nevertheless, to illustrate, we shall use the following criteria to identify the

compartments that shall be included in the Plantation (Overlapping) Working Circle:

1. The area should have some existing plantations that need to be cared for.

2. Major roads passing through the estate shall also be marked for roadside plantations.

To find out the compartments with existing significant plantations, we could execute the following query operation:

"Plantation area (Ha)" >= 5

The result, when put to a new layer, is depicted in figure 6.1.

The major roads passing through the estate are depicted in figure 6.2. Their lengths, as noted from the attribute table, are listed in table 6.1.

Table 6.1: List of roads for avenue plantation

Name of road Length	(km)
Assan barrage road	2.50
Dhaula road	6.53
Milvert road	6.10
Saharanpur-Dehradun road	10.49
Shimla bypass section	19.17
Shimla bypass section	29.62
Shimla bypass section	30.71
Total	45.11

Figures 6.1 and 6.2, along with table 6.1 define the Plantation (Overlapping) Working Circle.

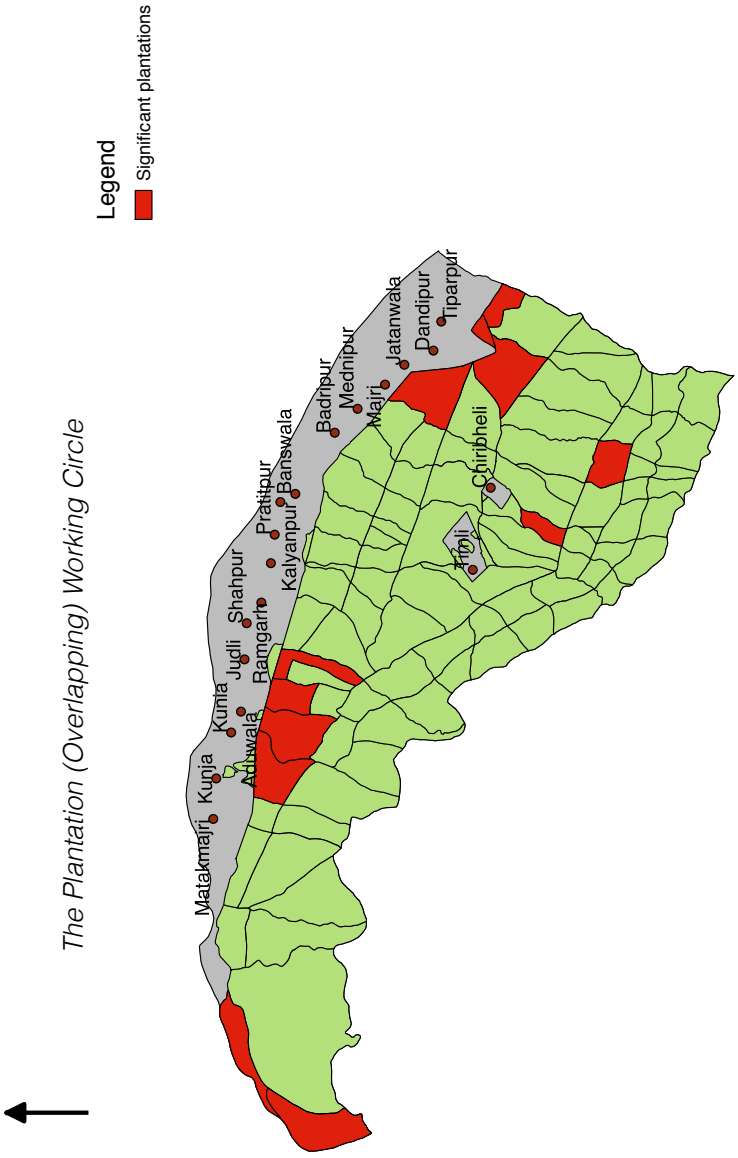


Figure 6.1: Map depicting compartments with significant plantations

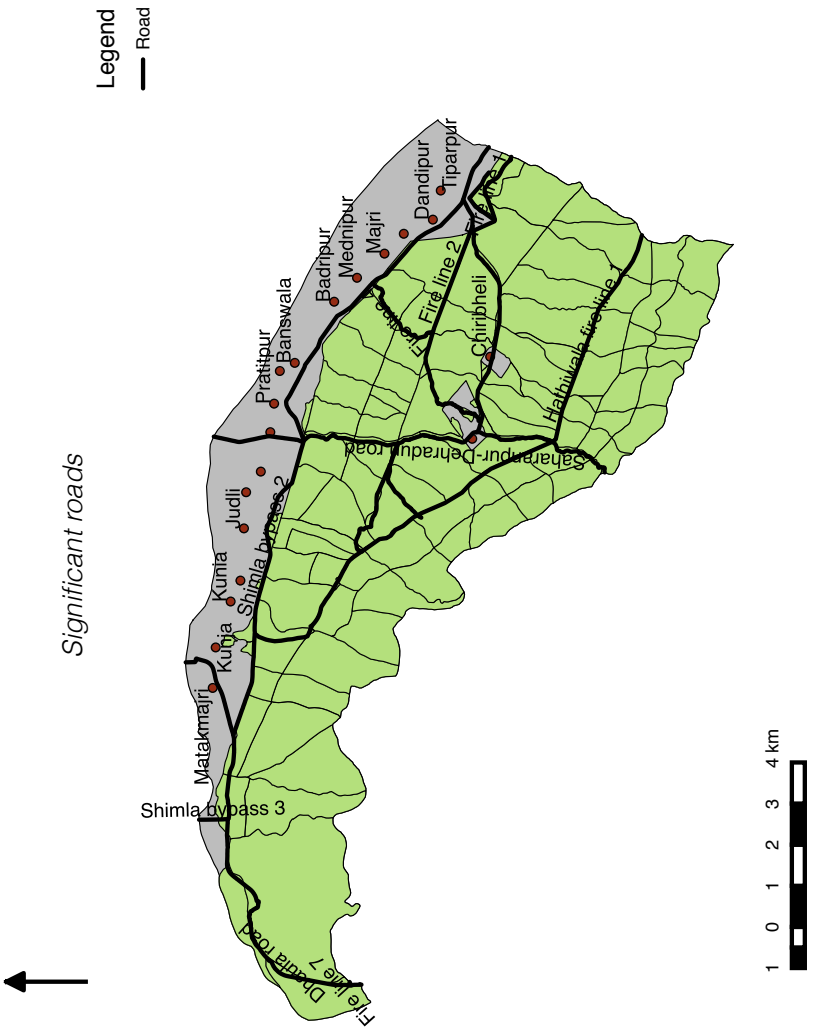


Figure 6.2: Map depicting major roads passing through the forest estate

Chapter 7

The MAP and NTFP (Overlapping) Working Circle

7.1 Introduction

Medicinal and aromatic plants (MAP) and non-timber forest produce (NTFP) are extremely important for local populations. They fulfil the needs for medicines, food, spices, fuel, fodder, gums, resins and other major and minor requirements of people.

Most of the species found in the forests of Uttarakhand have some medicinal importance. However, they are fast disappearing. Not only is this because of rampant infrastructural development, but also because the early policy of monoculture was exacerbated by overgrazing and over-utilisation of the forests. To counter this, the Uttarakhand government has declared itself

as a herbal state, and efforts are being made to conserve MAP and NTFP species in the forests.

7.2 Special objects of management

This working circle aims to conserve and develop all MAP and NTFP species existing in the forest, while ensuring their sustainable exploitation to meet the demands of local populace.

While developing MAP and NTFP species, this working circle will also aid in generation of employment opportunities for locals through value addition.

Besides, the management will also strive towards collection and compilation of information and indigenous knowledge about these species for their use in conservation and development.

7.3 Discernment of compartments

This working circle is a non-exclusive working circle, so we can include compartments that have already been included in the previous working circles.

The exact criteria to be used for the discernment of compartments for the current working circle are at the discretion of the working plan officer; nevertheless, to illustrate, we shall use the following criteria to identify the compartments that shall be included in the MAP & NTFP (Overlapping) Working Circle:

1. The area should be close to habitation / villages, since the MAP and NTFP species are meant to be used by the local populace.

2. Areas with special importance regarding presence of consequential plant species shall also be included in the working circle.

To discern areas close to habitations, let us create a buffer, say, of 1 km around the villages. The result is depicted in figure 7.1.

To find the compartments that intersect this buffer region, we execute the following command:

Vector → Spatial Query → Spatial Query → Select source features from Total Compartment where the feature intersects Reference features of Village Buffer And use the result to Create new selection → Apply

The result, when put to a new layer, is depicted in figure 7.2.

Since there are no areas that are differentially consequential regarding the presence of MAP and NTFP plant species, figure 7.2 also depicts the MAP & NTFP Working Circle.

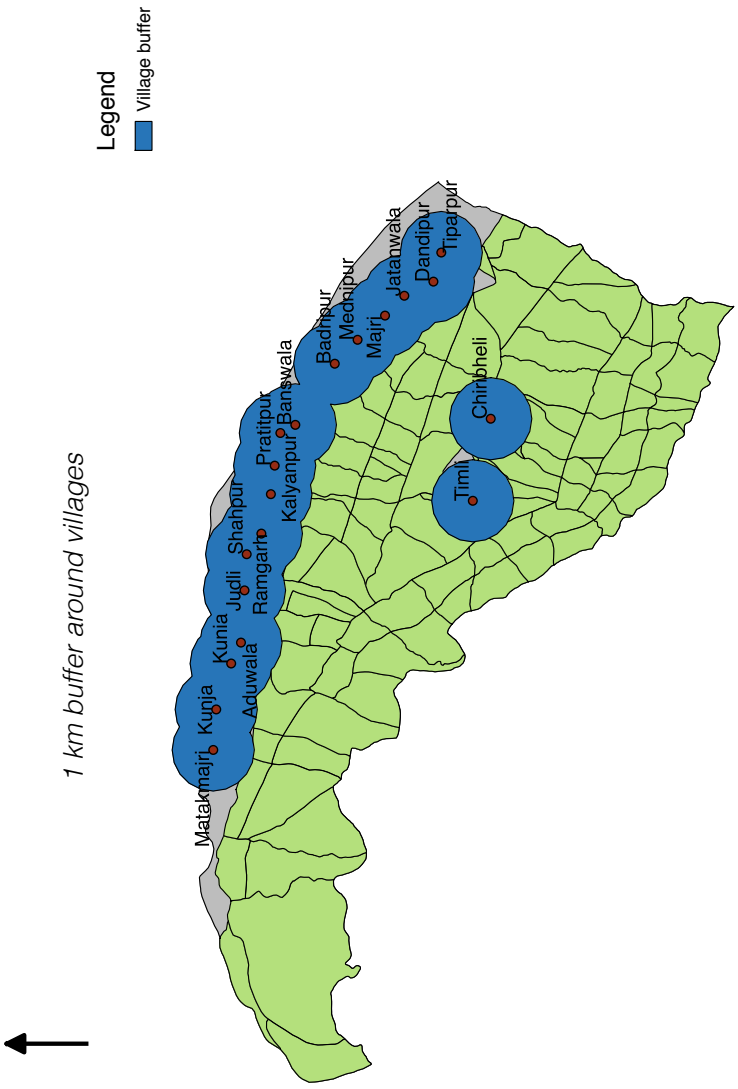


Figure 7.1: 1 km buffer around villages

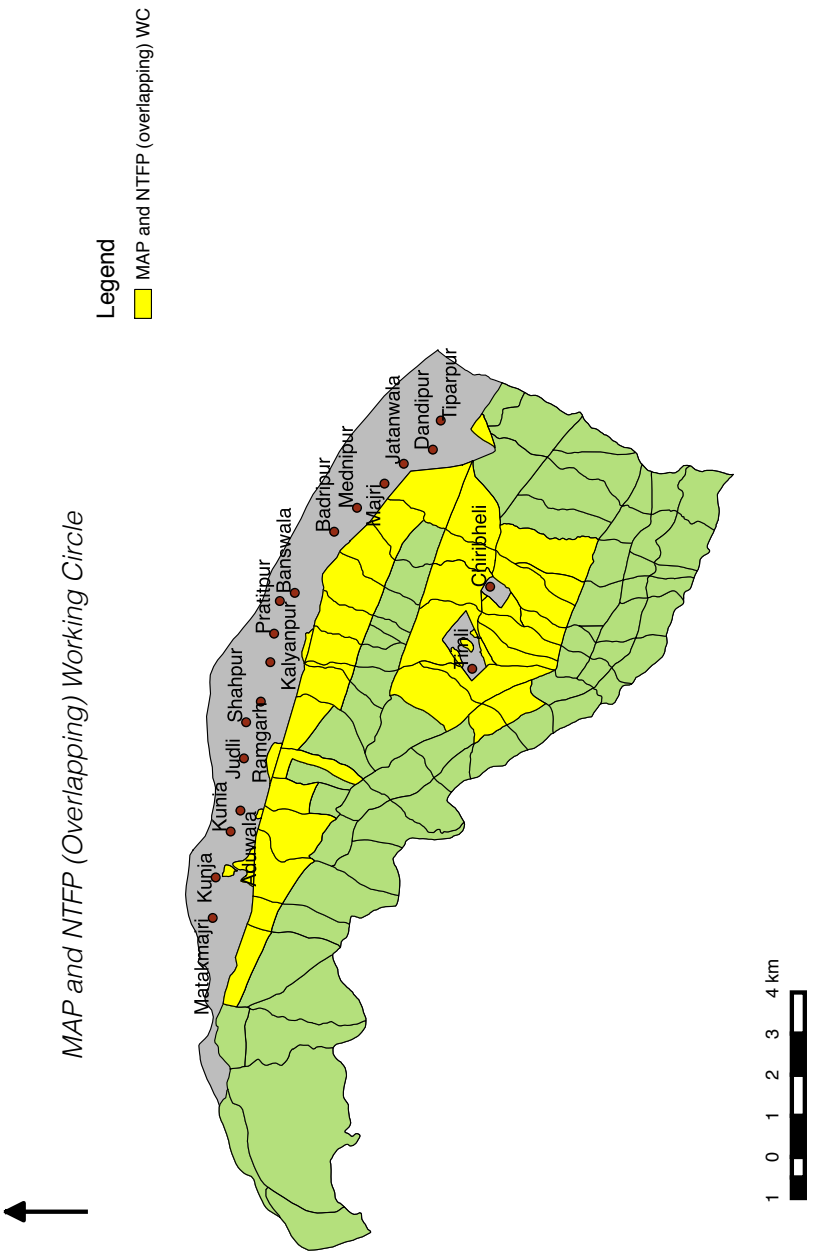


Figure 7.2: Map depicting compartments in MAP & NTFP Working Circle

Chapter 8

The Soil and Water Conservation (Overlapping) Working Circle

8.1 Introduction

Soil is an extremely valuable natural resource that is indispensable for supporting plant and animal life, including forests. In the absence of vegetal cover, soil gets lost through the process of erosion. In the forest estate under study, water erosion is the dominant form of erosion. Water erosion takes place through the formation of rills, raus and gullies. The situation has been exacerbated by uncontrolled grazing, lopping, forest fires and defective extraction paths that make soil more vulnerable towards erosion. When the land is left barren, the flow of water results not only in the loss of soil cover, but also reduces water percolation, resulting in the depletion of water table

and drying of water sources such as wells, ponds and springs.

Thus, the Soil and Water Conservation (Overlapping) Working Circle aims to solve the dual problems of soil loss and water scarcity.

8.2 Special objects of management

This working circle aims to prioritise critical areas that require immediate and effective preventive and remedial measures for water conservation and the control of soil erosion.

It tries to stabilise the erosion infected areas by the use of vegetative cover and / or mechanical measures.

On the preventive front, it also tries to minimise troublesome anthropogenic activities in and around forested areas.

Concomitantly, it endeavours to evolve an acceptable strategic methodology for diverse soil and water conservation works to be executed throughout the forest estate.

8.3 Discernment of compartments

This working circle is a non-exclusive working circle, so we can include compartments that have already been included in the previous working circles.

The exact criteria to be used for the discernment of compartments for the current working circle are at the discretion of the working plan officer. Never-

theless, for illustrative purposes, we shall use the following criteria to identify the compartments that shall be included in the Soil & Water Conservation (Overlapping) Working Circle:

1. The area should have a high slope that makes it susceptible to the impact of water flow.

2. Areas having conspicuous ramifications of soil erosion, viz. rills, raus, gullies and ravines shall also be included in this working circle.

To find out the compartments with high slope, we execute the following query operation:

"Slope" = 'Very steep' OR "Slope" = 'Steep'

The result, when put to a new layer, is depicted in figure 8.1.

Since we did not find any other area having conspicuous ramifications of soil erosion, viz. rills, raus, gullies and ravines to be included in a discretionary manner, figure 8.1 also represents the Soil & Water Conservation (Overlapping) Working Circle.

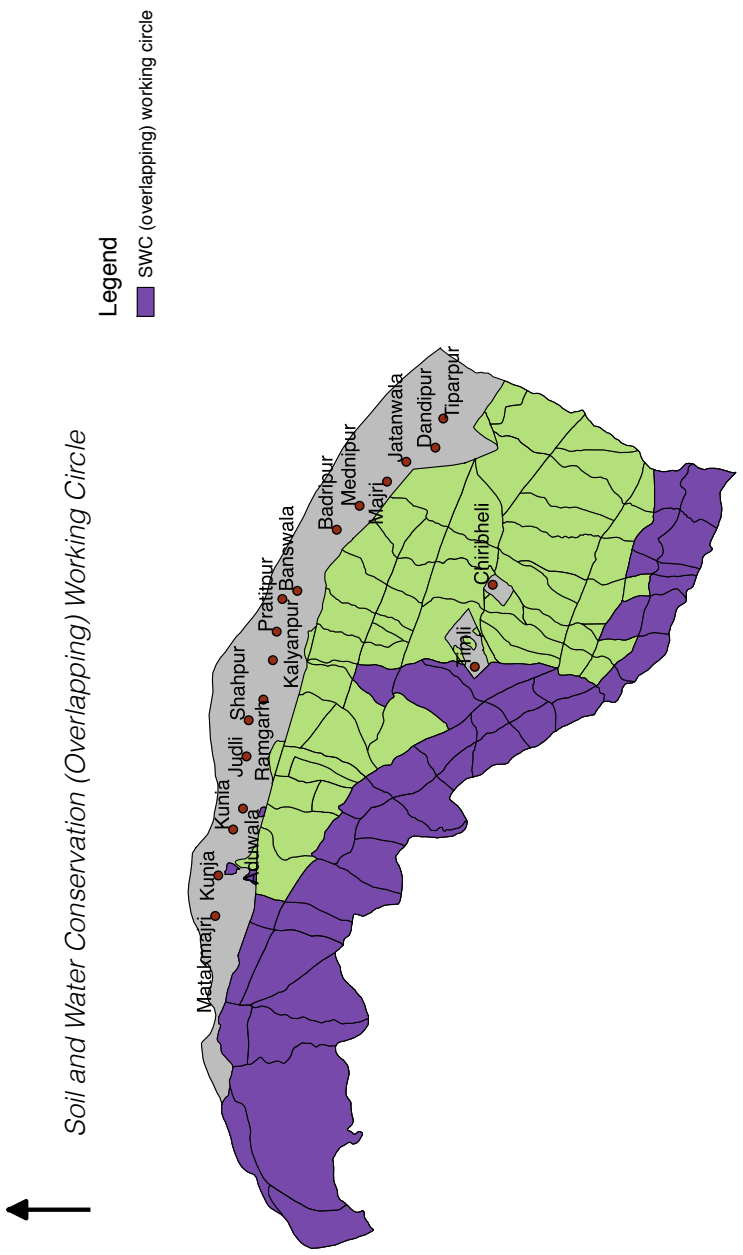


Figure 8.1: Map depicting compartments in Soil & Water Conservation (Overlapping) Working Circle

Chapter 9

The Forest Protection (Overlapping) Working Circle

9.1 Introduction

Forests are an open treasure. There are vast areas the need to be defended and protected. At the same time, men, money and materials are perennially in a short supply. This makes prioritisation of compartments a task of seminal importance. This is the task being discussed in the current chapter.

9.2 Special objects of management

This working circle aspires to undertake all measures: preventive and corrective, including administrative, technical, participatory, social and legal to

protect the forests from forest fires.

It also intends to reduce the biotic pressure, including overgrazing, smuggling, indiscriminate lopping and felling in forest areas. To achieve this, it plans to prevent encroachment through repair, maintenance and periodic monitoring of boundary pillars, and to harmonise the access of people to forests, and to educate and cultivate frontline staff and local people towards the benefits of forest protection, and to train them in the effective management of field situations.

9.3 Discernment of compartments

This working circle is a non-exclusive working circle, so we can include compartments that have already been included in the previous working circles.

The exact criteria to be used for the discernment of compartments for inclusion in the current working circle are at the discretion of the working plan officer. Nevertheless, to illustrate, we shall use the following criteria to identify the compartments that shall be included in the Forest Protection (Overlapping) Working Circle:

1. The compartments should be susceptible to forest fires and / or

2. the compartments should be susceptible to biotic pressure.

To find out the compartments most susceptible to forest fires, we could use the historical data as recorded in the compartment description forms.

We execute the following query operation:

"Fire susceptibility" = 'Most'

The result, when put to a new layer, is depicted in figure 9.1.

To find out compartments most susceptible to biotic pressure and smuggling, let us create a buffer, say, of 1 km, around the villages. The buffer is depicted in figure 9.2.

To find the compartments that intersect this buffer region, we execute the following command:

Vector → Spatial Query → Spatial Query → Select source features from Total Compartment where the feature intersects Reference features of Village Buffer And use the result to Create new selection → Apply

The result, when put to a new layer, is depicted in figure 9.3.

To discern compartments requiring protection, we need to find the union of the earlier two layers: Fire_susceptibility_most and Biotic_pressure_most. For this, we execute the following command:

Vector → Geoprocessing Tools → Union → Input vector layer: Fire_susceptibility_most; Union layer: Biotic_pressure_most; Output shapefile: Forest_protection.shp. → Add result to canvas → OK

The new layer that is created depicts the union of the two layers. This layer, as shown in figure 9.4 depicts the compartments that could be included in the Forest Protection (Overlapping) Working Circle.

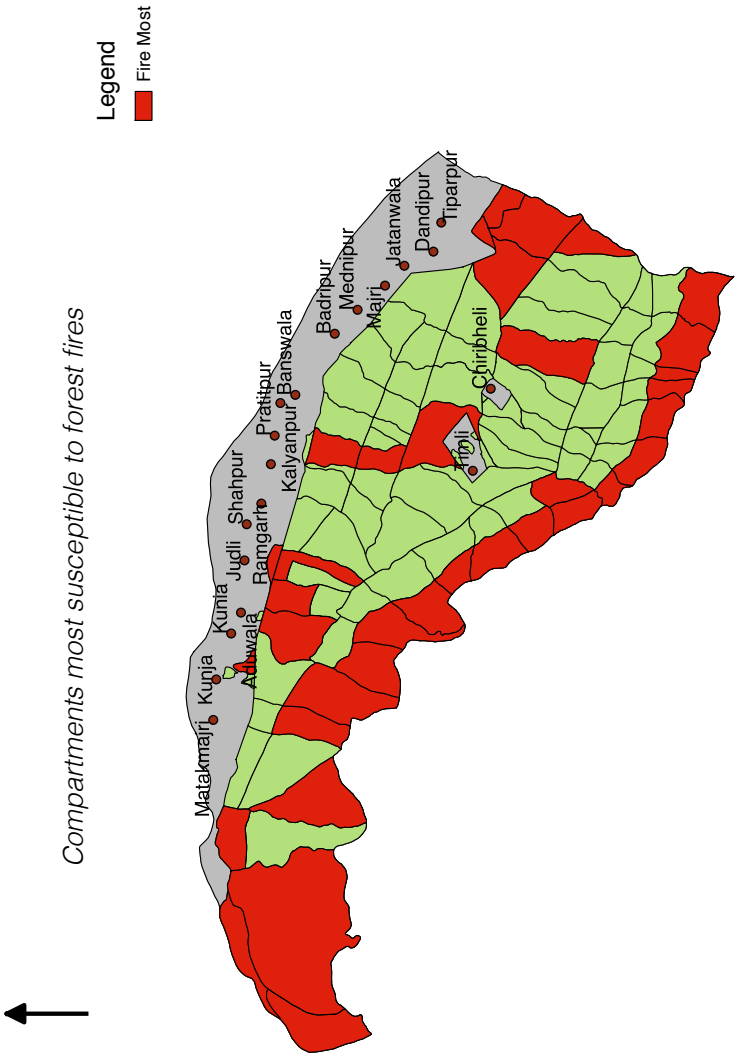


Figure 9.1: Map depicting compartments most susceptible to forest fires

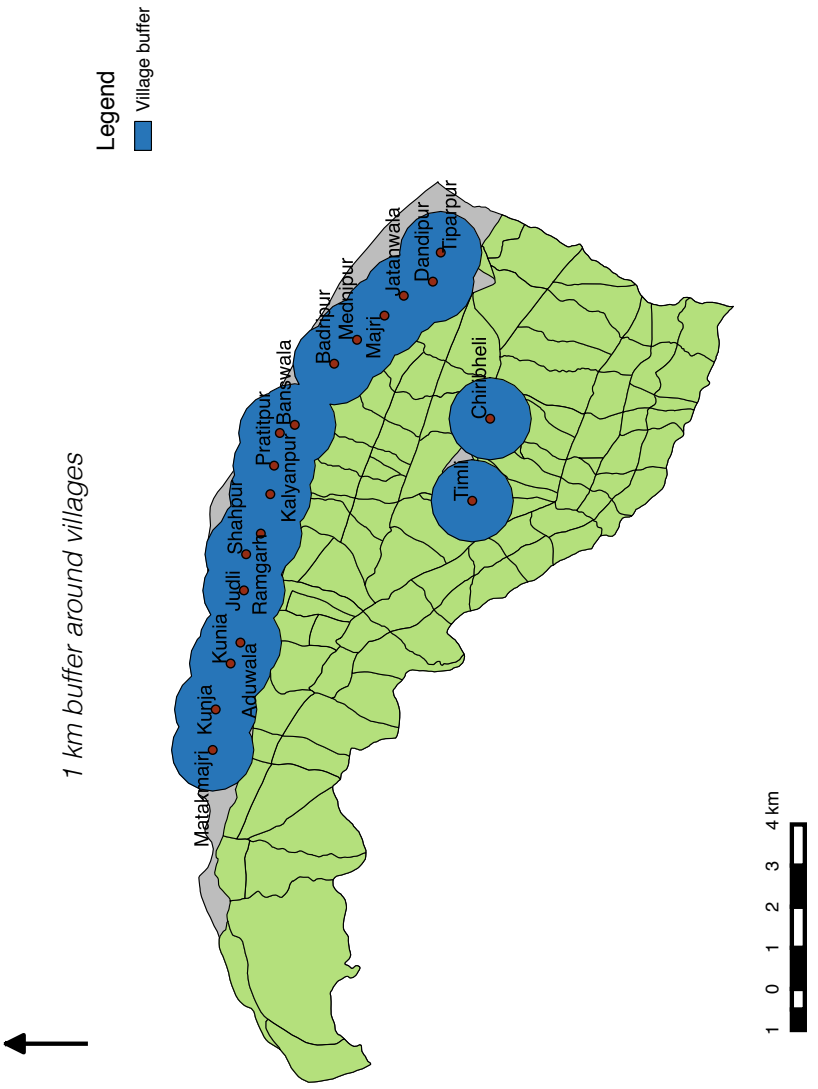


Figure 9.2: 1 km buffer around villages

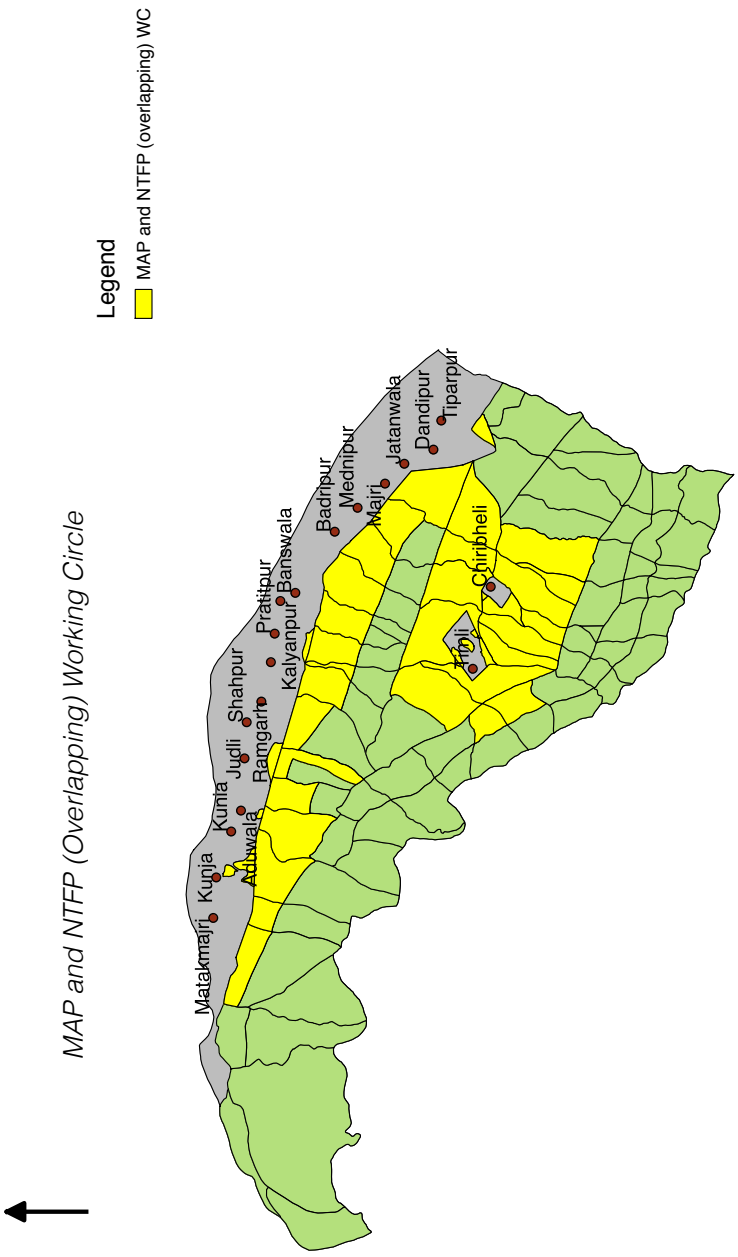


Figure 9.3: Map depicting compartments most susceptible to biotic pressure and smuggling

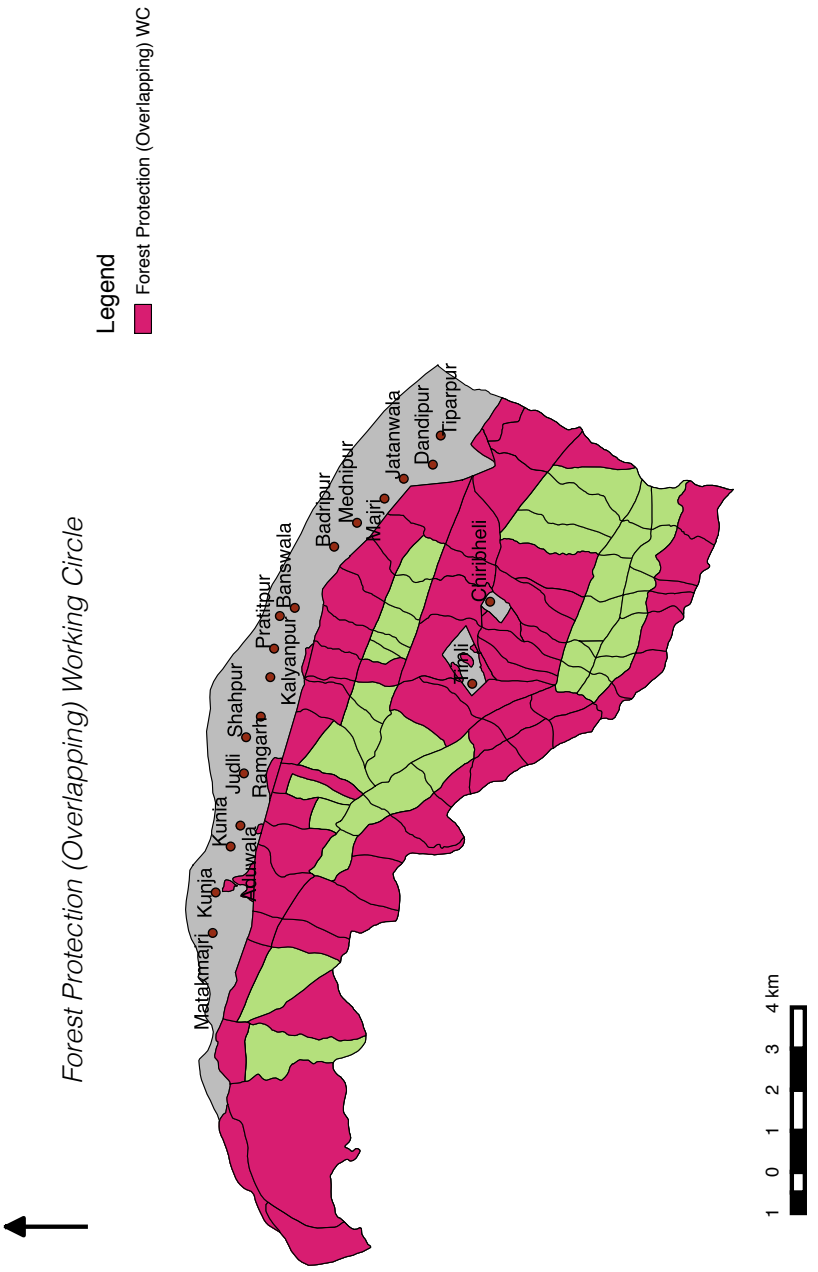


Figure 9.4: Map depicting compartments in the Forest Protection (Overlapping) Working Circle

Chapter 10

The Wildlife Management and Biodiversity Conservation (Overlapping) Working Circle

10.1 Introduction

As per the National Forest Policy 1988, the working plan should aim not towards maximising the sustained yield of timber, but towards sustainable forest management. This stresses at the management of the ecology of the forest estate, including its biodiversity.

During cruising and enumeration, biodiversity is noted as per National Working Plan Code 2014. Plant biodiversity is codified in the form of Simpson and Shannon indices, while the presence of wildlife is noted through vi-

sual confirmation and signs of wildlife including dung pellets, scratch marks, sounds, digging marks, etc., and codified empirically into high, medium and low categories. These can be resorted to for discerning the compartments with high plant and animal biodiversity.

10.2 Special objects of management

This working circle aims to link the objectives of conservation of biodiversity and management of wildlife with those of sustainable management of forests.

To achieve the above aim, it strives to make the forests more congenial to the existence and thriving of biodiversity through manipulation of macro and micro habitats, spreading awareness of the importance of wild animals and plants, and soliciting the active participation of local populace for conservation activities.

Special emphasis and care is bestowed upon the endangered species found in the estate.

10.3 Discernment of compartments

This working circle is a non-exclusive working circle, so we can include compartments that have already been included in the previous working circles.

The exact criteria to be used for the discernment of compartments for the current working circle are at the discretion of the working plan officer.

Nevertheless, for illustrative purposes, we shall use the following criteria to identify the compartments that shall be included in the Wildlife Management and Biodiversity Conservation (Overlapping) Working Circle:

1. The compartments should have a high plant biodiversity, as evidenced by Simpson index or Shannon index and / or

2. the compartments should have a high presence of wildlife.

To find out the compartments with high Simpson index, we open the attribute table of the layer with details of compartments. The columns can be arranged in ascending or descending order by clicking on the column name. This is illustrated in figure 10.1.

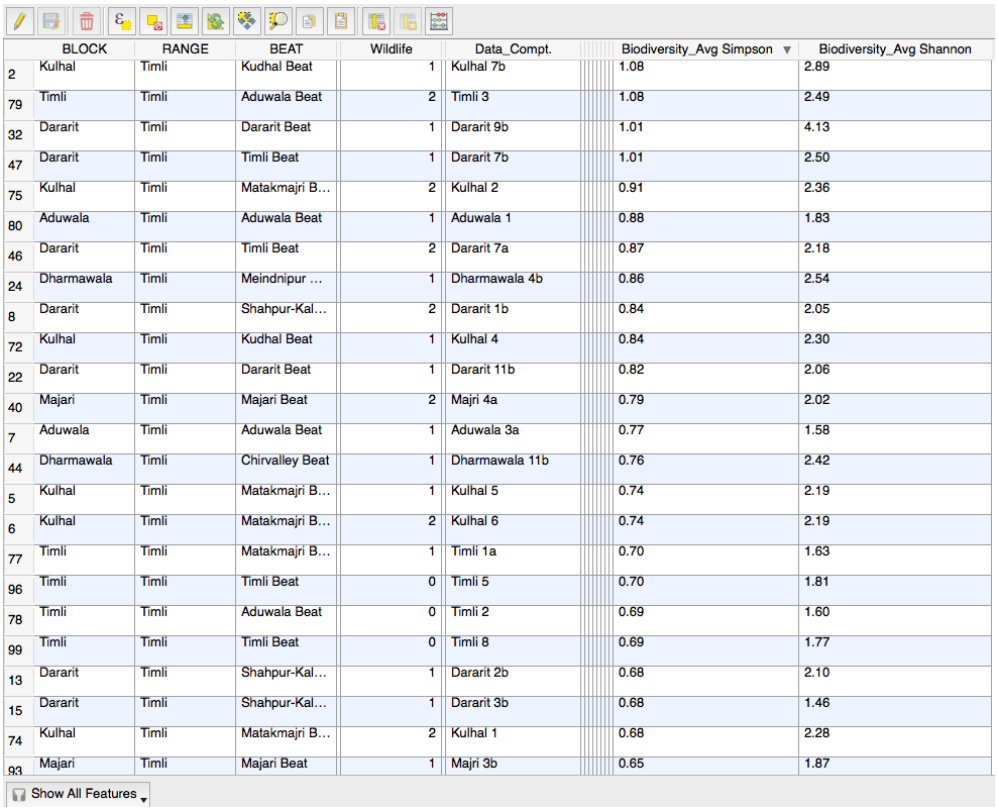
We arrange the compartments in descending order of Simpson's index, and select the compartments in the top quartile. These get selected on the map, and can be exported to a new layer, as depicted in figure 10.2.

Similarly, we can select compartments with high Shannon index, as depicted in figure 10.3.

To discern the compartments with high plant biodiversity, we can perform a union of the Simpson and Shannon layers by executing the following operation:

Vector → Geoprocessing Tools → Union → Input vector layer: Simpson_high; Union layer: Shannon_high; Output shapefile: High_plant_biodiversity.shp. → Add result to canvas → OK

The result is depicted in figure 10.4.



	BLOCK	RANGE	BEAT	Wildlife	Data_Compt.	Biodiversity_Avg Simpson	Biodiversity_Avg Shannon
2	Kulhal	Timli	Kudhal Beat	1	Kulhal 7b	1.08	2.89
79	Timli	Timli	Aduwala Beat	2	Timli 3	1.08	2.49
32	Dararit	Timli	Dararit Beat	1	Dararit 9b	1.01	4.13
47	Dararit	Timli	Timli Beat	1	Dararit 7b	1.01	2.50
75	Kulhal	Timli	Matakmajri B...	2	Kulhal 2	0.91	2.36
80	Aduwala	Timli	Aduwala Beat	1	Aduwala 1	0.88	1.83
46	Dararit	Timli	Timli Beat	2	Dararit 7a	0.87	2.18
24	Dharmawala	Timli	Meindnipur ...	1	Dharmawala 4b	0.86	2.54
8	Dararit	Timli	Shahpur-Kal...	2	Dararit 1b	0.84	2.05
72	Kulhal	Timli	Kudhal Beat	1	Kulhal 4	0.84	2.30
22	Dararit	Timli	Dararit Beat	1	Dararit 11b	0.82	2.06
40	Majari	Timli	Majari Beat	2	Majri 4a	0.79	2.02
7	Aduwala	Timli	Aduwala Beat	1	Aduwala 3a	0.77	1.58
44	Dharmawala	Timli	Chirvalley Beat	1	Dharmawala 11b	0.76	2.42
5	Kulhal	Timli	Matakmajri B...	1	Kulhal 5	0.74	2.19
6	Kulhal	Timli	Matakmajri B...	2	Kulhal 6	0.74	2.19
77	Timli	Timli	Matakmajri B...	1	Timli 1a	0.70	1.63
96	Timli	Timli	Timli Beat	0	Timli 5	0.70	1.81
78	Timli	Timli	Aduwala Beat	0	Timli 2	0.69	1.60
99	Timli	Timli	Timli Beat	0	Timli 8	0.69	1.77
13	Dararit	Timli	Shahpur-Kal...	1	Dararit 2b	0.68	2.10
15	Dararit	Timli	Shahpur-Kal...	1	Dararit 3b	0.68	1.46
74	Kulhal	Timli	Matakmajri B...	2	Kulhal 1	0.68	2.28
93	Majari	Timli	Majari Beat	1	Majri 3b	0.65	1.87

Show All Features

Figure 10.1: Arranging compartments in descending order of Simpson index

To find out the compartments with a high presence of wildlife, we execute the following query operation:

"Wildlife presence" = 'high'

The result, when put to a new layer, is depicted in figure 10.5.

To find the compartments to be included in the Wildlife Management and Biodiversity Conservation Working Circle, we need to perform a union of the layer depicting high plant biodiversity with the layer depicting a high presence of wildlife. We execute the following operation:

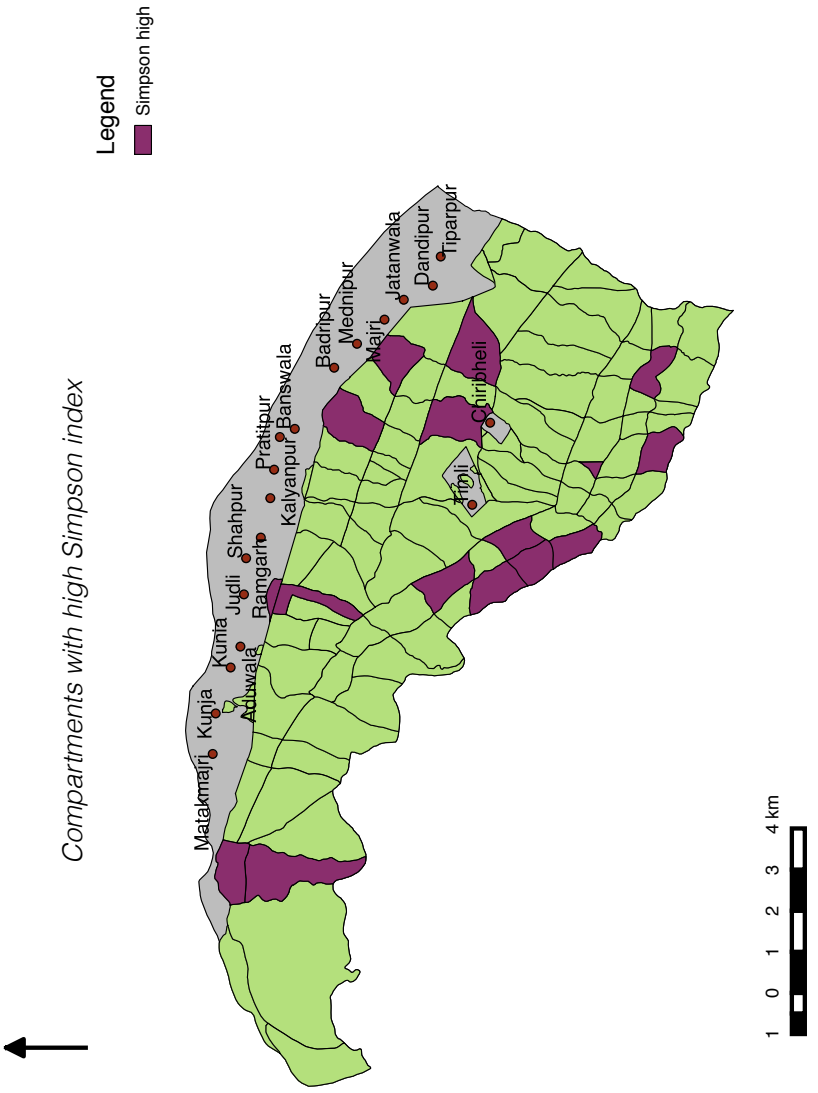


Figure 10.2: Compartments with high Simpson index

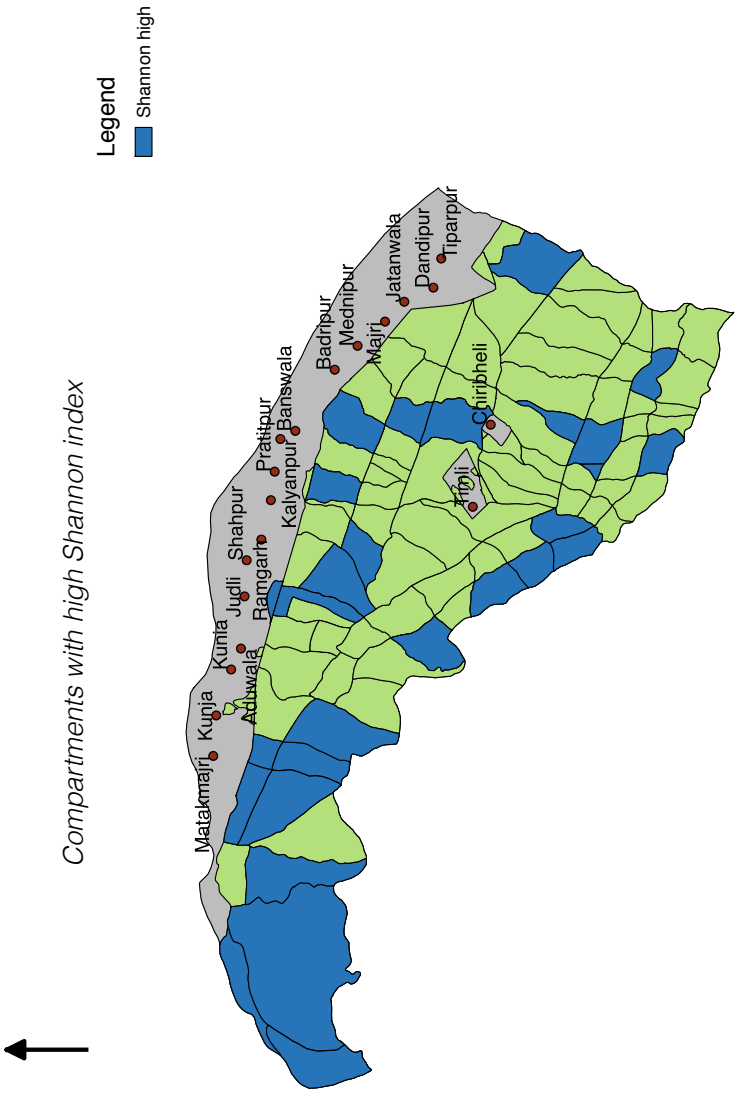


Figure 10.3: Compartments with high Shannon index

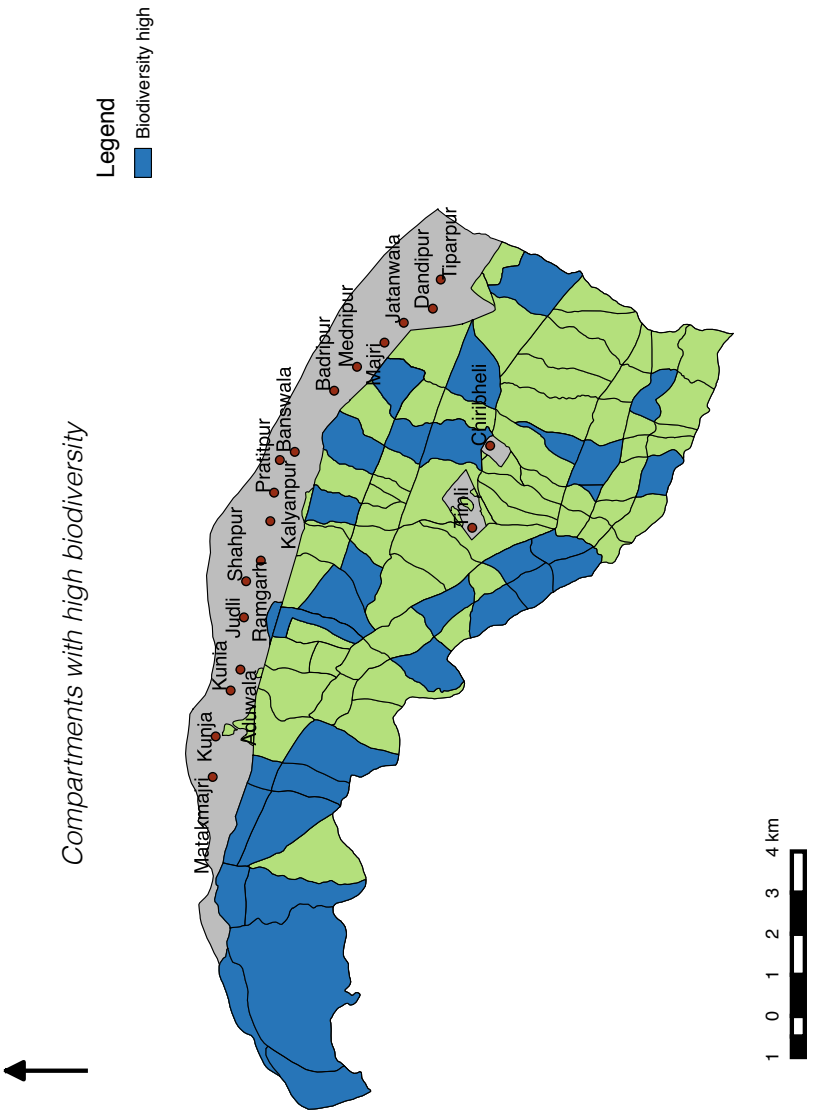


Figure 10.4: Compartments with high plant biodiversity

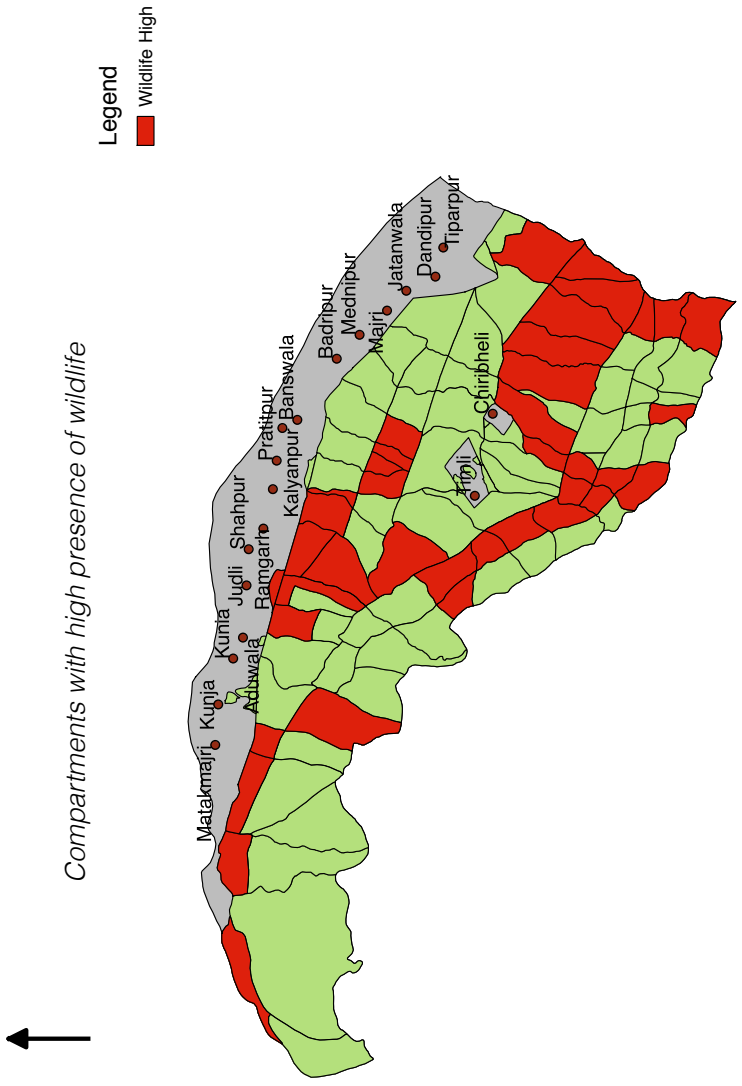


Figure 10.5: Map depicting compartments with high presence of wildlife

Vector → Geoprocessing Tools → Union → Input vector layer: High_ plant_ biodiversity; Union layer: High_ wildlife_ presence; Output shapefile: WMBC.shp. → Add result to canvas → OK

The new layer, as shown in figure 10.6, depicts the compartments in the Wildlife Management and Biodiversity Conservation (Overlapping) Working Circle.

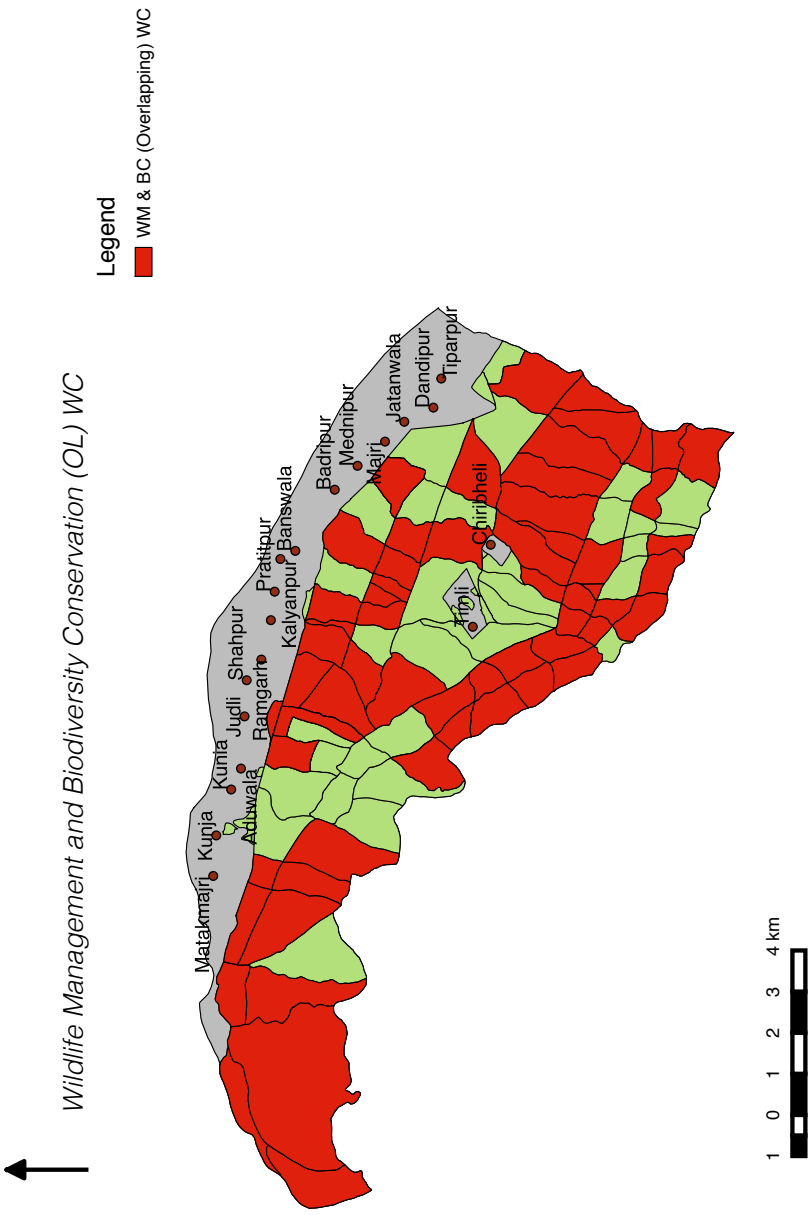


Figure 10.6: Map depicting compartments in the Wildlife Management and Biodiversity Conservation (Overlapping) Working Circle

Chapter 11

The Ecotourism (Overlapping) Working Circle

11.1 Introduction

Tourism is defined as the activities of persons travelling to and staying in places outside their usual place of residence for no more than one consecutive year for leisure, business, and other purposes. Forest areas are capable of being used for a specific kind of tourism, known as ecotourism.

The World Tourism Organisation (WTO) defines ecotourism as "tourism that involves travelling to relatively undisturbed natural areas with the specified object of studying, admiring and enjoying the scenery and its wild plants and animals, as well as any existing cultural aspects (both of the past or the present) found in these areas". The essence of ecotourism is environmentally

responsible tourism.

We aim to construct an Ecotourism (Overlapping) Working Circle in consonance with the ecotourism policies of the nation and the state.

11.2 Special objects of management

The specific objects of management of the Ecotourism (Overlapping) Working Circle are to raise conservation awareness amongst people through the provision of alternative, safe tourism destinations in forest areas.

It aims to ensure that there is a minimal impact on the environment and the ecology of the forests through this activity, while still maximising the economic development of these remote areas.

Concomitantly, it aims at securing additional economic benefits to the local population through numerous ancillary activities such as the sale of minor forest produce and non-timber forest produce to the tourists, acting as guides at tourist destinations, hospitality services, etc.

11.3 Discernment of compartments

This working circle is a non-exclusive working circle, so we can include the compartments that have already been included in the previous working circles.

The exact criteria to be used for the discernment of compartments to be

included in this working circle are at the discretion of the working plan officer. Nevertheless, to illustrate, we shall use the following criteria to identify the compartments that shall be included in the Ecotourism (Overlapping) Working Circle:

1. The compartment should be close to access points such as villages or roads so that people are able to reach the tourist destinations.

2. The compartment should have picturesque locations such as hilltops or waterfalls. Besides, it could have trails that are suitable to be used for trekking, or cliffs that could be used for rock climbing. Essentially, the characteristics required would depend on the target group of people such as school kids, mountaineers, trekkers, etc., towards which the ecotourism destination is to be specialised.

3. The compartment should not be extremely sensitive to anthropogenic influences that would ensue from its use as a tourism location. Areas that have extremely endangered species of plants, or animals that would abhor human presence, should not be included in this working circle.

To find out the compartments to be included, we execute the following query operation:

"Road" = 'True' AND "Picturesque locations" = 'True' AND "Extremely sensitive" = 'False'

The result, when put into a new layer, is depicted in figure 11.1. This

map represents the Ecotourism (Overlapping) Working Circle as per our set criteria.

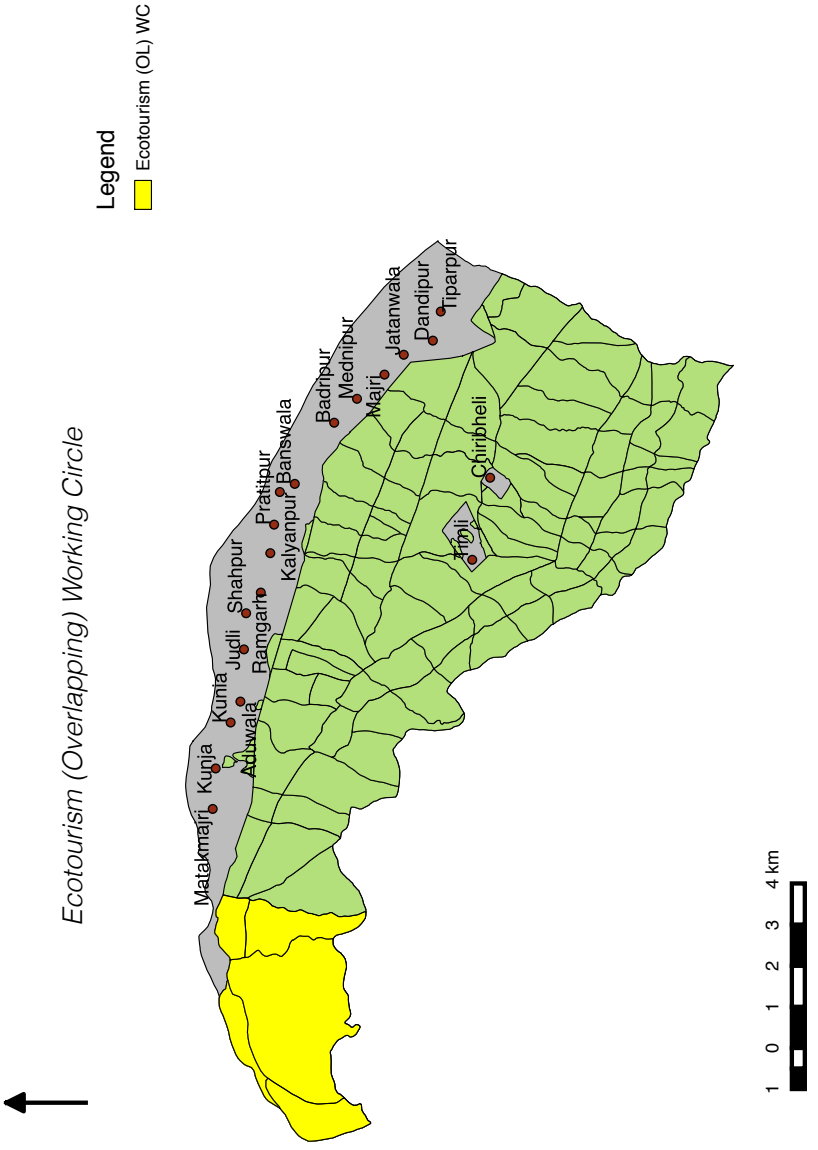


Figure 11.1: The Ecotourism (Overlapping) Working Circle

Chapter 12

The Participatory Management (Overlapping) Working Circle

12.1 Introduction

Participatory management of forests has been strongly advocated by the National Forest Policy 1988. It envisages management and protection of forests with the active participation and assistance of the local population.

Community participation in forestry is essential for two reasons. One, the local populations have some exclusive specialised knowledge about their local species. Thus, their contributions can augment our efforts at management of forests. And two, forests are an open treasure in the dearth of men, money and materials with the forest department for their autarchic protection. Thus, the aid of local populations in forest protection and man-

agement becomes obligatory for the effectiveness of the efforts of the forest department.

12.2 Special objects of management

This working circle aims to involve local people in the management of forests near their villages, especially for the improvement of degraded forests and their protection.

Concomitantly, it shall help in meeting the bona fide requirements of local populations with regards to fodder, fuel wood, medicinal plants and timber, while also improving their economic condition by provisions of employment and work.

12.3 Discernment of compartments

This working circle is a non-exclusive working circle, so we can include those compartments that have already been included in the previous working circles.

The exact criteria to be used for the discernment of compartments for the current working circle are at the discretion of the working plan officer. Nevertheless, to illustrate, we shall use the following criteria to identify the compartments that shall be included in the Participatory Management (Overlapping) Working Circle:

1. The compartments should be close to habitations, viz. villages, so that their residents could be induced to participate locally. In accordance with the Uttarakhand Joint Forest Management policy, we can include compartments touching the 1500 m buffer of villages in the Participatory Management (Overlapping) Working Circle.

To find these compartments, let us create a buffer of 1500 m around the villages. The result is depicted in figure 12.1.

To find the compartments that intersect this buffer region, we execute the following command:

Vector → Spatial Query → Spatial Query → Select source features from Total Compartment where the feature intersects Reference features of PM Buffer And use the result to Create new selection → Apply

The result, when put into a new layer, is depicted in figure 12.2. This depicts the compartments that could be included in the Participatory Management (Overlapping) Working Circle.

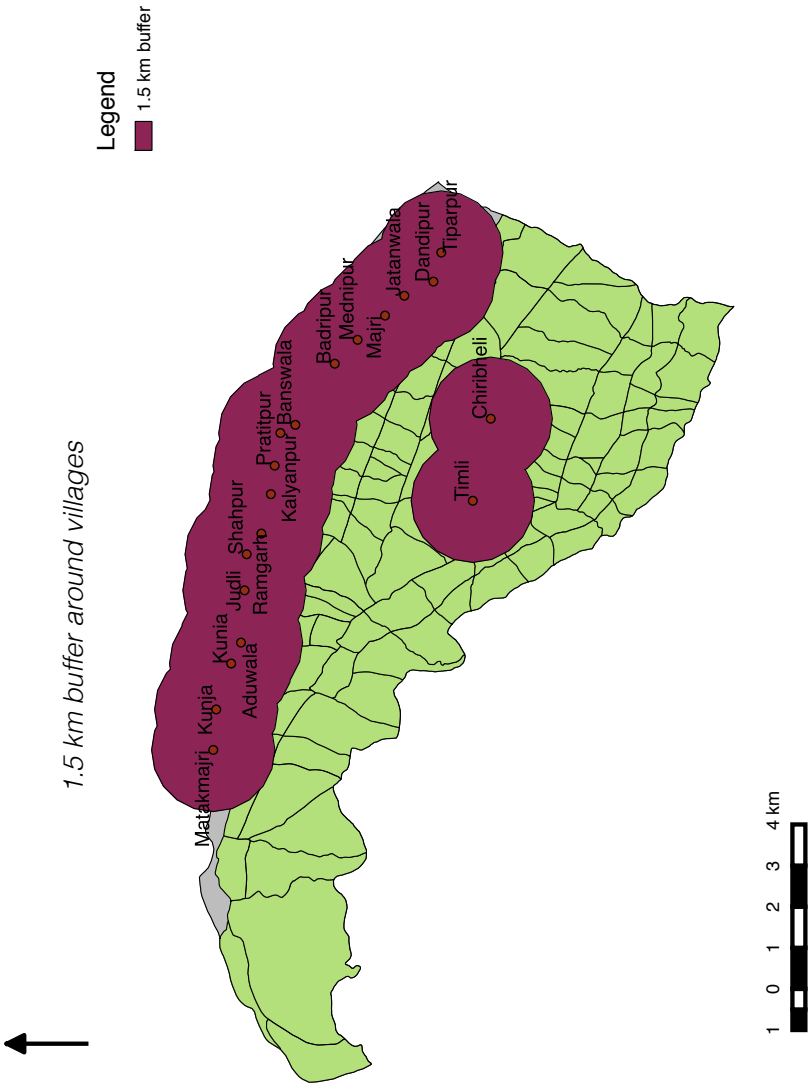


Figure 12.1: 1.5 km buffer around villages

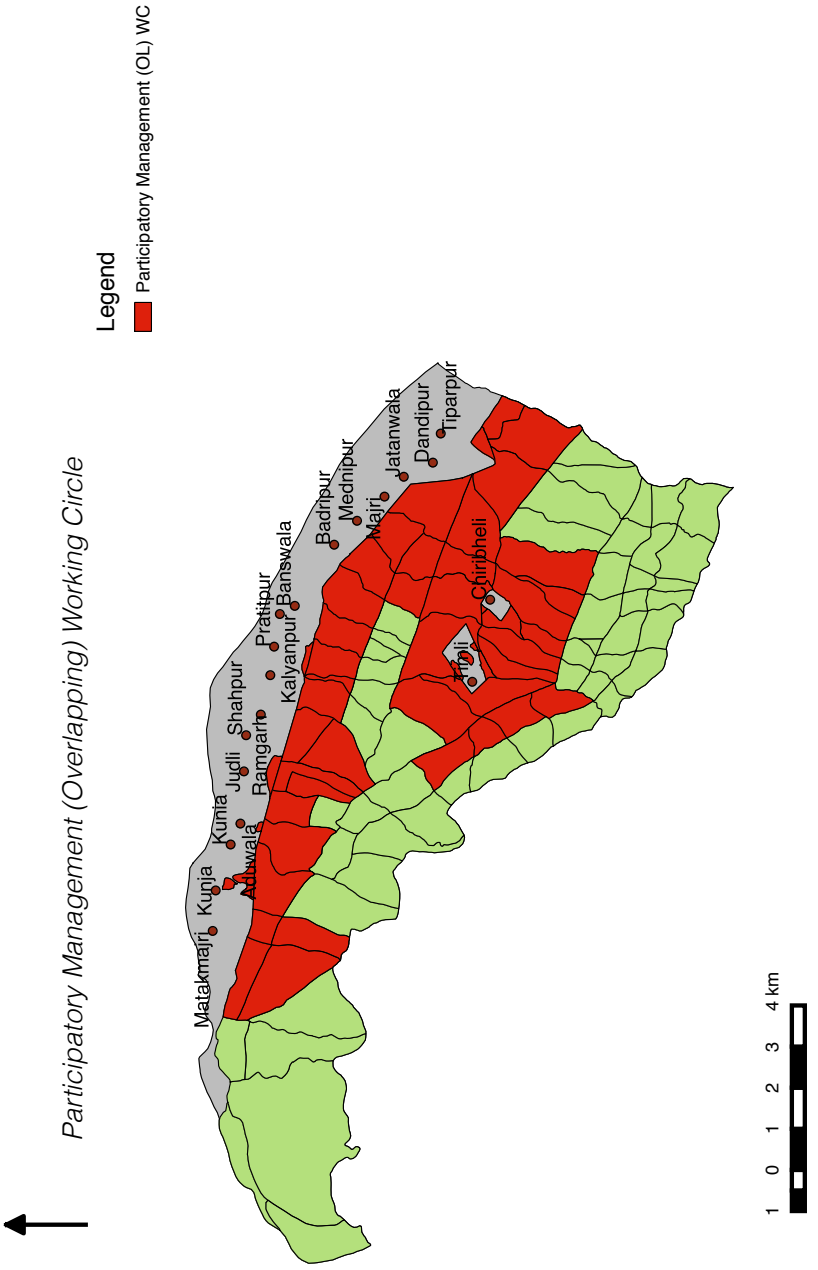


Figure 12.2: Map depicting compartments in Participatory Management (Overlapping) Working Circle

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