सत्यमेव जयते

STATUS, DENSITY AND CHANGE IN FOREST COVER OF TIGER RESERVES IN RESPECT OF 'SHIVALIK GANGETIC PLAIN LANDSCAPE'

Forest Survey of India
Ministry of Environment &
Forest and Climate Change
Government of India

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Forest Survey of India
(Ministry of Environment & Forests)
Government of India
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Maps are based on the Survey of India maps with the permission of the Surveyor General of India. The territorial waters of India extent into the sea to a distance of twelve nautical miles measured from the appropriate baseline.

प्रकाश जावडेकर
Prakash Javadekar

सत्यमेव जयते

राज्य मंत्री (स्वतंत्र प्रभार)
पर्यावरण, वन एवं जलवायु परिवर्तन
भारत सरकार

MINISTER OF STATE (INDEPENDENT CHARGE)
ENVIRONMENT, FORESTS AND CLIMATE CHANGE
GOVERNMENT OF INDIA

Message

Launched way back in the early seventies with 9 tiger reserves, Project Tiger now encompasses 47 reserves spread out in 18 tiger States within the country. This is little more than 2% of our geographical area, besides being almost 10% of country's recorded forests.

Project Tiger, besides putting the endangered tiger on an assured path of recovery, has also resulted in the revival of ecosystems across various diverse landscapes. The in-situ approach of Project Tiger has improved the forest status in tiger reserves.

This is an important report on the 'Status, density and change in forest cover of tiger reserves in respect of Shivalik-Gangetic Plain Landscape', brought by the National Tiger Conservation Authority in collaboration with the Forest Survey of India. The Shivalik-Gangetic Landscape is crucial for tiger conservation with several tiger rich reserves like Corbett, Dudhwa and Valmiki. The report indicates an improvement of forest cover in core areas of tiger reserves. The findings would be useful as a baseline for comparing the forest status of buffer areas notified by States at a later date.

I compliment the National Tiger Conservation Authority and Forest Survey of India for this important initiative.

(Prakash Javadekar)

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Dr. Anmol Kumar
Director General

सत्यमेव जयते

भारत सरकार
भारतीय वन सर्वेक्षण
पर्यावरण एवं वन मंत्रालय

Government of India
Forest Survey of India
Ministry of Environment & Forest

PREFACE

Recognizing the need to preserve the tiger against mounting pressure of anthropogenic activities, 47 Tiger Reserves have been constituted in selected regions of the country aimed at protecting the habitat of the tiger. Tiger Reserve is a protected area that is notified as such under section 38 V of the Wildlife (Protection) Act 1972 (vide Amendment of 2006).The State Government shall, on the recommendation of the Tiger Conservation Authority notify an area under Tiger Reserve. The area designated as "Tiger Reserve" includes Core and Buffer areas. Core is a critical tiger habitat area of National Park and sanctuaries, where it has been established, on the basis of scientific and objective criteria. These areas are required to be kept as inviolate for the purpose of tiger conservation without affecting the rights of the Scheduled Tribes or such other forest dwellers and notified as such by the State Government in consultation with an Expert Committee constituted for the purpose.

The 'Terai Arc Landscape' sprawling the northern belt of the country is filled with dense forests and undulating terrain that has been a favourite abode of the tiger since time immemorial. It was in the fitness of things that some major Tiger reserves of the country were established in this region. The Tiger Reserves are major centers of tourist attraction and an ideal ground to study the feeding and mating habits of the tiger. Preserving these Reserves are vital for protecting the rich biodiversity and the environment in this part of the country.

In the changed scenario of resurgent economic growth,it is necessary that economic development go hand in hand with the conservation of the environment and biodiversity of Indian forests. From this arose the present attempt to verify scientifically the change in the status of forest cover in the tiger's habitat in the Terai Arc Landscape over a period of two decades from 1990 to 2010. This has also been a period when the assessment of carbon stocks sequestered in the world's forests became an activity of crucial importance. As environmental concerns mount over growing anthropogenic activities, the role of forests as carbon sinks is recognized as never before. Tiger Reserves enjoying a high degree of legal protection are expected to contain precious pools of carbon reserves that augment the

resources available in other areas. Thus forest cover and carbon stocks emerged as the two parameters for a concerted study on the status of Tiger Reserves in the Terai land an landscape.

At the behest of the National Tiger Conservation Authority (NTCA), FSI took up the project of tiger reserves in the country in 2013 to assess the status, density and change in forest cover of three tiger reserves situated in the Shivalik Gangetic Plain – the Corbett Tiger Reserve, Dudhwa Tiger Reserve and Valmiki Tiger reserve. The mandate laid down the following objectives to be achieved in the study:

- To study the status & density changes of Forest Cover since last 20 years in the Tiger Reserve falling in Shivalik Gangetic Plain.
- To study the Forest Cover change beyond Tiger Reserve boundary (upto 10km) for last 20 years.
- To assess the status of the Forest Cover change in forest corridors for last 20 years.
- To quantify the carbon sequestered in Tiger Reserves.

It is a matter of gratification that despite enormous pressure on land as a result of expanding aspirations of our people, the forest cover in Tiger Reserves has been successfully protected and has been improved in terms of quality in core areas. This has been the result of vigorous protection measures taken by the Government. Floods and changes in the course of the rivers have often accounted for reduction in the forest cover both in terms of areal extent and density cover. The results provide us with satisfaction over the results of conservation efforts, but they do not permit lowering of guard at a time when wildlife all over the world faces threat from the expansion of economic activities. The study clearly shows that core areas have maintained tree cover in a very satisfactory manner in all the tiger reserves under study and it is perhaps the right time to undertake such studies for the remaining tiger reserves. It would not only reaffirm the critical importance of tiger reserves but would also document the changes of these critical landscapes.

(Dr. Anmol Kumar)
Director General

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Acronyms and Abbreviations

MoEF & CC	Ministry of Environment And Forest & Climate Change
AUTKBTR	Area upto 10km from the boundary of Tiger Reserve
FSI	Forest Survey of India
NTCA	National Tiger Conservation Authority
DIP	Digital Image Processing
FCC	False Color Composite
GCP	Ground Control Point
GIS	Geographical Information System
GPS	Global Positioning System
IRS	Indian Remote Sensing (Satellite)
ISRO	Indian Space Research Organization
LISS	Linear Imaging and Self-scanning Sensor
MSS	Multi Spectral Scanner
VDF	Very Dense Forest
MDF	Moderately Dense Forest
OF	Open Forest
NF	Non Forest
PA	Protected Area
PF	Protected Forest
RF	Reserved Forest
RFA	Recorded Forest Area
SOI	Survey of India
CTR	Corbett Tiger Reserve
DTR	Dudhwa Tiger Reserve
VTR	Valmiki Tiger Reserve

Glossary

Tiger Reserve:

Tiger Reserve is the protected area that is notified as such under section 38 V of the Wildlife (Protection) Act 1972 (vide Amendment of 2006).The State Govt shall, on the recommendation of the Tiger Conservation Authority notify an area under Tiger Reserve.

Core:

Core is a critical tiger habitat area of National Park and sanctuaries, where it has been established, on the basis of scientific and objective criteria. These areas are required to be kept as inviolate for the purpose of tiger conservation

Buffer:

Buffer area or peripheral area consisting of the area peripheral to critical tiger habitat or core area, identified and established in accordance with the provisions contained in above, where a lesser degree of habitat protection is required to ensure the integrity of the critical tiger habitat with adequate dispersal of tiger species

Tiger Corridor:

Tiger Corridors are the connection between different Protected Areas and Forest Divisions and are essential to ensure movement of tigers across the entire landscape.

Canopy (or Crown):

The cover of branches and foliage formed by the crown of trees.

Canopy Density:

Percentage of area covered by canopy of trees of land, also referred as “Crown Density”.

Cartographic Limitation/Resolution:

The minimum mappable size or dimension of features at a given map scale (about 25 ha at 1:25,000 scale and about 1 ha at 1:50,000 scale).

Digital Image Processing (DIP):

Rectification, interpretation and classification of land use or land cover from digital data (from remote sensing satellites) using computer aided technology.

Glossary

False Color Composite:

Product generated by combining the area contained in three different spectral bands into one image by assigning blue, green and red color to the data in three spectral bands, respectively.

Forest Cover:

All lands with tree a canopy density of more than 10 percent and area of more than 0.125 ha. irrespective of ownership & legal status. Such lands may not necessarily be recorded forest area. It also includes orchards, bamboo, road side and canal side plantations etc.

Forest area:

Geographic area recorded as forests in Government records it is also referred as "recorded forest area".

Forest Cover:

All lands, more than 0.125 ha. in area, with tree canopy density more than 10 percent.

Geographic area:

The total physical area within the boundaries on the map.

Land Cover:

Broad land use classes interpreted from satellite data. The land cover classes used in this report are moderately dense forest, open forest, scrub, water and Non-forest.

Very Dense Forest:

All lands with a forest cover with canopy density of 70 percent and above.

Moderately Dense Forest:

All lands with a forest cover with canopy density of 40% to 70%.

Open Forest:

All lands with a forest cover with canopy density of 10-40 percent.

Scrub:

All lands, generally in and around forest areas, having bushes and/or poor tree growth chiefly of small or stunted trees with canopy density less than 10 percent.

Glossary

Non Forest:

Land without any forest cover.

Protected Forest:

An area notified under the provisions of the Indian Forest Act or other State Forest Acts, having limited degree of protection is Protected Forest. In Protected forest all activities are permitted unless prohibited.

Raster:

A regular grid of cells covering an area.

Vector:

The representation of spatial data by points, lines and polygons.

Recorded Forest Area:

Same as "forest area", i.e., geographical areas recorded as forests in Government records.

Reserved Forests:

An area constituted under the provision of the Indian Forest Act or other State Forest Acts, having full degree of protection is Reserved Forest area. In Reserved forests all activities are prohibited unless permitted.

Spatial Resolution:

The area on earth's surface that can be "seen" by a sensor at a glance, called spatial resolution. It is represented by pixel (smallest picture element).

Spectral Resolution:

The range of wavelengths that a satellite imaging system can detect, it refers to the width and number of spectral bands. The narrower the band, the greater is spectral resolution.

Thematic Maps:

Maps showing forest types, major species composition, crown density and other land uses prepared by interpretation of satellite images and verified by ground truthing.

INTRODUCTION

INTRODUCTION & METHODOLOGY

BACKGROUND

After the enactment of Wildlife (Protection) Act 1972 and based on the recommendation of the task force committee, constituted in 1972 by the Ministry of Agriculture, Govt. of India, the "Project Tiger" was launched in India on April 1,1973 with the following objectives:

- To ensure the maintenance of a viable population of tigers in India for scientific, economic, asthetic, cultural and ecological values.
- To preserve for all times, the areas of such biological importance as a national heritage for the benefit, education and enjoyment of the people.

From the conservation and management point of view, information on status of forest cover in Tiger Reserve and its periodic monitoring is essential. The nature, extent and spatial distribution of the changes in the forest cover would greatly help in planning appropriate management interventions for the future. Space-borne Remote Sensing technology has proved to be very useful tool in monitoring periodic changes in the forest cover of an area.

Tiger Reserve is the protected area that is notified as such under section 38 V of the Wildlife (Protection) Act 1972 (vide Amendment of 2006).The State Govt shall, on the recommendation of the Tiger Conservation Authority notify an area under Tiger Reserve. The expression "Tiger Reserve" includes-**Core and Buffer.**

- **CORE OF TIGER RESERVE:**
  Core is a critical tiger habitat area of National Park and sanctuaries, where it has been established, on the basis of scientific and objective criteria. These areas are required to be kept as inviolate for the purpose of tiger conservation without affecting the rights of the Scheduled Tribes or such other forest dwellers and notified as such by the State Government in consultation with an Expert Committee constituted for the purpose;

- **BUFFER OF TIGER RESERVE:**
  Buffer area or peripheral area consisting of the area peripheral to critical tiger habitat or core area, identified and established in accordance with the provisions contained in above, where a lesser degree of habitat protection is required to ensure the integrity of the critical tiger habitat with adequate dispersal of tiger species, and which aim at promoting co-existence between wildlife and human activity with due recognition of the livelihood, developmental, social and cultural rights of the local people, wherein the limits of such areas are determined on the basis of scientific and objective criteria in consultation with the concerned Gram Sabha and Expert Committee constituted for the purpose.

1.1 OBJECTIVES

1. To study the status & density changes of Forest Cover since last 20 years in the Tiger Reserve falling in Shivalik Gangetic Plain.
2. To study the Forest Cover change beyond Tiger Reserve boundary (upto 10km) for last 20 years.
3. To assess the status of the Forest Cover change in forest corridors for last 20 years.
4. To quantify the carbon sequestered in Tiger Reserves.

1.2 STUDY AREA AND PERIOD OF ASSESSMENT

At the behest of National Tiger Conservation Authority (NTCA), Forest Survey of India has taken up a project on Tiger Reserves in 2013 to assess the Status, Density and Change in Forest Cover of Tiger Reserves named Corbett Tiger Reserve, Dudhwa Tiger Reserve, Valmiki Tiger Reserve falling in 'Shivalik Gangetic Plain Landscape'.

The present study shall be carried out as a decadal assessment in three phases;

- Phase I: 1990 – 2000
- Phase II: 2000 – 2010
- Phase III: 1990 – 2010

1.3 DATASET USED

Satellite Data Used:

The satellite data used for the study of the Dudhwa Tiger Reserve, Corbett Tiger Reserve and Valimiki Tiger Reserve was procured from National Remote Sensing Agency (NRSA). The details are given below:

ASSESSMENT YEAR	DATASET USED
1990	Landsat-5 TM
2000	IRS – 1C/1D LISS III
2010	IRS – P6 LISS III

Table 1.3a: FEATURES OF LANDSAT TM SENSOR DATA

TYPE	RANGE
Spatial Resolution	30m
Spectral Resolution • **Blue** • **Green** • **Red** • **Near Infrared**	 0.45-0.52 µm 0.52-0.59 µm 0.62-0.68 µm 0.77-0.86 µm
Radiometric Resolution	8 bits
Temporal Resolution(Receptivity)	18 days
Swath (Width of the strip)	185 km

Table 1.3b: FEATURES OF IRS LISS III SENSOR DATA

TYPE	RANGE
Spatial Resolution	23.5m
Spectral Resolution • **Green** • **Red** • **Near Infrared** • **Short wave infrared**	 0.52-0.59 µm 0.62-0.68 µm 0.77-0.86 µm 1.5-1.7 µm
Radiometric Resolution	7 bits
Temporal Resolution(Receptivity)	24 days
Swath (Width of the strip)	141 km
Area coverage of one scene	20,000 sq km (approx)

1.4 Software's Used:

ERDAS Imagine

ERDAS Imagine is a remote sensing application with raster graphics editor abilities designed by ERDAS for geospatial applications. ERDAS imagine is aimed primarily at geospatial raster data processing and allows the user to prepare, display and enhance digital images for mapping use in geographic information system(GIS). Erdas Imagine 2011/2013 Version have been used for this project.

Image rectification, classification, mosaicing ,map composition has been processed in in Erdas Imagine.

ArcGIS

Esri's ArcGIS is a geographic information system for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information.Arc GIS 10.1 Version has been used for GIS based analysis.

Boundary demarcation in international border ,Buffer generation of notified boundary of reserve have been executed in ArcGIS.

1.5 METHODOLOGY FOR ASSESSMENT OF FOREST COVER:

The methodology of forest cover mapping involves a series of steps of processing satellite data in digital image processing software (Erdas Imagine). The flow chart showing methodology is given in Fig No 1.5.

1.5.1 Geometric Correction/Rectification:

Geometric correction has been carried out to relate the image features to the corresponding ground objects. Satellite imageries were registered geometrically using appropriate numbers of GCPs (Ground Control Points) from geo-referenced toposheets (1:50,000 scale) of Survey of India. Mosaicing was followed by edge matching with the neighboring images.

1.5.2 Unsupervised Classification/NDVI:

The reflectance from the forests is dependent on the crown foliage and its chlorophyll content. Due to seasonal variability of the tree penology over the year, season of satellite data acquisition is of utmost importance for forest cover assessment. Deciduous forest allows more reflectance from the ground surface during leaf less period thus making its own detection and classification difficult. Hence data of the spring-summer season is not suitable for interpretation of such forest types. During rainy season, the situation is compounded due

to non availability of cloud-free data and mixing of agricultural and other green covers with forest cover due to similarity in there spectral reflectance. Taking these limitations into consideration satellite data of the period October to December is considered to be the most suitable for forest cover mapping of the entire country.

Hybrid classification approach was used for forest cover mapping after masking out forest area and non forest area sequentially using. Initial classification was carried out using ISODATA algorithm was followed to visually interpret forest cover in satellite data. Normalized Difference Vegetation Index (NDVI) transformation was used to remove non-vegetated areas from scene. Subsequently on screen editing based on ground truthing was carried to refine the classification.

The forest cover assessed in classified into the following classes:

Very Dense Forest	All lands with tree cover having canopy density of 70% and above
Moderate dense Forest	All lands with tree cover having canopy density between 40% - 70%
Open Forest	All lands with tree cover having canopy density between 10% - 40%
Scrub	Degraded forest having tree canopy density less than 10% has been classified as scrub
Non forest	Any area not included in the above classes.

1.5.3 Ground Verification:

Reference data collected was collected through ground truthing to assess the accuracy of the classification and to further refine it on the basis of ground based observations. During ground truthing ancillary information (species composition) from State Forest Department was also collected. All the necessary corrections were subsequently incorporated in forest cover maps on the basis of information collected during ground truth verification and online high resolution imageries.

Further, an analysis of the ground truthing work was carried to ascertain the accuracy of the classification. In time of ground verification of Dudhwa Tiger Reserve 30 ground control points, in Corbett Tiger Reserve 20 points and in Valmiki Tiger Reserve 54 points have been verified on the field to assess the accuracy of classification and to clarify doubtful change point interpretation in case of few satellite scenes.

1.5.4 Mosaicing and Post ground truthing correction and Refinement

Mosaicing of forest cover maps was carried out in order to obtain Forest Cover Maps. After the mosaicing of forest cover maps the post classification refinements were carried out. Clump function was used to identify the contiguous groups of pixels in one thematic class and ELIMINATE function used to remove the small clumps by replacing the values of pixels in these clumps with the value of nearby larger clumps. In this project, Clump has been processed for 8 neighboring pixels and 1 hectare has been specified as minimum threshold for elimination.

1.5.5 Preparation of Forest Cover Maps in Raster format:

The forest cover maps have been produced of Dudhwa,Corbett and Valmiki Tiger Reserve in raster format.

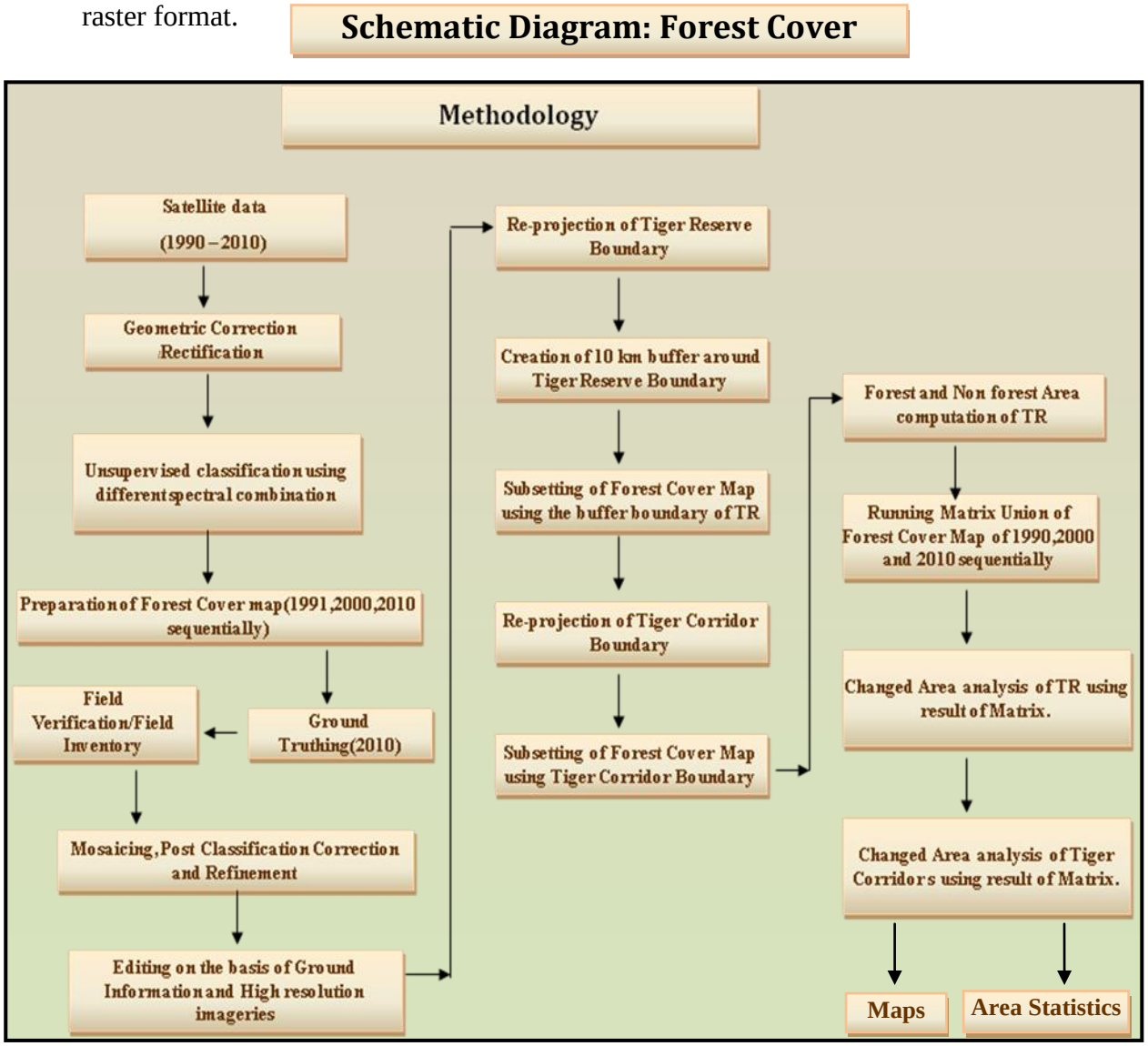


Fig 1.5.: Schematic diagram showing methodology of Forest cover mapping.

1.6 GENERAL LIMITATIONS OF SATELLITE DATA USED IN FOREST COVER MAPPING OF TIGER RESERVE

The following problems generally encountered during the interpretation of satellite imageries.

- ✓ Since the resolution of the LISS III sensor data is 23.5 m, the land cover having dimension less than the above are not captured.
- ✓ Younger plantations are difficult to identify.
- ✓ Poor reflectance of certain species of trees in core area of Tiger reserve causes problem in defining correct density classes of forest.
- ✓ Considerable ground details may sometimes be obscured due to cloud and shadows. Such areas are difficult to classify without the help of collateral data or ground truthing.

However the limitation discussed above have been minimized or have played an insignificant role in present study.

CORBETT TIGER RESERVE

2.1 Introduction

The Tiger Reserve lies between the latitudes **29^{o} 25' N to 29^{o} 40'N** & longitudes **78^{o} 5' E** to **79^{o} 5' E**. The Corbett Tiger reserve spreads through 3 districts of Uttarakhand namely Pauri, Nainital, Almora and a small part falls in Amangarh,Bijnore district of eastern Uttar Pradesh. It comprises of the Corbett National Park (christened after Edward James 'Jim' Corbett, the famous conservationist), Sonanadi Wildlife Sanctuary, parts of Kalagarh Forest Division and Ramnagar Forest Division.The Ramganga Reservoir on its western boundary, constructed in 1974, inundated 46 km^2 of the riverine habitat of the reserve while 92 villages are located within 2-3 kilometres of the Tiger Reserve. The headquarters of the Tiger Reserve is situated at Ramnagar, district Nainital,Uttarakhand. This tiger reserve has long been referred to as the 'land of roar trumpet and song'. These attributes refer to the roar of tigers, the trumpet of elephant and the melodious song of birds.

The corbett tiger reserve was among the first 9 tiger reserves of India to be included in Project Tiger by the National Tiger Conservation Authority (NTCA). The Corbett and Rajaji National Park between them hold India's northwesternmost population of tigers, and one of the world's most significant populations of Asian Elephants. In this exquisite tiger land, birdwatchers can seek out nearly 700 species of birds out of the nearly 1300 reported from India. Corbett can be categorized as one of the India's most crucial gharial breeding sites. It also happens to be one of the last surviving stretches of untouched sub-Himalayan wilderness.

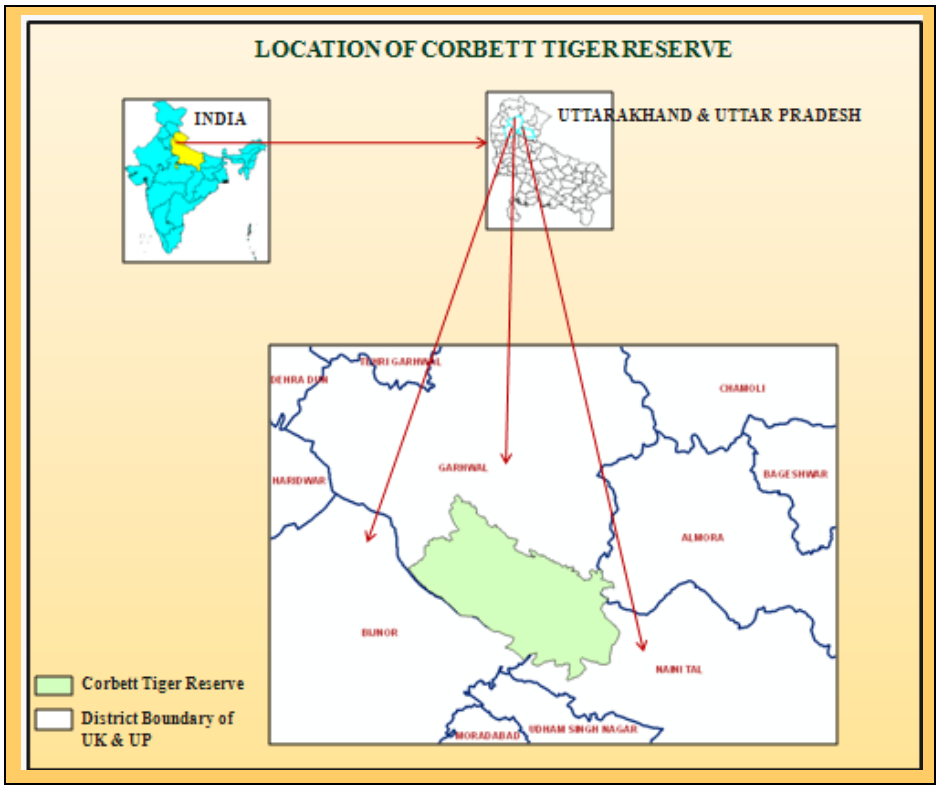
Earlier, the Corbett National Park, the Sonanadi Wildlife Sanctuary and the surrounding Reserve Forests were collectively referred as Corbett Tiger Reserve. Subsequently under the provisions of Wildlife Protection act 1972 (as amended in 2006), the Government of Uttarakhand, following the recommendation of the National Tiger Conservation Authority, notified the area as Corbett Tiger Reserve, on 26th February 2010. Corbett National Park and Sonanadi Wildlife Sanctuary are the core-critical tiger habitat and the rest is the buffer area.The total area of Corbett Tiger Reserve is 1368.91 sq.km, which is divided as follows:

Core-critical Tiger Habitat - 821.99 sq.km

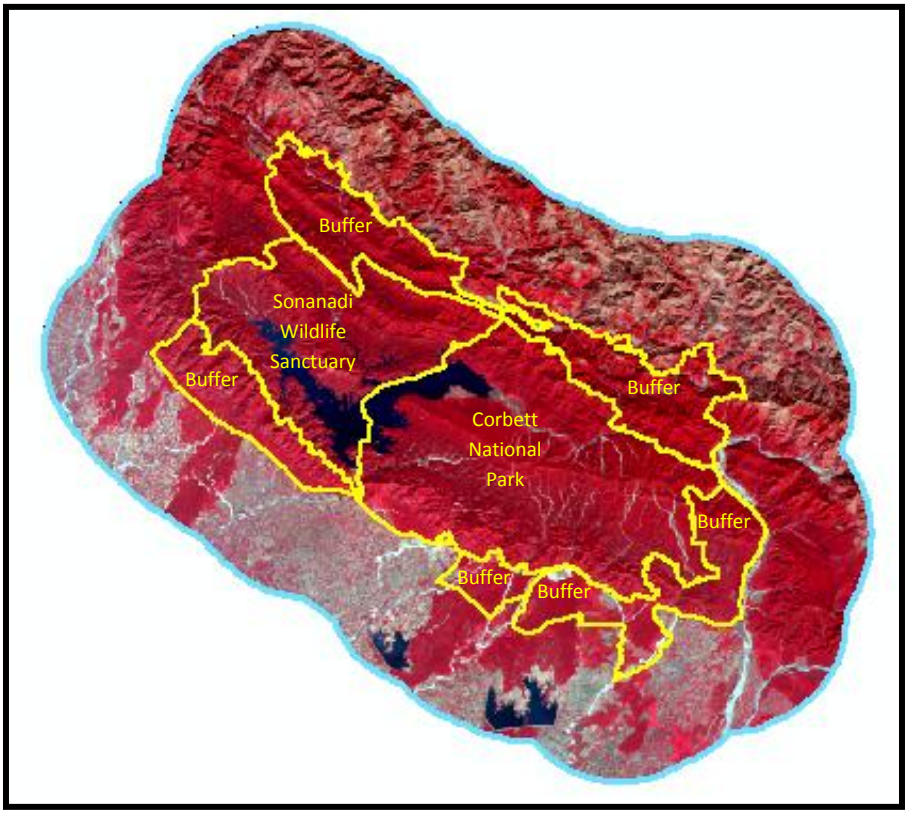
Buffer zone (falling in Uttarakhand) - 466.32 sq.km

Buffer zone (falling in Uttar Pradesh) - 80.60 sq.km

CORBETT TIGER RESERVE



CORBETT TIGER RESERVE BOUNDARY OVERLAID ON IRS 1C/1D LISS III DATA



Area Statement of the Core critical Area

S.No.	Name of the Division	Name of the Range	Area Statement		Total Area in ha
			Corbett National Park	Sonanadi	
1	Ramanagr Tiger Reserve Division, Ramnagar	Dhikala	7564.40	0.00	7564.40
		Sarpduli	9400.50	0.00	9400.50
		Bijrani	6602.63	0.00	6602.63
		Dhela	3550.30	0.00	3550.30
		Jhirna	6084.50	0.00	6084.50
		Kalagarh	15182.07	1836.90	17018.97
Total			**48384.40**	1836.90	**50221.3**
2	Kalagarh Tiger Reserve Division, Lansdowne	Sonanadi	0.00	13228.10	13228.10
		Palain	0.00	5228.90	5228.90
		Mandal	0.00	0.00	0.00
		Adnala	0.00	7236.60	7236.60
		Maidavan	3698.00	2587.10	6285.1
Total			**3698.00**	**28280.70**	**31978.7**
Grand Total			**52082.40**	**30117.60**	**82220.0 Ha.** **Or 822 Sq. km**

Significance of conservation

Knowledge of the distribution and habitat requirements of a species are essential to formulate conservation strategies. While some species are considered habitat generalists, they are still vulnerable to habitat loss and fragmentation. India holds more than half of the current estimated wild tiger population of the world (Seidensticker 2010; Walston et al. 2010;

Wikramanayake et al. 2011). Wild tigers experience unparalleled coercion due to habitat destruction, prey reduction and commercial poaching. These factors along with prey depletion and poaching are responsible for the decline of the tiger (*Panthera tigris*) across its geographic distribution (Sunquist *et al.* 1999). It has been estimated that the tiger exists in only seven percent of its historical range (Dinerstein *et al.* 2007). The tiger needs a high biomass of large-sized prey (Karanth and Sunquist 1995), therefore it is even more necessary to maintain a viable population of large size herbivore species in the tiger habitats.

Tiger is not only a flag bearer of conservation but also an umbrella species for majority of eco-regions in the Indian sub-continent. Its role as a top predator is vital in regulating and perpetuating ecological processes and systems (Terborgh J. 1991, Sunquist at el. 1999). The tiger needs large undisturbed landscapes with ample prey to raise young and to maintain long term genetic and demographic viability (Seidensticker and McDogul 1993, Karanth and Sunquist 1995, Carbone at el 1999). According to the **Status of Tigers, Co-predators and Prey in India – 2010** report of Wildlife Institute of India the tiger presence is reported in an area of 2,287 km^2 with an estimate of 214 (190-239) individuals. The tiger reserve sustains the highest tiger density in the world (9.4 tigers/100 km2 at the landscape scale) and serves as a source for the entire landscape extending from Kalesar in Haryana to Pilibhit Forest Division in Uttar Pradesh.

1. Geology, Rock & Soil

The general sequence of geological formations of the area may typically be represented in ascending order as follows:-

(i) Recent Deposits

(a) Horizontal River gravel alluvium.

(b) Deposits of Bhabar Zone.

(ii) Shivalik Series

(a) Upper Shivalik Conglomerates.

(b) Middle Shivalik Sand Rock.

(c) Lower Shivalik (Nahan) Sandstone.

(d) Great Boundary Fault.

(iii) Older Himalayan Rock

(a) Upper Tal

(b) Lower Tal

(c) Basic effusive

(d) Karol

(e) Infra Karol

(f) Naghthat

(g) Chandpur

(h) Metamorphic

The Geological distribution has a significant influence on the distribution of various forests types because of related differences in drainage, soil depth, fertility and topography.

2. Terrain

The terrain of the area is generally undulating, comprising of a series of ridges running NW to SE interspersed with several valleys. The Ramganga, Palain and Sonanadi river flow through these valleys.

3. Hydrology & water sources:

Corbett Tiger Reserve is spread in the Bhabar and lower Shiwalik region and has typical hydrology of these areas. The land is very porous and is composed of boulder and sand deposits. The water received through rainfall easily seeps-off and then resurfaces in the Terai area which lies down below the CTR boundary. The water table is very low. Still the area has some perennial water sources like River Ramganga, Palain, Mandal and Sonanadi besides a number of seasonal streams. Ramganga river is the lifeline of CTR and the major perennial source of water. Kosi river is another perennial water source for the wildlife of CTR though it runs outside and along the eastern boundary of the TR.

The core of the Tiger Reserve also has a good network of *kachha* and *pacca* man-made waterholes. Many temporary dug-out ponds are also spread across the beds of *sots* There are some natural ponds also such as Nakatal, Malanital and Phooltal.. The Kalagarh dam constructed has created a vast reservoir spread over an area of about 80 sq. km. of which 42 sq km. falls in Corbett National Park and the rest in Sonanadi sanctuary. Artificial borings have also been done which are used for drinking water facility as well as for supplying water for the waterholes.

The Palain, Mandal, Ramganga rivers which travel through parts of the tiger reserve in the Buffer, contains water all year round alongwith numerous seasonal water course that carry water in the rainy season only. Water scarcity is seen in many parts of the buffer forest especially in the southern area. To augment water supply in these areas water-holes both temporary and permanent have been created. During summer months water is fed using water tankers or collecting water of a small stream.

4. Flora

4.1. Grasslands

Flat grassy plains are found in the reserve as a result of man-made clearings in the past for cultivation and settlements that have been subsequently abandoned. These are sometimes quite

extensive and are locally termed as '*chaur*'. The important grasslands are Dhikala *chaur* (Boxar chaur which was a continuation of Dhikala chaur is now submerged in the reservoir), *Phulai chaur, terpani chaur, Mohanpani chaur, Bhadhai chaur, Bijrani chaur.* Apart from these extensive grasslands, many other smaller ones are also found in the tiger reserve. These grasslands are characterised by rich dense growth of various medium size to tall grasses, both palatable as well as unpalatable in varying density. These are the most favoured grazing grounds of the ungulates and elephants that congregate here in large herds for grazing. Grassland vegetation occupies nearly 20% of the Corbett National Park. The flat anthropogenic grasslands are dominated by *Vetiveria zizanioides, Saccharum benghalense, and Dichanthium annulatum*. Most important being Dhikala chaur which supports high ungulate population. The grassy slopes are dominated by *Chrysopogon fulvus, Neyraudia arundinacea*, and *Heteropogon contortus*. Very steep slopes and ridge tops have *Eulaliopsis binata*, Locally known as *"Bhabar*" grass.

4.2. Plantations

The most common tree species planted during 1960 and 1970s is *Eucalyptus hybridus*. This is followed by teak (*Tectona grandis), Haplophragma adenophylla, Acacia catechu, Ailanthus excelsa*, and *Dalbergia sisso*. Bamboo (*Dendrocalamus strictus),* most important food for elephants which was very common in the past is now scarce causing a problem of man & animal conflict in the nearby buffer area. Most of the old plantations are in the buffer areas.

4.3. Vegetation

The vegetation in CTR is of forests, grasslands and riparian types. Floral diversity of CTR is very rich as the major portion of the reserve is confined to Bhabar tract of Shiwalik formation. There are 617 species of the flora under 410 genera 111 families of Angiosperms (Monocot-132, Dicots-462), 1 Gymnosperm and 22 Fern and fern allies. There are more than 110 tree species in the forest. Notably 73% is constituted by Sal (*Shorea robusta)* forests. A frequent associate of Sal is Haldu (*Adina cordifolia).*

The predominant species in the higher ridges is Bakli (*Anogiesus latifolia)* and the other associates are Khetwa (*Piliostigma malabaricum),* Gurial (*Bauhinia rausinosa),* Dhauri (*Lagerstromia parviflora),* Amaltas (*Cassia fistula),* Bhilawa (*Semecarpus anacardium),* Amla (*Phyllanthus emblica),* Papri, Kumbhi, Mahua (*Madhuca indica),* Rohini (*Mallotus phillipensis)* and Jamun (*Eugenia jumbolana).* Chir (*Pinus roxburgii)* the only conifer is confined to some of the highest ridges around Sultan. The river valley, high banks and islands are dominated by *Delbergia sissoo.*

Among the shrubs (51spp), *Clerodendron* spp, *Helicteres isora* are predominant, while climbers like *Milettia auriculata, Porana paniculata, Vallaris solanacea, Phamera vahlii* are commonly found. *Lantana camara* is profusely invading in the reserve, inhibiting the growth of other species. *Cannabis sativa* is also found extensively in the grasslands.

4.4. Forest Types

- **3C/C2 a- Moist Shiwalik Sal forests**

Most of the Sal forests in the Sonanadi W.L.S, Malani block, Dhikala block and Kalagarh block belong to this type which occupies the whole of Malani, Jamunagwar, Dhikala, Sarpdulli, Gaujera , Bailanala, Adnala, Tumeria, Sheeshamkhatta, Chiplighatti, Lal Darwaza, Hathikund, Motasal and Mandalti. It occurs on the lower Shiwalik (Sand Stone) with light soil. At places the terrain is simply undulating and not too rugged.

The top canopy consists of Sal (*Shorea robusta*), Sain (*Terminalia alata*), occasionally Jhingan (*Lannea coromandelica*), Bahera (*Terminalia bellerica*), Jamun (*Syzygium cumini*), etc. and rarely Chir (*Pinus roxburghii*), on northern slopes and higher ridges tops. The middle storey contains Sandhan (*Ougeinia oojeinensis*), Rohini (*Mallotus philippensis*), Bhilawa (*Semecarpus anacardium*), Karhbhillawa (*Buchanania lanzan*), Kura (*Hollarhena antidysenterica*), Chilla (*Casearia tomentosa*), Amaltas (*Cassia fistula*), Aonla (*Emblica officinalis*), Bauhinia spp. etc. and in moister valleys Gair (*Olea glandulifera*), Kaula (*Machilus odoratissima*), Garhmahua (*Engelhardtia colebrookiana*) etc.

Bamboo occurs in patches and is dense at places. The undergrowth is moderate and consists chiefly of Bindu (*Colebrookia oppositifolia*), Gandhela (*Murraya koenigii*), Karu (*Clerodendrum viscosum*), Raudera (*Pogostemon plectranthoides*), Dhaula (*Woodfordia fruticosa*), Daia (*Callicarpa macrophylla*), etc. and occasionally Kilmora (*Berberis spp*.), Tushiari (*Debregesia velutina),* Tilphara (*Cocculus laurifolius*), Sakina (*Indigofera spp*.) etc. The common climbers are Maljhan (*Bauhinia vahlii*), Gauj (*Milletia auriculata*). Grasses are scarce. The common being Ullansu (*Thysanolaena maxima*) in shady places and Guria (*Chrysopogon montanus*), Kumeria (*Heteropogon contortus*) etc. on exposed parts.

- **3C/C2c Moist Tarai Sal Forest**

This subtype occurs on grey clayey alluvium with wet subsoil and perhaps best characterized with the presence of *Calamus*. The sal is of Q.C. III-IV and there is fair coppice regeneration. The top canopy consists of *Shorea robusta*, *Adina cordifolia*, *Trewia nudiflora*, *Syzygium cumini*. The understory is mainly of *Lagerstremia parviflora, Litsea glutinosa, Elaeagnus latifolia*. *Bambusa arundinacea* and *Calamus tenuis* is found in plenty.

- **3C/C3 a West Gangetic Moist Mixed Deciduous Forest**

This type of forest occurs sporadically throughout the Moist Siwalik Sal forests and is confined to favorable localities where Sal is unable to establish itself and is characterized by good growth of Sain ,Bahera, Tun *(Toona ciliata),* Kharpat , Safed siris *(Albizzia procera),* in the top canopy, with an under storey of Rohini, Sandan, Aonla etc. with scattered bamboo clumps. Maljhan climber is occasionally present.

- **5B/C1a-Dry Shiwalik Sal Forest**

The remaining Sal forest, lying in the southern part of the TR, belongs to this type, which occupies the following areas: This type occurs on the Middle Siwalik Sand-rock formation, which gives rise to shallow, dry and completely drained sandy soils. Humus is scanty. The ground is very broken up, generally steep, stony and rugged. Knife- edge ridges are numerous and the terrain is cut up by many *nalas*. Denudation is active and there are signs of erosion at many places. The distribution of Sal in this type is governed chiefly by aspect and gradient. On the northern, western and irregular groups and patches of varying extent and density, grading off into badly formed single Sal trees on the steep slopes. The top canopy consists of Sal, Bankuli, Khair, Sain, Tendu, Bhilawa, Kathbhilwa, Jhingan, Pula, Kusum,Chir etc, with an under story of Sandan, Amaltas, Aonla, Bel, Ber, Kathber, Kura, Khoda, Grewia species; Bauhinia species etc. Bamboo is common. The undergrowth is scanty, mainly of Bindu, Harsingar, Dhaula etc. but grasses like Guria, Baib, Kumeria, Nathlia, Bichhroo, Siru etc, are plentiful. The southern slopes carry an open but similar crop of a more xerophytic nature, with a very low proportion of Sal which usually occurs in patches or as single trees in sheltered and favorable localities. Bamboo is dense at places and grasses like Guria, Baib, and Kueria are dense and distributed throughout the area. In this type, Sal is of poor quality. Sal regeneration is generally deficient and very slow growing and is difficult to obtain, except in hollows and moist places, where it is good.

- **5B/C1 b Dry Plains Sal Forest**

This subtype is commonly found on flat grounds in the area occupied by moist bhabhar sal (3C/C2b) and moist plains sal (3C/C2d). It occurs at the bhabhar, slightly above the bhabhar-tarai transition and spring levels are usually low. The rainfall is at the lower limit for moist type and maximum temperatures higher. The top soil may be rather clayey, the subsoil also clayey often with dense clay layers almost forming a pan, underlain by gravel or coarse sand. There is superficial water logging in the rains, the surface drainage also being sluggish. Recurring waves of mortality are characteristic of this forest type, reducing the forest to a mixed dry deciduous type.

The top storey is made up with species like *Shorea robusta*, *Terminalia tomentosa*, *T.bellerica*, *Diospyros tomentosa*, *Anogeissus latifolia* having an under storey of *Miliusa velutia*, *Buchanania lanzan*, *Semecarpus anacardium*, *Acacia catechu*, *Zizyphus xylopyrus*, *Z.mauritiana*, *Mallotus philippensis*, *Aegle marmelos*. The undergrowth is mainly constituted by *Clerodendrum viscosum* and *Glycosmis pentaphylla*. Grasses are in plenty mainly *Imperata cylindrica* and *Eulaliopsis binata*.

- **5B/C2 Northern Dry mixed Deciduous Forest**

In most localities the forest type is under heavy anthropogenic pressure, therefore scattered trees and small groups are now typical. In the climax state, however, it would appear that this upper canopy would be thin but fairly complete, most trees having low spreading crowns. Transitions to the still dryer types would be characterized by a broken top canopy. Many tracts are occupied almost exclusively by large shrubs and small trees such as *Nyctanthes arbor-tristis*. It is found mostly on sites with southern aspect, flat hill tops, eroded ground and high intensively drained gravel terraces. Species composition found in this forest type is chiefly of *Anogeissus latifolia, Acacia catechu, Shorea robusta, Bauhinia spp., Terminalia tomentosa, Garuga pinnata, Kydia calycina, Mitragyna parviflora, Bridelia retusa, Nyctanthes arbor-tristis, Ougeinia oojeinensis, Ehretia laevis, Aegle marmelos, Emblica officinalis, Hollarrhena antidysentrica, Cordia dichotoma, Zizyphus xylopyrus, Cassia fistula, Butea monosperma, Flacourtia indica, Woodfordia fruticosa, Eulaliopsis binata* etc.

- **5/DS1 Dry Deciduous Scrub**

A low broken soil cover of shrubby growth 3 to 6m high including some tree species reduced to similar conditions usually many stemmed from the base. Some bamboo is often present. Many of the shrubs are distasteful to cattle (Holarrhena, Dodonea) or thorny (*Randia, Carissa*). Thin grass occurs throughout. It is found throughout the dry deciduous area where biotic interference is more. Species composition is mainly of *Nyctanthes arbor-tristis, Zizyphus nummularia, Dodonea viscose, Woodfordia fruticosa, Flacourtia indica, Aegle marmelos, Cassia fistula, Acacia catechu* etc.

- **5/1S2 Khair Sissoo Forest**

It is a deciduous forest type in which *Dalbergia sissoo* predominates. The canopy is light but usually complete. Acacia catechu is usually but not always present and is very inconspicuous but sometimes it occurs in pure patches. This forest type has one peculiar feature that resembles to the moist deciduous more, that they are in new foliage in March and remain in full leaf throughout the hot weather. However, this feature is specific of the dominant *Dalbergia* and is not shared by most of its associates. It is distributed on river banks and on new sandy and gravelly alluvium soil. The top soil is very porous and surface runoff is seen. Humus is almost nil. The forest type is characterized by the composition of species such as *Dalbergia sissoo, Acacia catechu, Holoptelea integrifolia, Grewia oppositifolia, Cassia tora,* Canabis sativa, *Murraya koenigii, Adhatoda vasica, Helicteres isora, Saccharum spontaneum, Chrysopogon fulvus, Vetiveria zizanoides, Pogostemon plectranthoides* etc.

- **9/C1 b Upper or Himalayan Chir Pine Forest**

This type is represented by high forests of Chir pine where the trees (20-35m height) form a canopy from one third to two third complete and in some case lighter than this. No other species reach the top canopy and only few scattered trees form the second storey. Annual fires are common in these areas which prevent the under growth to flourish. The ground has a rich grass cover during the monsoon season which dries up in winters and till the next rains the land has no vegetation except the cover of fallen needles. This type overlaps the tropical deciduous forest at the lower elevation and temperate forests at the higher elevations. Pine forests are rarely found on level ground and experience heavy grazing. The general floristics of the forest type is *Pinus roxburghii, Syzygium cumini, Quercus incana, Lyonia ovalifolia, Rhododendron arboreum, Pyrus pashia*. The Shrub storey is comprised mainly of *Berberis lycium, Rubus ellipticus, Moghania fruticulosa*. The herbs and grasses found in this forest type are *Plectranthus strictus, Rosocea, Eulalia mollis, Arundinella intricata* etc.

- **12/C1 a Ban Oak Forest (Q.incana)**

The trees in this forest type form a closed canopy when well developed otherwise they form somewhat open forests with short boles and extensive branching. *Rhododendron arboreum* and *Lyonia ovalifolia* are its associates below the oak canopy. It is found at elevations between 1800 to 2300m on southern aspects and lower on northern aspects by 150 to 300m. The soil is rich in humus and well drained. They experience heavy anthropogenic pressures of lopping, grazing and browsing. The ban oak forests suffer forest fires spreading from the lower pine zone. *Quercus incana* is by far the commonest oak and *Quercus glauca* is locally abundant along shady ravines. Other species found are *Carpinus viminea, Cedrela serrata, Rhododendron arboreum, Lyonia ovalifolia, Viburnum cotinifolium, Desmodium tiliaefolium, Rubus niveus, Vitis spp., Hedera* etc.

- ***5B/C1b – Dry Plains Sal* Forests**

This type of forest found where the soil is a hard, dry and somewhat impermeable stiff loam overlying almost pure sand. The crop consists chiefly of middle aged and mature trees, while the younger age classes are generally in deficit. Most of the forests placed in this category were at one time average forests of the type 3C/C2d(i) (Western Light Alluvium Plains Sal) but recurring drought mortality has resulted in creation of large gaps with scattered trees of Sal. The forests have changed to dry deciduous type with poor soil conditions. The other species found are asna, rohini, dudhi, *Bauhinia malabarica, Randia dumetorum* and tendu. The under growth contains a large variety of grasses such as ulla, kaans, *Imperata cyclindrica, Heteropogon contortus, Veteveria zizanioides, Eulaliopsis binata, Chrysopogon fulvus* and *Bothriochloa intermedia*. The under growth also contains ber, karaonda and marorphal (*Helicteres isora*).

Table 2.1a Area according to Forest Types of the Core Area of Corbett Tiger Reserve

Forest Types	Area In (%) Assessment Year 2004
3C/C2 a Moist Siwalik Sal Forest	68.81
3C/C3 a West Gangatic Moist Mixed Deciduous Forest	4.95
5/1S2 Khair Sissoo Forest	0.69
5B/C2 Northern Dry Mixed Deciduous Forest	0.36
5B/C1 a Dry Siwalik Sal Forest	2.86
5/DS1 Dry Deciduous Scrub	6.70
9/C1 b Upper or Himalayan Chir Pine Forest	1.34
12/C1 a Ban Oak Forest (Q.incana)	0.07
Plantation/TOF	1.62

Table 2.1b Area according to Forest Types of the Buffer Area of Corbett Tiger Reserve

Forest Types	Area In (%) Assessment Year 2004
3C/C2 a Moist Siwalik Sal Forest	49.88
3C/C2 c Moist Tarai Sal Forest	0.37
3C/C3 a West Gangatic Moist Mixed Deciduous Forest	13.26
5B/C1 a Dry Siwalik Sal Forest	5.07
5/DS1 Dry Deciduous Scrub	4.17
5/1S2 Khair Sissoo Forest	2.21
5B/C2 Northern Dry Mixed Deciduous Forest	2.34
5B/C1 b Dry Plains Sal Forest	1.77
9/C1 b Upper or Himalayan Chir Pine Forest	5.89
12/C1 a Ban Oak Forest (Q.incana)	0.21
Plantation/TOF	7.83

Table 2.1c Area according to Forest Types of the Area upto 10 km from the boundary of Corbett Tiger Reserve

Forest Types	Area In (%) Assessment Year 2004
3C/C2 a Moist Siwalik Sal Forest	13.04
3C/C3 a West Gangatic Moist Mixed Deciduous Forest	5.68
3C/C2 c Moist Tarai Sal Forest	0.79
5/DS1 Dry Deciduous Scrub	2.01
5B/C1 a Dry Siwalik Sal Forest	1.95
5B/C1 b Dry Plains Sal Forest	1.31
5B/C2 Northern Dry Mixed Deciduous Forest	6.12
5/1S2 Khair Sissoo Forest	0.85
9/C1 b Upper or Himalayan Chir Pine Forest	10.97
9/DS1 Himalayan SubTropical Scrub	0.06
12/C1 a Ban Oak Forest (Q.incana)	0.85
12/C1 d Western Mixed Coniferous Forest (spruce, Blue Pin)	0.01
Plantation/TOF	4.38

5. Fauna

The Corbett Tiger Reserve is popularly known as the 'land of Roar, Trumpet and Song'. These are represented by Tiger, Elephant and Birds, respectively. CTR harbors extensive variety of fauna owing to the rich and diverse habitats and prey base. As per the Zoological Survey of India's "*Fauna of Corbett Tiger Reserve"* a sum total of 1013 species of fauna have been documented.

5.1. Mammals

Corbett Tiger Reserve is abundantly populated by:

- Tiger (Panthera tigris)

- Panther (Panthera pardus)
- Leopard cat (Felis bengalensis)
- Wild boar
- Jungle cat (Felis chaus)
- Rusty Spotted Cat (Prionailurus rubiginosa)
- Jackals (Canis aureus)
- Asiatic Elephants (Elephas maximus)
- Sambhar
- Spotted Deer,
- Barking Deer
- Hog Deer
- Goral (Nemorhaedus goral)
- Langoor (Presbytis entellus)
- Porcupines (Hystrix indica)
- (Melursus ursinus)
- Hare (Lepus nigricollis
- Otter (Lutrogale perspicillata)

5.2. Reptiles

Indian Crocodile i.e. Mugger *(Crocodilus palustria)* are found in the river Ramganga. Gharials *(Gavialis gangeticus)* are also seen in Ramganga River. The Gharial population of Corbett Tiger Reserve assumes special significance as this species which is listed as Critically Endangered in the IUCN Red Data Book, makes the river Ramganga flowing inside the Tiger Reserve home as the third largest breeding population of the Gharial in Northern India (other populations are found in the National Chambal WLS and Katarniyaghat WLS). This is of special significance as this population has adapted the congenial environment of - a reservoir.

Other terrestrial reptiles are represented by various species of snakes. Important species are King Cobra *(Ophiophagus hannah),* Common Krait *(Bungarus caeruleus),* Cobra *(Naja naja),* Russel viper *(Vipera ruselli)* and Python *(Python molorus).* Important lizard found are monitor lizard *(Varanus bengalensis),* and Corbett Tiger reserve is also endowed with fresh water turtle.

5.3. Birds

Corbett is very rich in avifauna. The check list produced by the Zoological Survey of India mentioned a total of 685 species which belongs to 294 genera and 75 families of which four species are Critical, three endangered, fourteen vulnerable and nineteen near threatened.

5.4. Pisces

The river Ramganga sustains a large variety of fishes.

- Mahaseer *(– Tor spp)*
- Kalabasu *(Labeo calabasu)*,
- chilwa *(Oxygaster bacaila)*,
- Chaal (*Barilus* spp),
- Gunthala (*Gara* spp),
- *Puntius* spp.,
- Lanchi (*Wallago* spp),
- Gadiyal (*Nemacheilus* spp.),
- Sori (*Channa* spp.),
- Gaidi (*Mastacembelus armatus*),
- Kawwa (Xenentodon cancila)
- Goonch *(Bagarius bagarius)*

5.5. List of Critical, Endangered and Vulnerable Species of CTR

Species	Critical	Endangered	Vulnerable
Mammals	_____	_____	• *Panthera tigris* • *Elephas maximus*
Fishes	_____	• *Raiamas bola* • *Tor chelynoides* • *Tor putitora* • *Tor tor* • *Botia lohachata* • *Nemachilus montanus*	• *Barilius vagara* • *Labeo dero* • *Puntius chola* • *Puntius conchonius* • *Garra gotyla gotyla* • *Mystus vittatus* • *Bagarius bagarius*
	• *Gyps bengalensis* • *Gyps indicus*	• *Leptoptilos dubius* • *Falco cherrug*	• *Pelecanus philippensis* • *Leptoptilos javanicus*

Birds	• *Gyps tenuirostris* • *Vanellus gregarious*	• *Houbaropsis bengalensis*	• *Marmaronetta angustirostris* • *Haliaeetus leucoryphus* • *Aquila clanga* • *Aquila heliacal* • *Grus antigone* • *Gallinago nemoricola* • *Rynchops albicollis* • *Aceros nipalensis* • *Sexicola insignis* • *Prinia cinereocapilla* • *Chaetornis striatus* • *Ploceus megarhynchus*
Reptiles	———	———	• *Gavialis gangeticus* • *Crocodylus palustris* • *Melanochelys tricarinata*
Frog and Toads	———	———	• *Paa minica*

2.2 FOREST COVER IN CORBETT TIGER RESERVE

2.2.1 Forest Cover in the year of 1990

- **Core Area:**

As per the List of Core and Buffer area of the Tiger Reserves in India published by **National Tiger Conservation Authority/Project Tiger**, notified under the Wildlife (Protection) Act 1972, amended in 2006 ,area of the Core of Corbett Tiger Reserve is **821.99 sq km**(as on 03.09.2014).

The assessment of forest cover in the core area of Corbett Tiger Reserve is **708.89 sq km** which is about **86.24%** of the notified core area of reserve. The study of 1990 image interpretation is based on the satellite data of Landsat-5 TM .The study reveals that **380.22 sq km** of forest falls in Very Dense Forest category, **276.67 sq km** of forest lie in Moderately Dense Forest category and **52.00 sq km** forest is in Open Forest category.

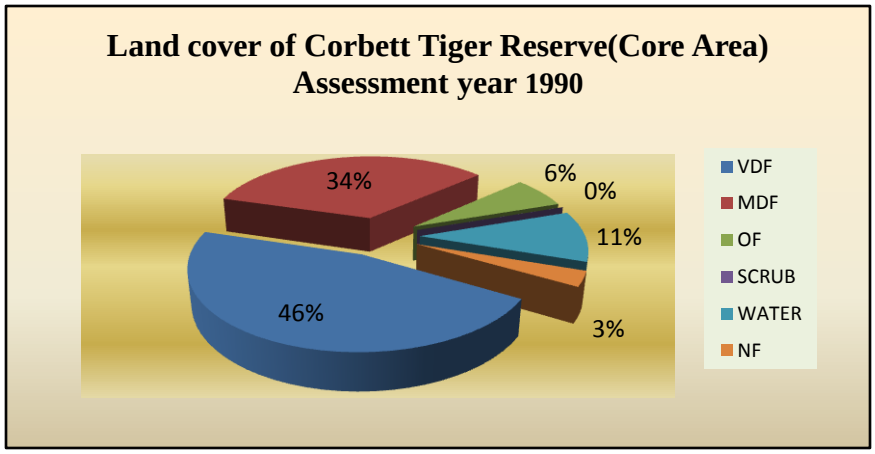


Fig 2.2.1a Pie chart showing percentage of Land Cover in the core area of Corbett TR (1990)

- **Buffer Area:**

The notified area of Buffer under the Wildlife (Protection) Act 1972, amended in 2006 of Corbett Tiger Reserve is **466.32 sq km (**falling in Uttarakhand) **and 80.60 sq km (**falling in Uttar Pradesh).

The assessment of forest cover in the buffer area of Corbett Tiger Reserve falling in **Uttarakhand** is **444.28 sq km** which is about **95.27%** of its buffer area. The study of 1990 image interpretation is based on the satellite data of Landsat-5TM. The study reveals that **177.02 sq km** of forest falls in Very Dense Forest category, **225.16 sq km** of forest lies in Moderately Dense Forest category and **42.10 sq km** forest is in Open Forest category.

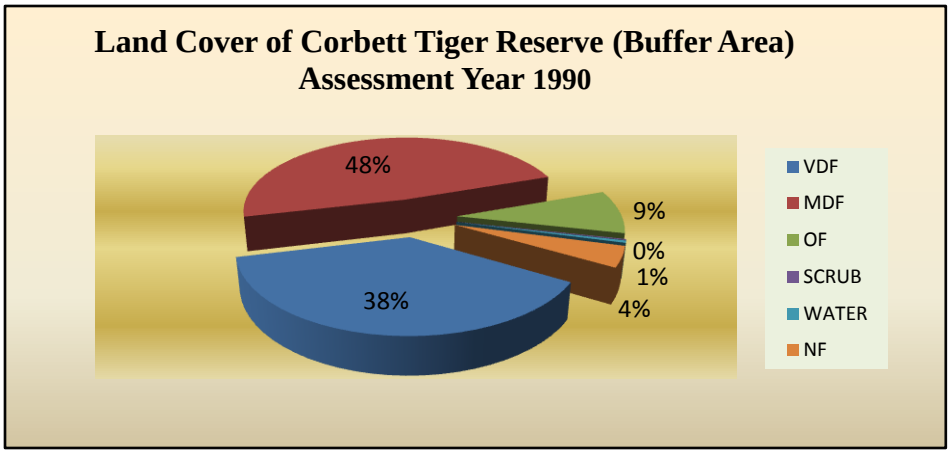


Fig 2.2.1b Pie chart showing percentage of Land Cover in the buffer area of Corbett TR (1990)

The assessment of forest cover in the buffer area of Corbett Tiger Reserve falling in **Uttar Pradesh** is **65.33 sq km** which is about **81.05%** of its buffer area. The study of 1990 image interpretation is based on the satellite data of Landsat-5 TM. The study reveals that **31.67 sq km** of forest falls in Very Dense Forest category, **20.86 sq km** of forest lies in Moderately Dense Forest category and **12.80 sq km** forest is in Open Forest category.

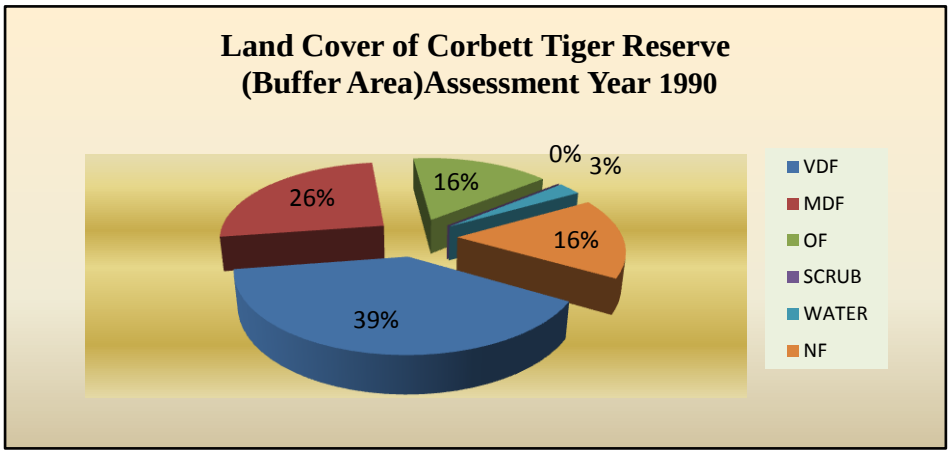


Fig 2.2.1c Pie chart showing percentage of Land Cover in the buffer area of Corbett TR (1990)

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

The outer surround of 10km radius from the notified boundary (core & buffer) of the tiger reserve having area of **2082.42 sq km.**

The assessment of forest cover in AUTKBTR of Corbett Tiger Reserve is **1039.32 sq km** which is about **49.90 %** of its AUTKBTR area. The study of 1990 image interpretation is based on the satellite data of Landsat-5 TM. The study reveals that **261.02 sq km** of forest falls in Very Dense Forest category, **541.67 sq km** of forest lies in Moderately Dense Forest category and **236.63 sq km** forest is in Open Forest category.

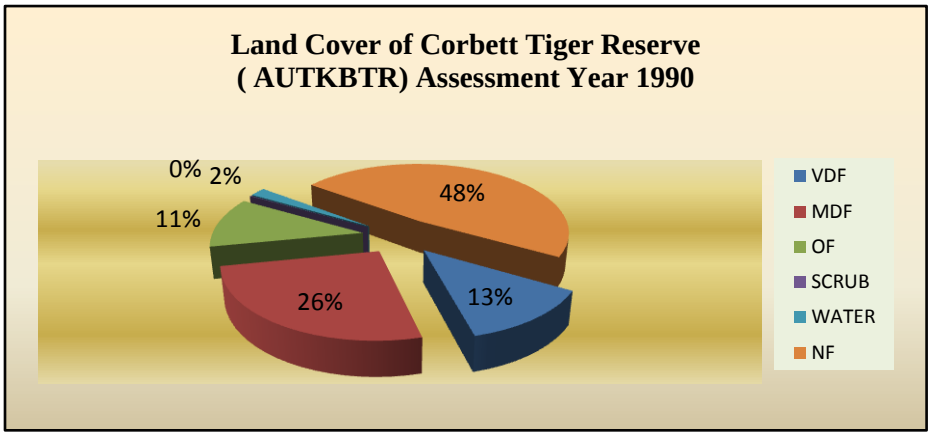


Fig 2.2.1d Pie chart showing percentage of Land Cover in the AUTKBTR of Corbett TR (1990)

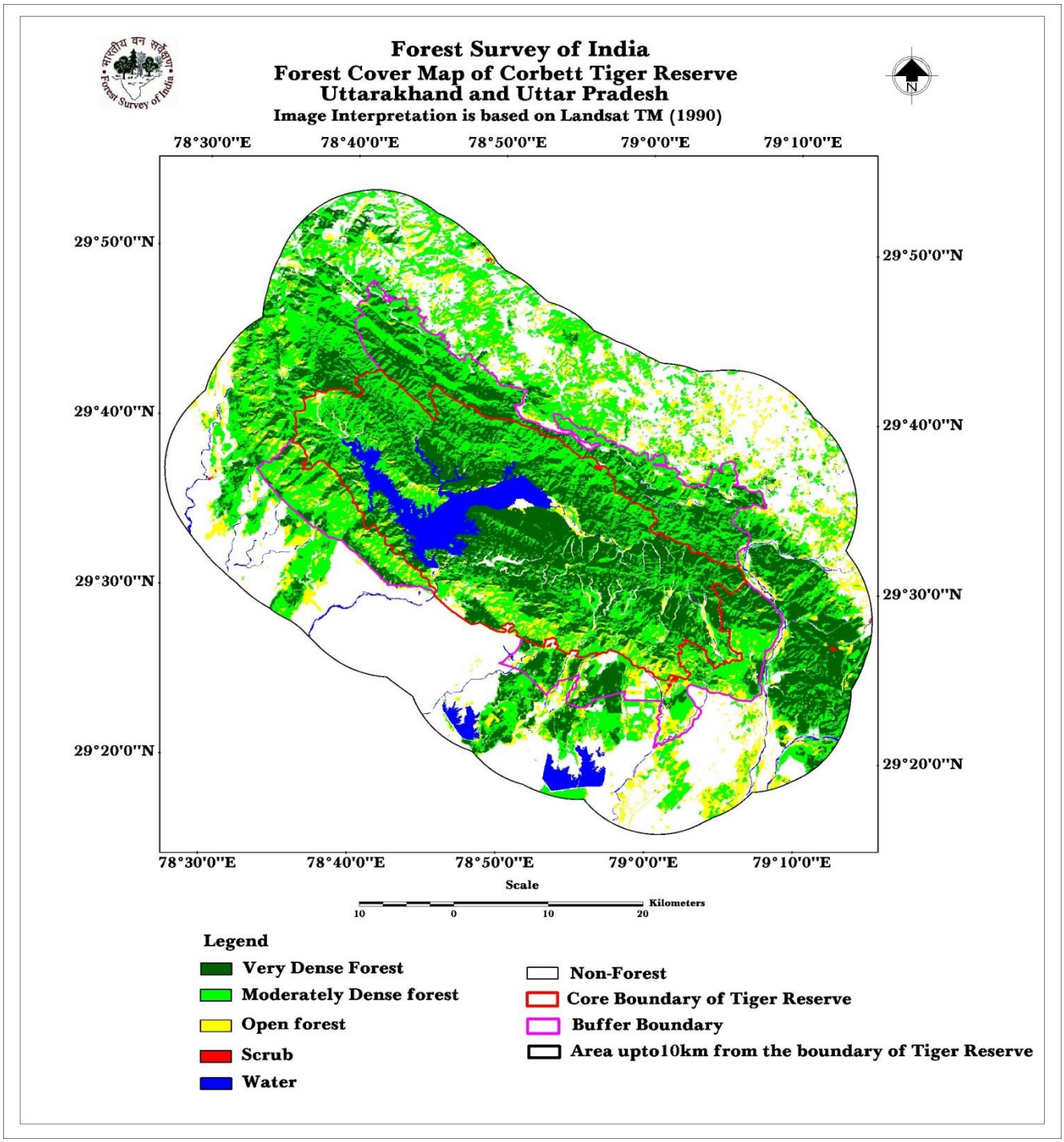


Fig.2.2.1: Forest Cover Map of Corbett Tiger Reserve (1990)

2.2.2 Forest Cover in the year of 2000

- **Core Area:**

The assessment of forest cover in the core area of Corbett Tiger Reserve is **708.95 sq km** which is about **86.25%** of its notified core area. The study of 2000 image interpretation is based on the satellite data of IRS – 1C/1D LISS III. The study reveals that **380.63 sq km** of forest falls in Very Dense Forest category, **277.82 sq km** of forest lie in Moderately Dense Forest category and **50.50 sq km** forest is in Open Forest category.

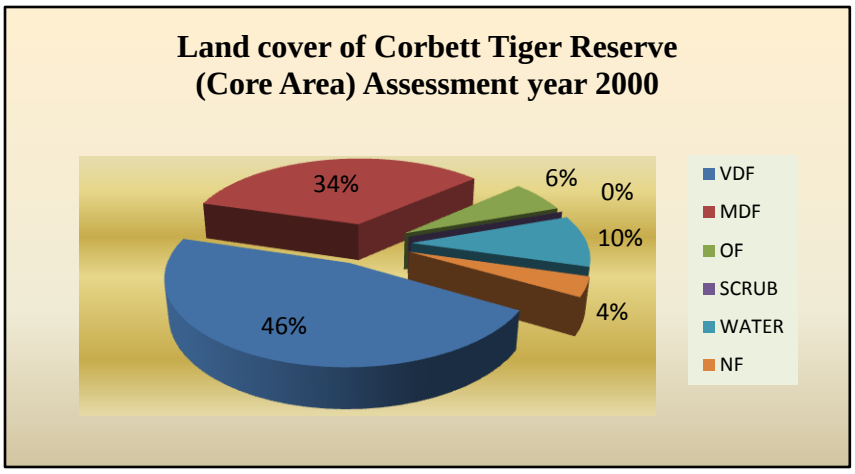


Fig 2.2.2a Pie chart showing percentage of Land Cover in the core area of Corbett TR (2000)

- **Buffer Area :**

The assessment of forest cover in the buffer area of Corbett Tiger Reserve falling in **Uttarakhand** is **447.44 sq km** which is about **95.95%** of its notified buffer area. The study of 2000 image interpretation is based on the satellite data of IRS – 1C/1D LISS III. The study reveals that **177.33 sq km** of forest falls in Very Dense Forest category, **227.38 sq km** of forest lies in Moderately Dense Forest category and **42.73 sq km** forest is in Open Forest category.

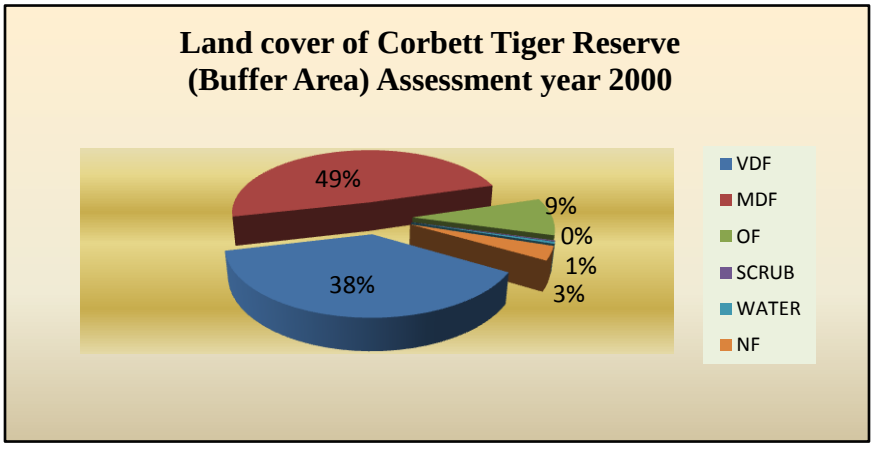


Fig 2.2.2b Pie chart showing percentage of Land Cover in the buffer area of Corbett TR (2000)

The assessment of forest cover in the buffer area of Corbett Tiger Reserve falling in **Uttar Pradesh** is **65.25 sq km** which is about **80.96**% of its notified buffer area. The study of 2000 image interpretation is based on the satellite data of IRS – 1C/1D LISS III. The study reveals that **31.10 sq km** of forest falls in Very Dense Forest category, **21.75 sq km** of forest lies in Moderately Dense Forest category and **12.40 sq km** forest is in Open Forest category.

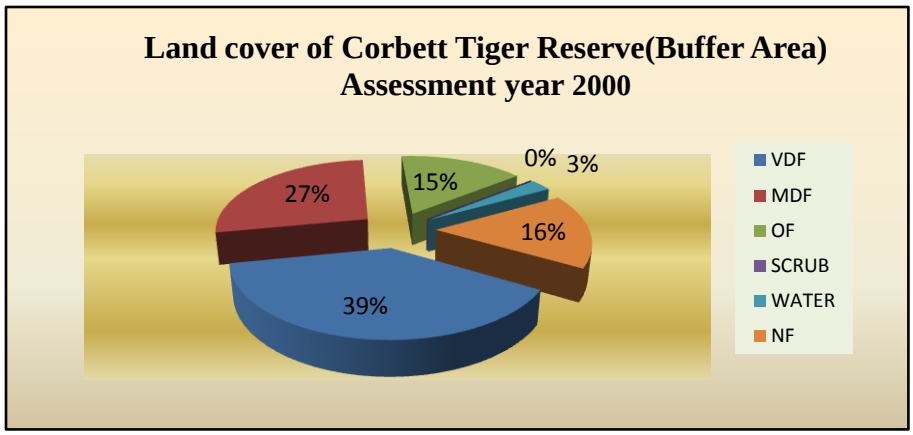


Fig 2.2.2c Pie chart showing percentage of Land Cover in the buffer area of Corbett TR (2000)

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

The assessment of forest cover in AUTKBTR of Corbett Tiger Reserve is **1033.89 sq km** which is about **49.65 %** of AUTKBTR area. For the study of 2000 image interpretation is based on the satellite data of IRS – 1C/1D LISS III. The study reveals that **260.46 sq km** of forest falls in Very Dense Forest category, **538.83 sq km** of forest lies in Moderately Dense Forest category and **234.60 sq km** forest is in Open Forest category.

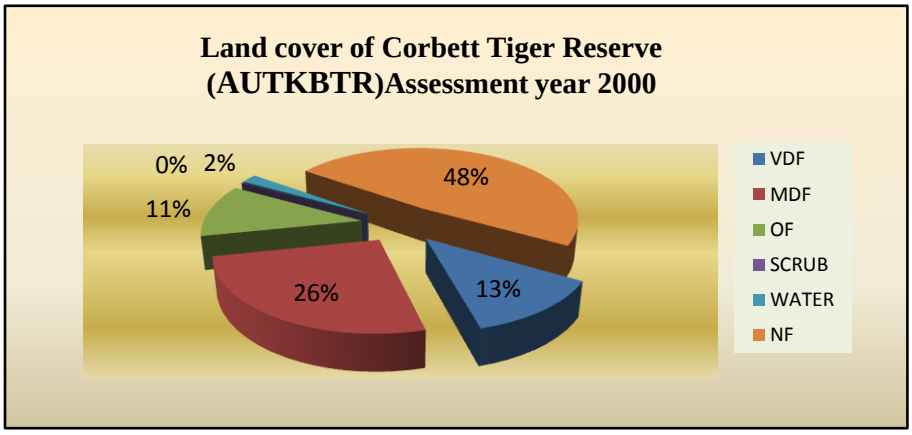


Fig 2.2.2d Pie chart showing percentage of Land Cover in AUTKBTR of Corbett TR (2000)

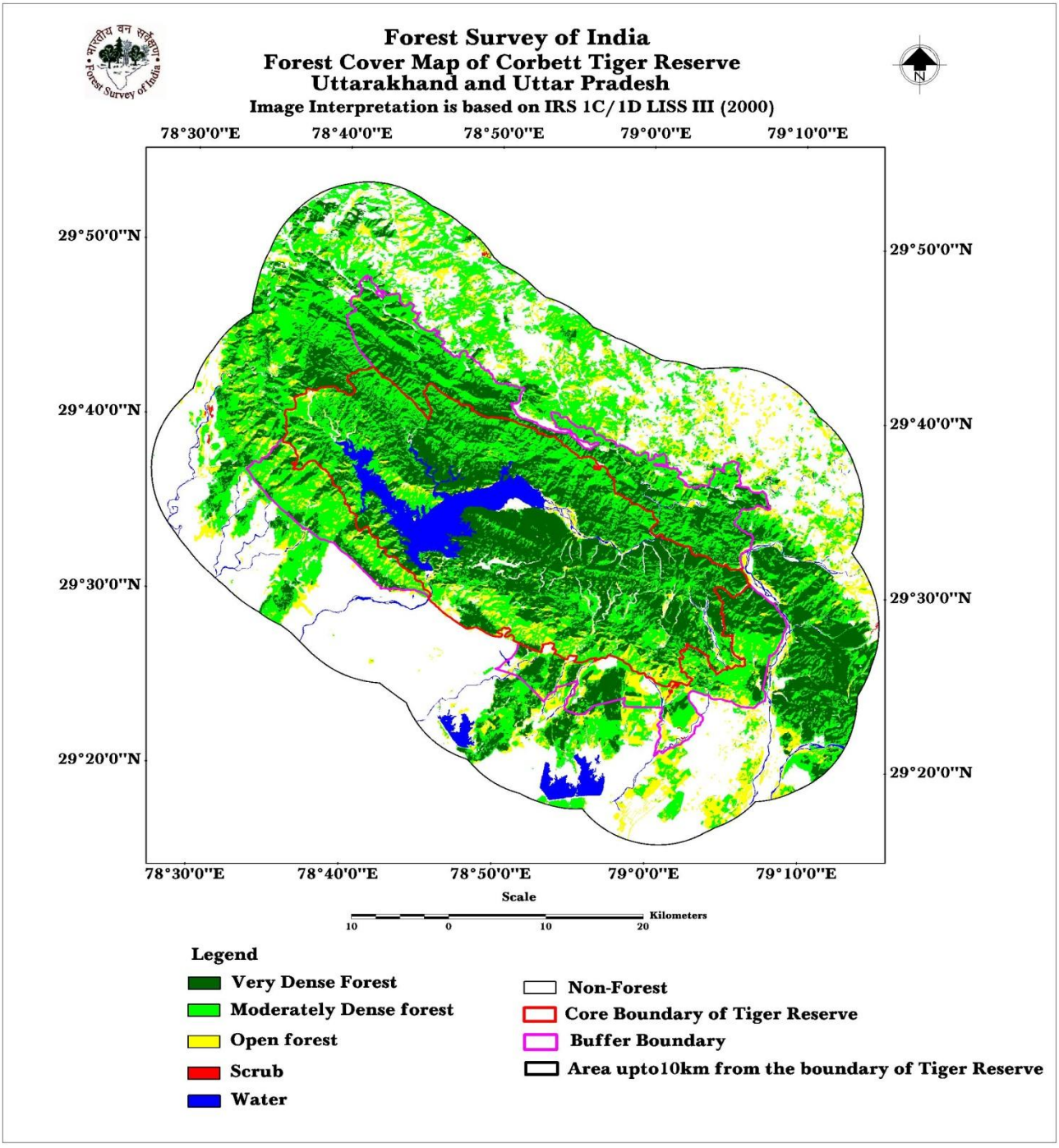


Fig.2.2.2: Forest Cover Map of Corbett Tiger Reserve (2000)

2.2.3 Forest Cover in the year of 2010

- **Core Area:**

The assessment of forest cover in the core area of Corbett Tiger Reserve is **706.73 sq km** which is about **85.98 %** of its notified core area. The study of 2010 image interpretation is based on the satellite data of IRS – P6 LISS III. The study reveals that **380.78 sq km** of forest falls in Very Dense Forest category, **277.91 sq km** of forest lie in Moderately Dense Forest category and **48.04 sq km** forest is in Open Forest category.

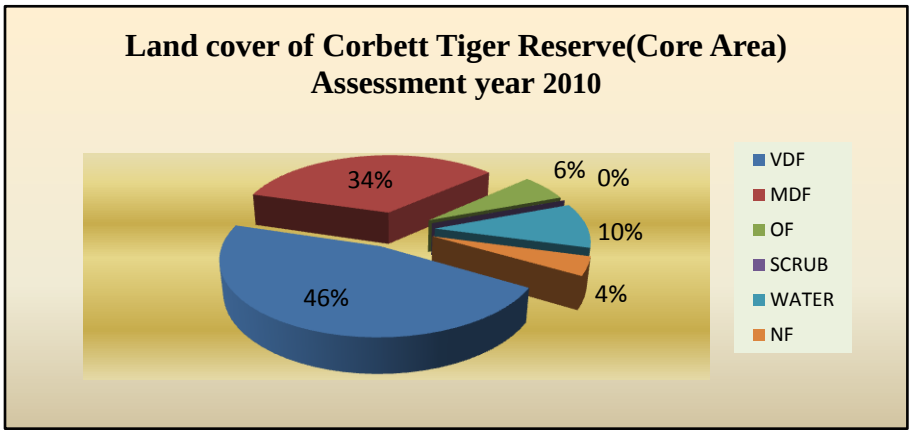


Fig 2.2.3a Pie chart showing percentage of Land Cover in the core area of Corbett TR (2010)

- **Buffer Area :**

The assessment of forest cover in the buffer area of Corbett Tiger Reserve falling in **Uttarakhand** is **445.55 sq km** which is about **95.54 %** of its notified buffer area. For the study of 2010 image interpretation is based on the satellite data of IRS – P6 LISS III. The study reveals that **177.16 sq km** of forest falls in Very Dense Forest category, **226.71sq km** of forest lies in Moderately Dense Forest category and **41.68 sq km** forest is in Open Forest category.

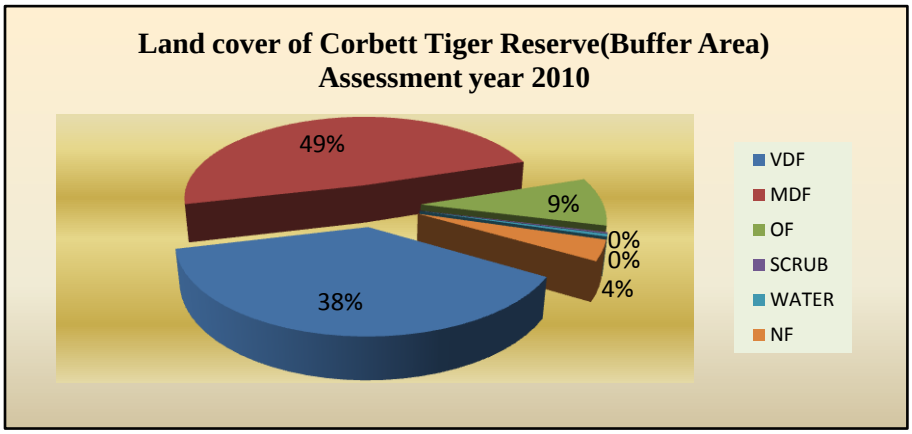


Fig 2.2.3b Pie chart showing percentage of Land Cover in the buffer area of Corbett TR (2010)

The assessment of forest cover in the buffer area of Corbett Tiger Reserve falling in **Uttar Pradesh** is **64.07 sq km** which is about **79.49 %** of its notified buffer area. The study of 2010 image interpretation is based on the satellite data of IRS – P6 LISS III. The study reveals that **31.01 sq km** of forest falls in Very Dense Forest category, **20.66 sq km** of forest lies in Moderately Dense Forest category and **12.40 sq km** forest is in Open Forest category.

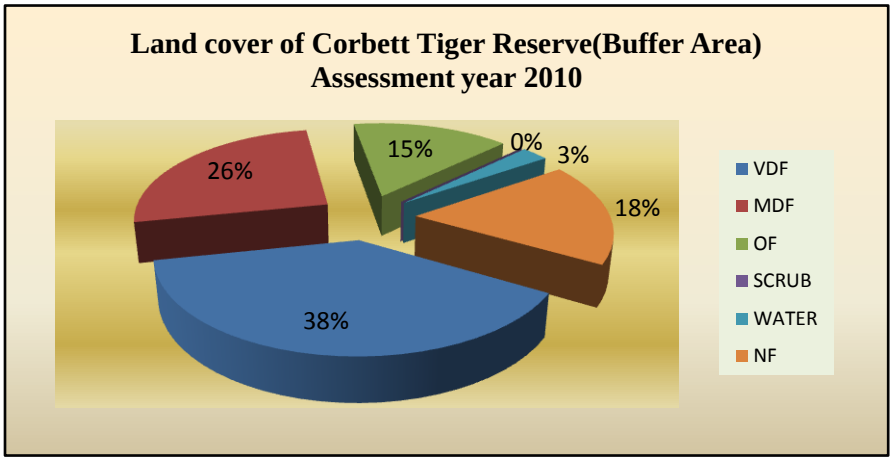


Fig 2.2.3c Pie chart showing percentage of Land Cover in the buffer area of Corbett TR (2010)

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

The assessment of forest cover in AUTKBTR of Corbett Tiger Reserve is **1025.94 sq km** which is about **49.27 %** of its AUTKBTR area. For the study of 2000 image interpretation is based on the satellite data of IRS – P6 LISS III. The study reveals that **260.61 sq km** of forest falls in Very Dense Forest category, **531.82 sq km** of forest lies in Moderately Dense Forest category and **233.51sq km** forest is in Open Forest category.

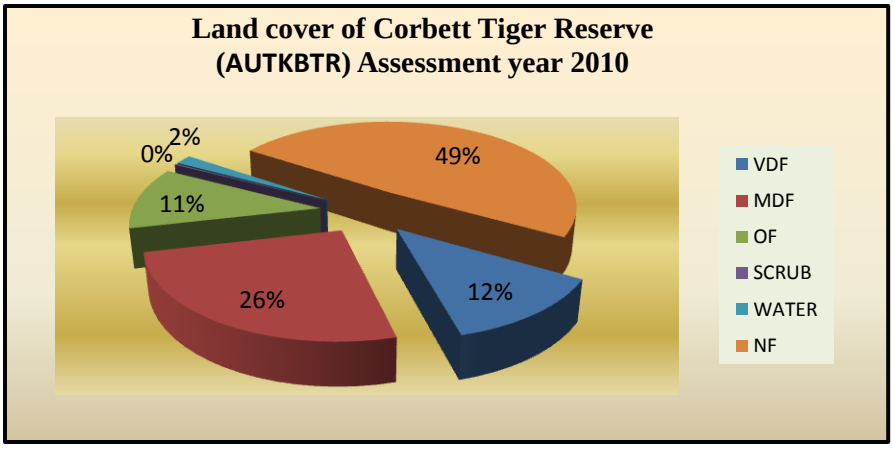


Fig 2.2.3d Pie chart showing percentage of Land Cover in AUTKBTR of Corbett TR (2010)

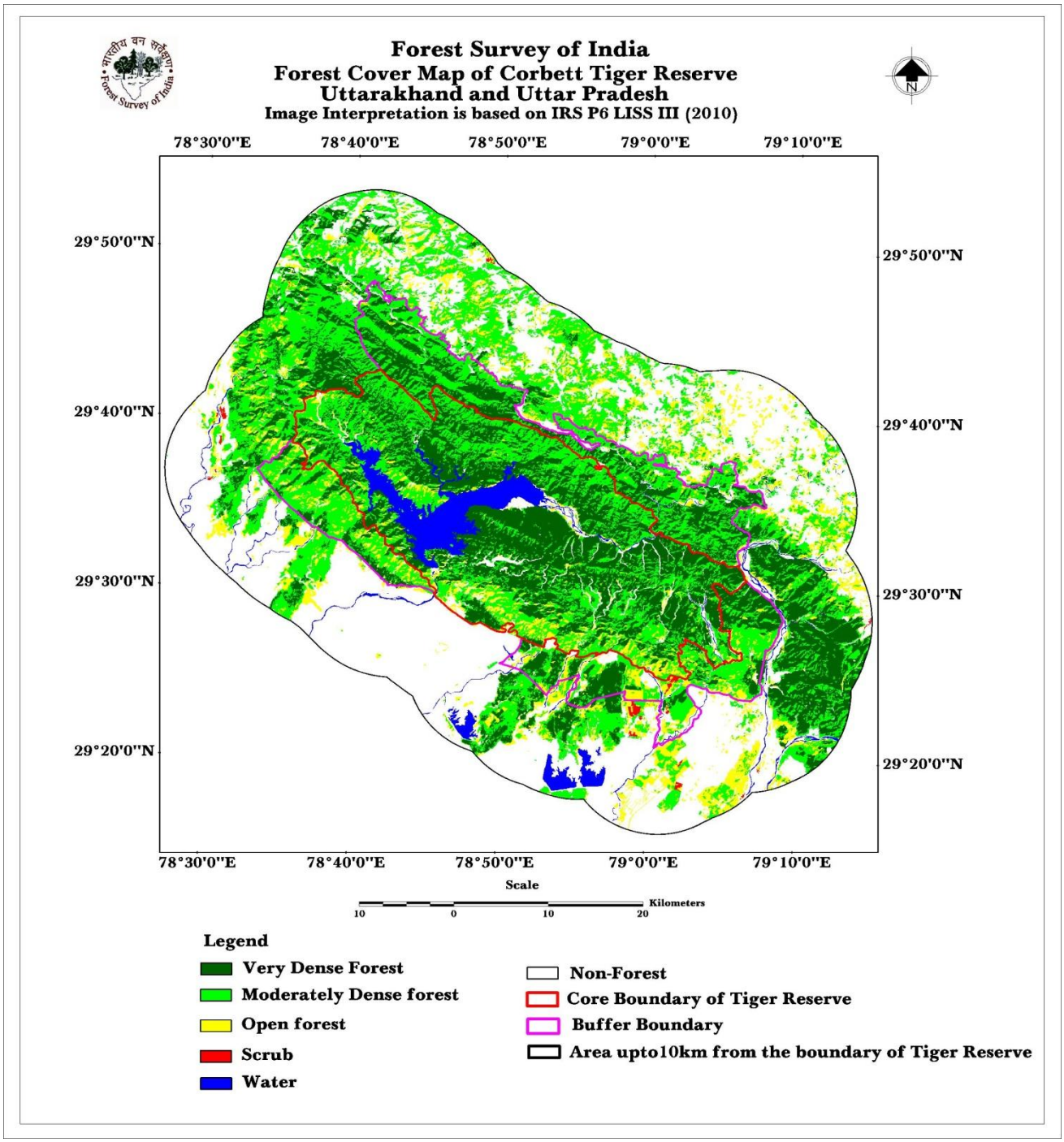


Fig.2.2.3: Forest Cover Map of Corbett Tiger Reserve (2010)

Table 2.2: Forest Cover in Core, Buffer Area and AUTKBTR of Corbett Tiger Reserve

(Area in sq km)

ASSESSMENT YEAR	TIGER RESERVE BOUNDARY	VDF	MDF	OF	TOTAL FOREST	SCRUB	WATER	NON FOREST
1990	Area (Core)	380.22	276.67	52.00	708.89	0.11	85.20	27.79
	Area (Buffer-UK)	177.02	225.16	42.10	444.28	0.86	2.16	19.02
	Area (Buffer- UP)	31.67	20.86	12.80	65.33	0.54	2.15	12.58
	AUTKBTR	261.02	541.67	236.63	1039.32	1.03	40.76	1001.31
2000	Area (Core)	380.63	277.82	50.50	708.95	0.10	81.79	31.15
	Area (Buffer-UK)	177.33	227.38	42.73	447.44	0.95	2.23	15.70
	Area (Buffer- UP)	31.10	21.75	12.40	65.25	0.00	2.13	13.22
	AUTKBTR	260.46	538.83	234.60	1033.89	1.19	39.72	1007.62
2010	Area (Core)	380.78	277.91	48.04	706.73	0.10	81.45	33.71
	Area (Buffer-UK)	177.16	226.71	41.68	445.55	0.99	2.23	17.55
	Area (Buffer- UP)	31.01	20.66	12.40	64.07	0.00	2.12	14.41
	AUTKBTR	260.61	531.82	233.51	1025.94	4.02	34.97	1017.49

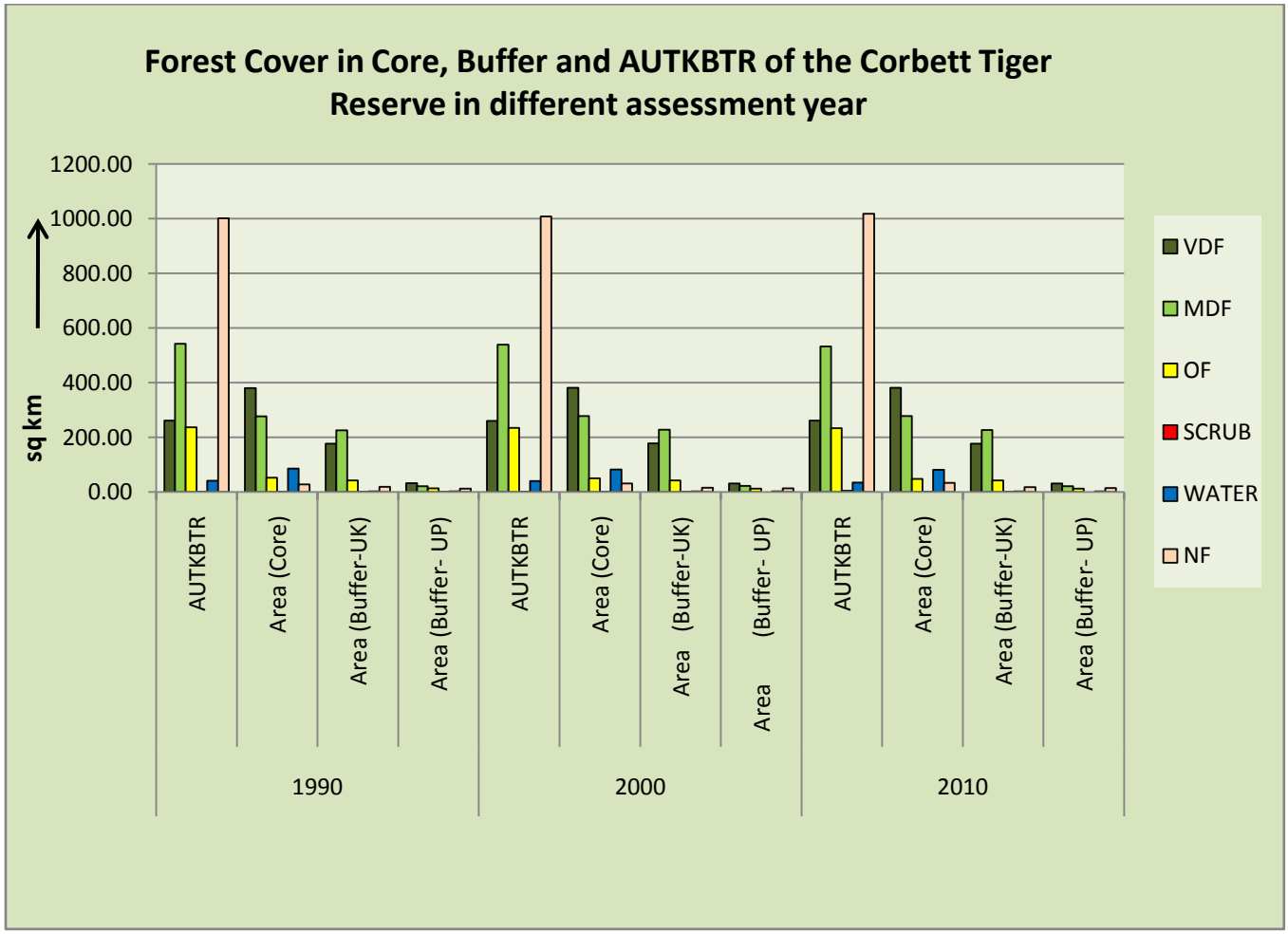


Fig 2.2. Bar diagram showing Land Cover of Corbett Tiger Reserve in Core, Buffer and AUTKBTR (during 1990-2010)

2.3 CHANGE OF FOREST COVER IN CORBETT TIGER RESERVE DURING 1990-2010

2.3.1 Changes in Forest Cover during 1990-2000

- **Core Area:**

During the period of 1990 to 2000 total forest cover has been increased by **0.06 sq km** in the core area of Corbett Tiger Reserve. It reveals that very dense forest in 1990 was **380.22 sq km** and in 2000 it has been increased up **to 380.63 sq km**. Moderately dense forest shows a positive change from **276.67 sq km** to **277.82 sq km** during 1990 to 2000 .Open forest cover have been decreased from **52.00 sq km** to **50.50 sq km** during that period of time.

The net change shows that very dense forest has a positive change of **0.41 sq km**, moderately dense forest has a positive change of **1.15 sq km** and open forest has a negative change of **1.50 sq km**. The positive change in the forest cover of core area is due to better protection, conservation strategies deployed at local level. Subsequently lesser intervention due to anthropogenic factors has played an important role in increase in the quality and quantity of forest cover. During the study it was found out that there is an enhancement in the quality of the forest in terms of growing stock. This is also evident in the carbon stock estimation which shows that there is an improvement and stability in the forest stock.

Table2.3.1a: Forest Cover changes in Core Area of Corbett Tiger Reserve (1990-2000)

(Area in sq km)

Category	Assessment Year		Change
	1990	2000	
Very Dense Forest	380.22	380.63	0.41
Moderately Dense Forest	276.67	277.82	1.15
Open Forest	52.00	50.50	-1.50
Total Forest	708.89	708.95	0.06
Scrub	0.11	0.10	-0.01
Non Forest	112.99	112.94	-0.05

- **Buffer Area :**

The notified buffer area of Corbett Tiger Reserve is distributed in two states, **466.32 sq km** is **falling** in Uttarakhand **and 80.60 sq km** is falling in Uttar Pradesh.

During the period of 1990 to 2000 total forest cover increased by **3.08 sq km** in the buffer area of Corbett Tiger Reserve. It reveals that very dense forest in 1990 was **208.69 sq km** and in 2000 it has been decreased to 208.43 sq km. Moderately dense forest shows a positive change from **246.02 sq km** to **249.13 sq km** during 1990 to 2000 and also in case of Open forest, area figure have been increased from **54.90 sq km** to **55.13 sq km** during that period of time.

The net change shows that very dense forest has a negative change of **0.26 sq km**, moderately dense forest has a positive change of **3.11 sq km** and open forest has also a positive change of **0.23 sq km**. Better management practices and better habitat management strategies by the Park authority yielded positive change or improvement in forest cover both qualitatively and quantitatively from 1990 to 2000.Other reason of changes observed during study is rotational felling, changes in river course flowing through the Reserve. The overall increase in forest cover is also substantiated by the Carbon stock assessment of the above mentioned period.

Table2.3.1b: Forest Cover changes in Buffer Area of Corbett Tiger Reserve (1990-2000)

(Area in sq km)

Category	Assessment Year		Change
	1990	2000	
Very Dense Forest	208.69	208.43	-0.26
Moderately Dense Forest	246.02	249.13	3.11
Open Forest	54.90	55.13	0.23
Total Forest	509.61	512.69	3.08
Scrub	1.40	0.95	-0.45
Non Forest	35.91	33.28	-2.63

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

The outer surround of 10 km radius from the notified boundary (core & buffer) of the tiger reserve having area of **2082.42 sq km**.

During the period of 1990 to 2000 total forest cover decreased by **5.43 sq km** in the AUTKBTR of Corbett Tiger Reserve. It shows that very dense forest in 1990 was **261.02 sq km** and in 2000 it has been decreased to **260.46 sq km**. Moderately dense forest shows a negative change from **541.67 sq km** to **538.83 sq km** during 1990 to 2000 but in case of Open forest cover also area figure have been decreased from **236.63 sq km** to **234.60 sq km** during that period of time.

The net change shows that very dense forest, moderately dense forest and open forest have a negative change of **0.56 sq km**, 2.84 **sq km**, **and 2.03 sq km** sequentially at that period of time. Over a period of time there has been a constant of pressure over forest resources due to increase of population, anthropogenic activity, rotational felling, change in river course and collection of fuel wood. As a result a negative change of **5.43 sq km** forest has been observed during that period of time.

Table2.3.1c: Forest Cover changes in AUTKBTR of Corbett Tiger Reserve (1990-2000)

(Area in sq km)

Category	Assessment Year		Change
	1990	2000	
Very Dense Forest	261.02	260.46	-0.56
Moderately Dense Forest	541.67	538.83	-2.84
Open Forest	236.63	234.60	-2.03
Total Forest	1039.32	1033.89	-5.43
Scrub	1.03	1.19	0.16
Non Forest	1042.07	1047.34	5.27

CHANGES OF FOREST COVER DURING 10 YEARS (1990-2000)

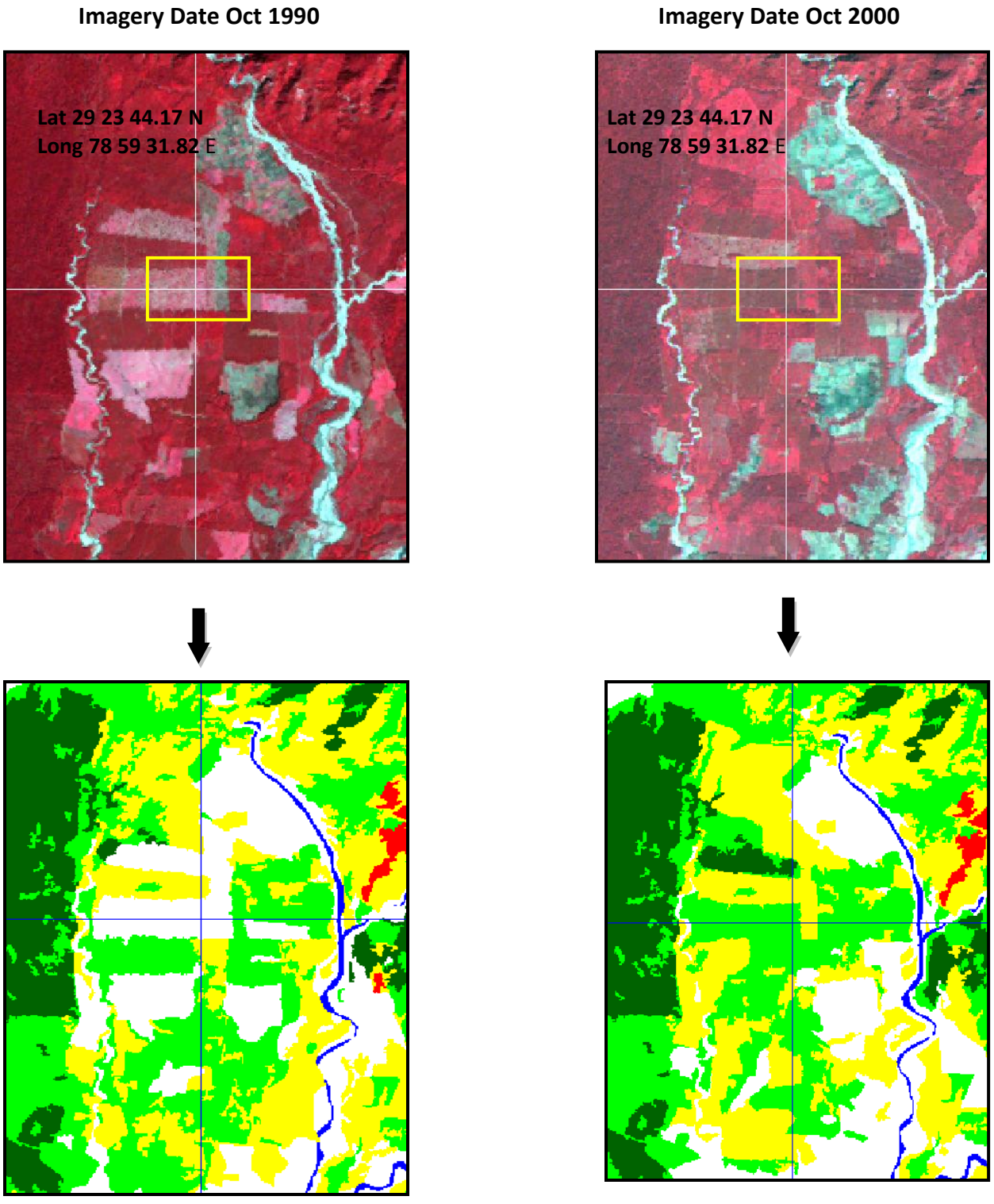


Fig. 1: **Area showing in maps falling in Buffer area (Dhela Range) of the reserve**

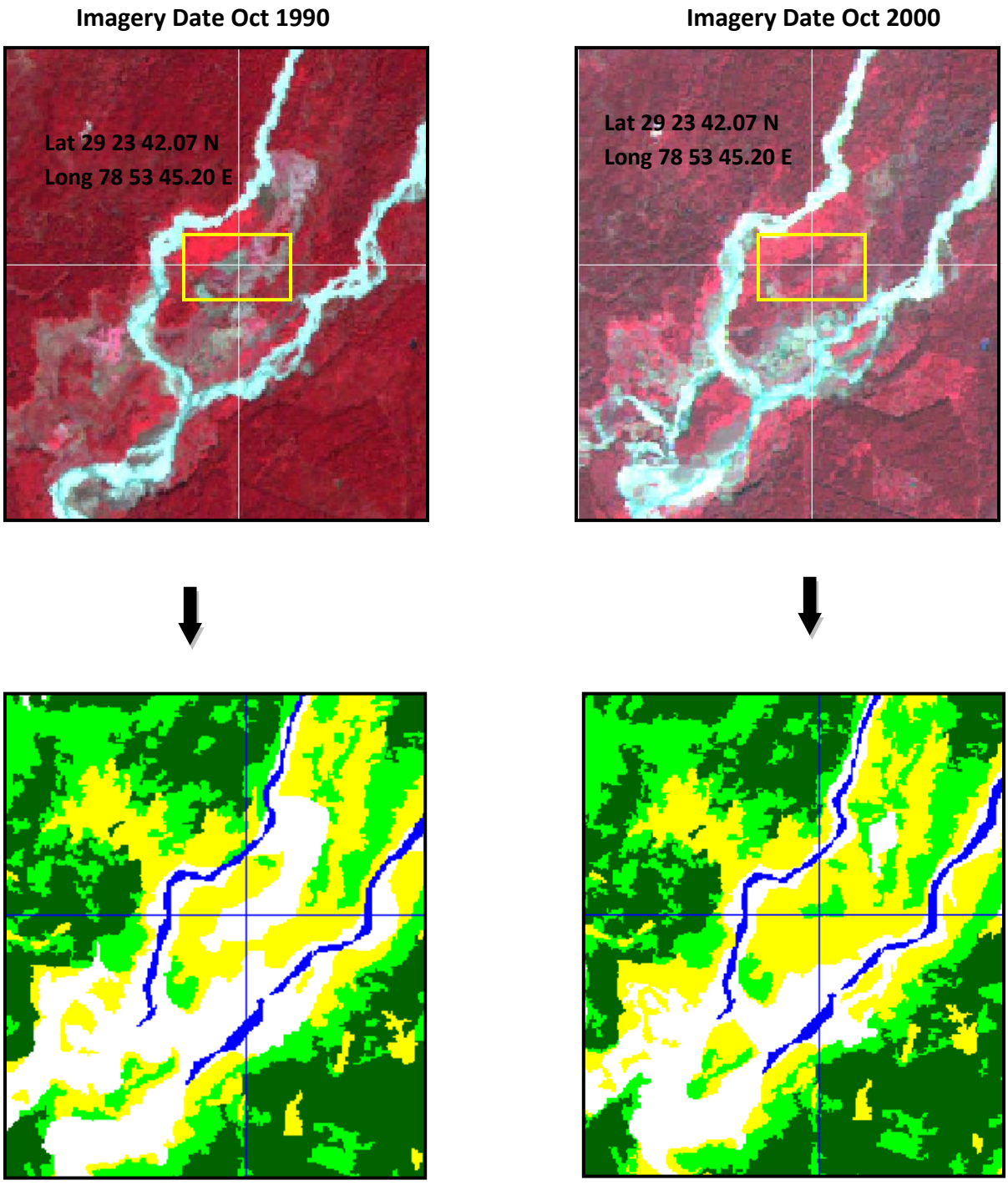


Fig. 2: **Area showing in maps falling in AUTKBTR of the reserve**

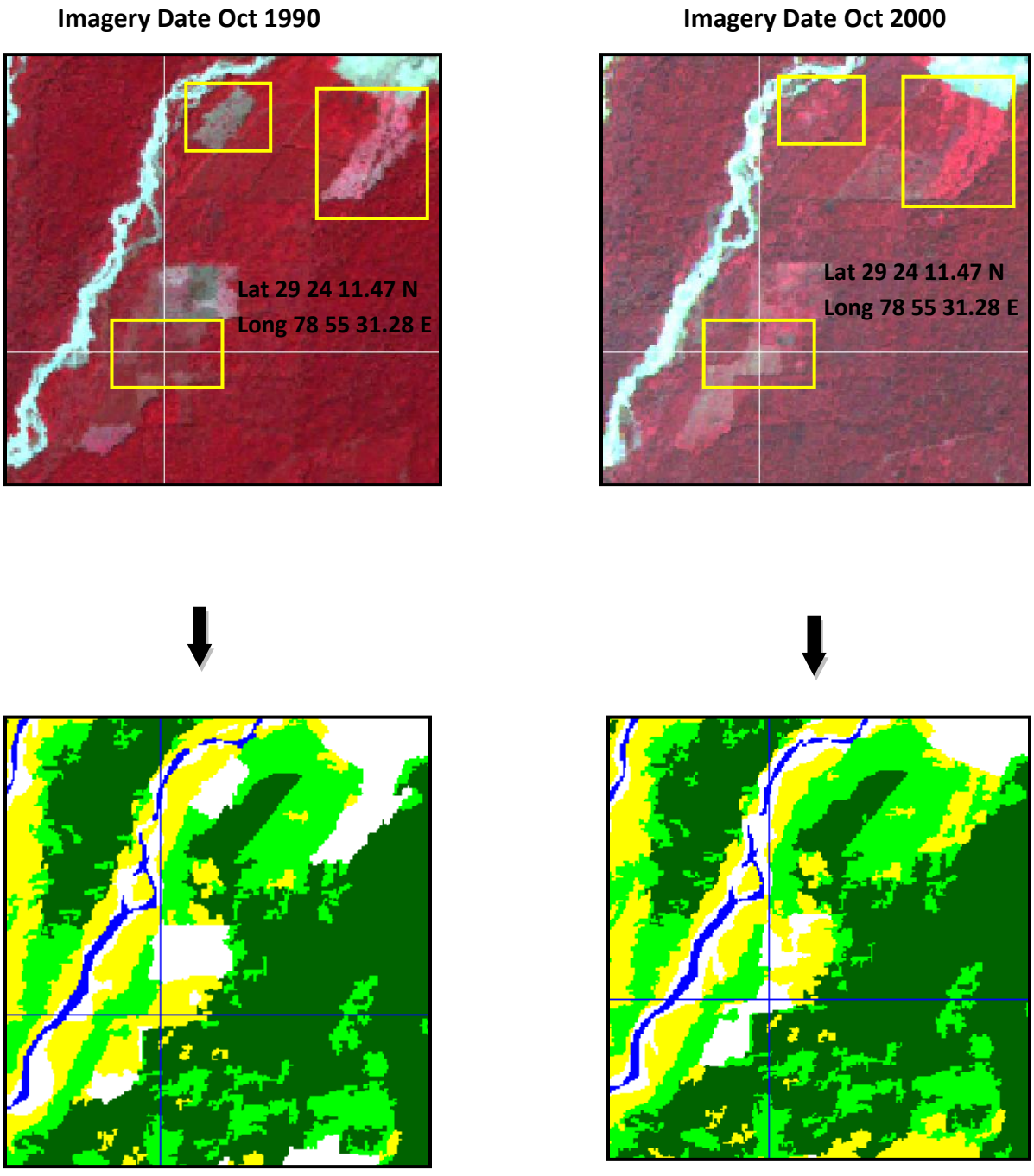


Fig. 3: **Area showing in maps falling in Buffer area (Jhirna Range) of the reserve**

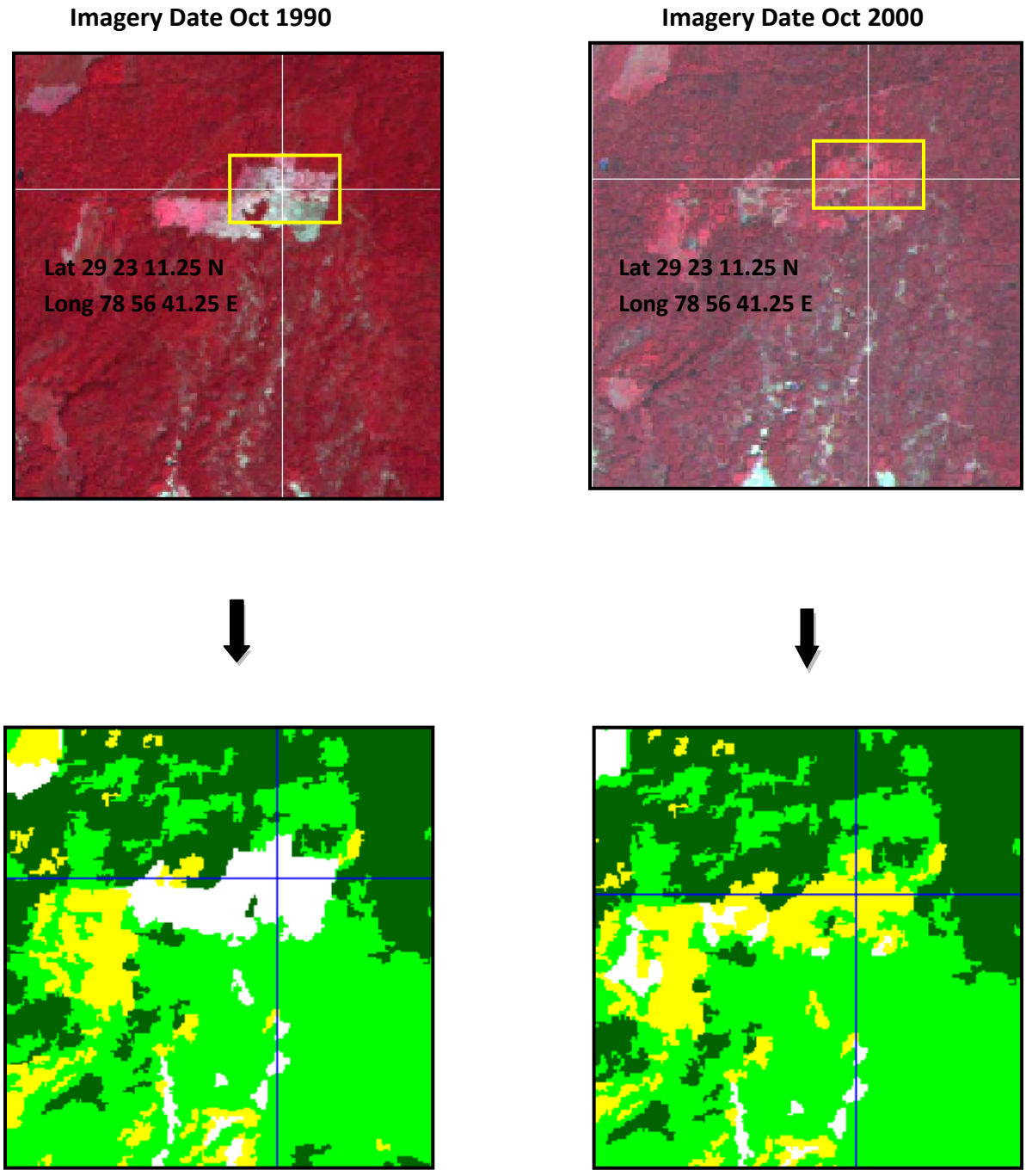


Fig. 4: **Area showing in maps falling in AUTKBTR of the reserve**

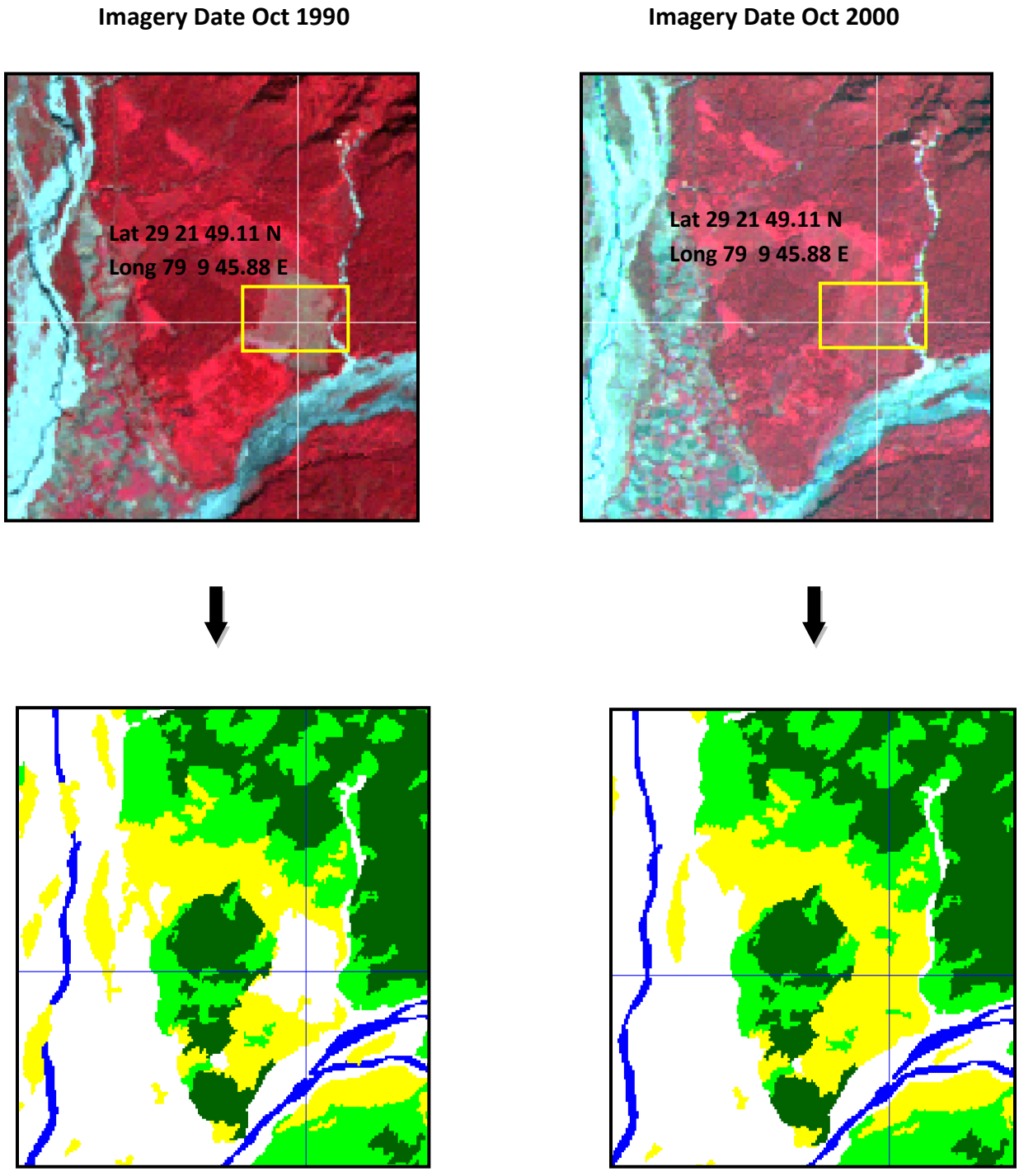


Fig. 5: **Area showing in maps falling in AUTKBTR of the reserve**

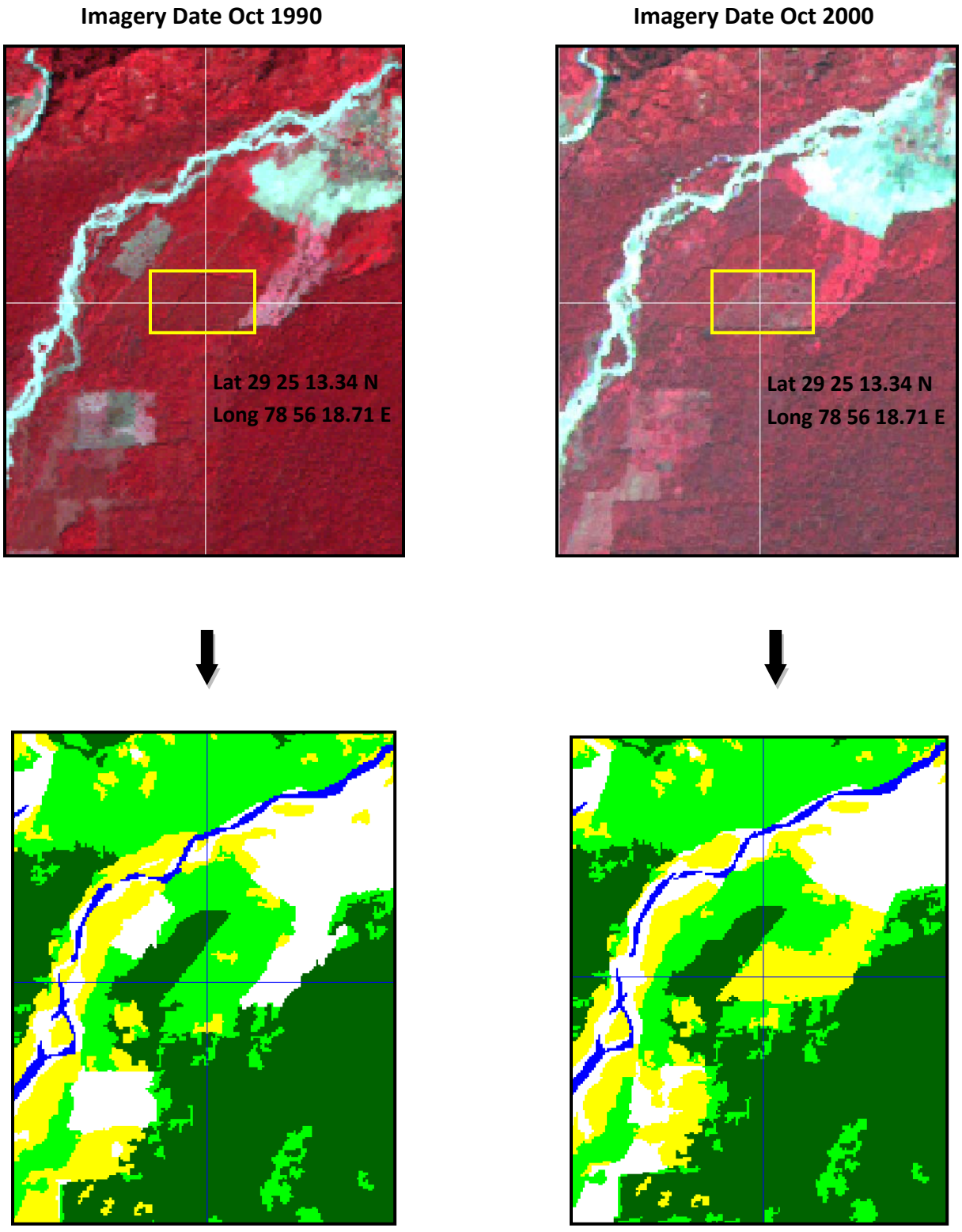


Fig. 6: **Area showing in maps falling in Buffer area (Dhela Range) of the reserve**

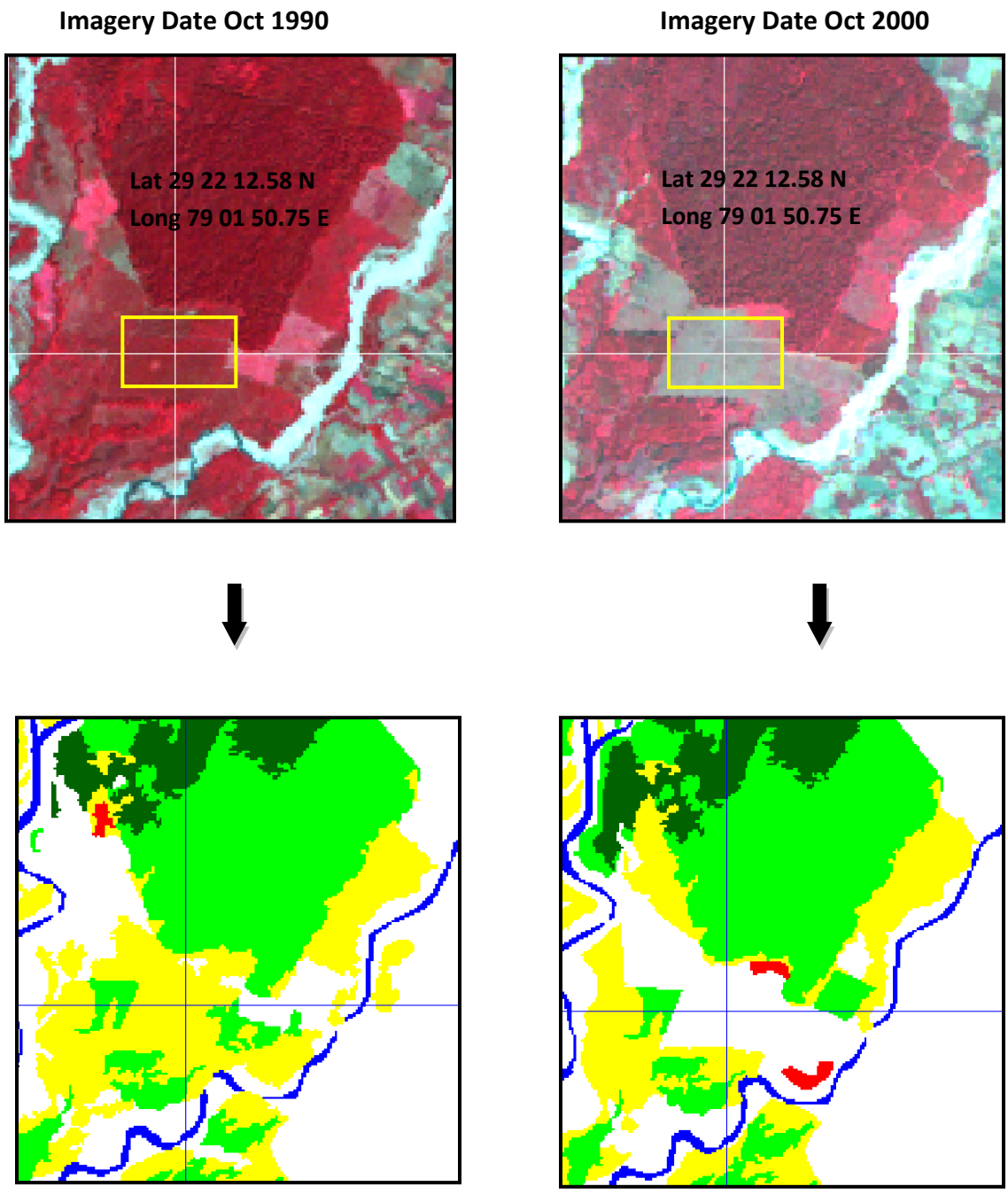


Fig. 7: **Area showing in maps falling in Buffer area (Dhela Range) of the reserve**

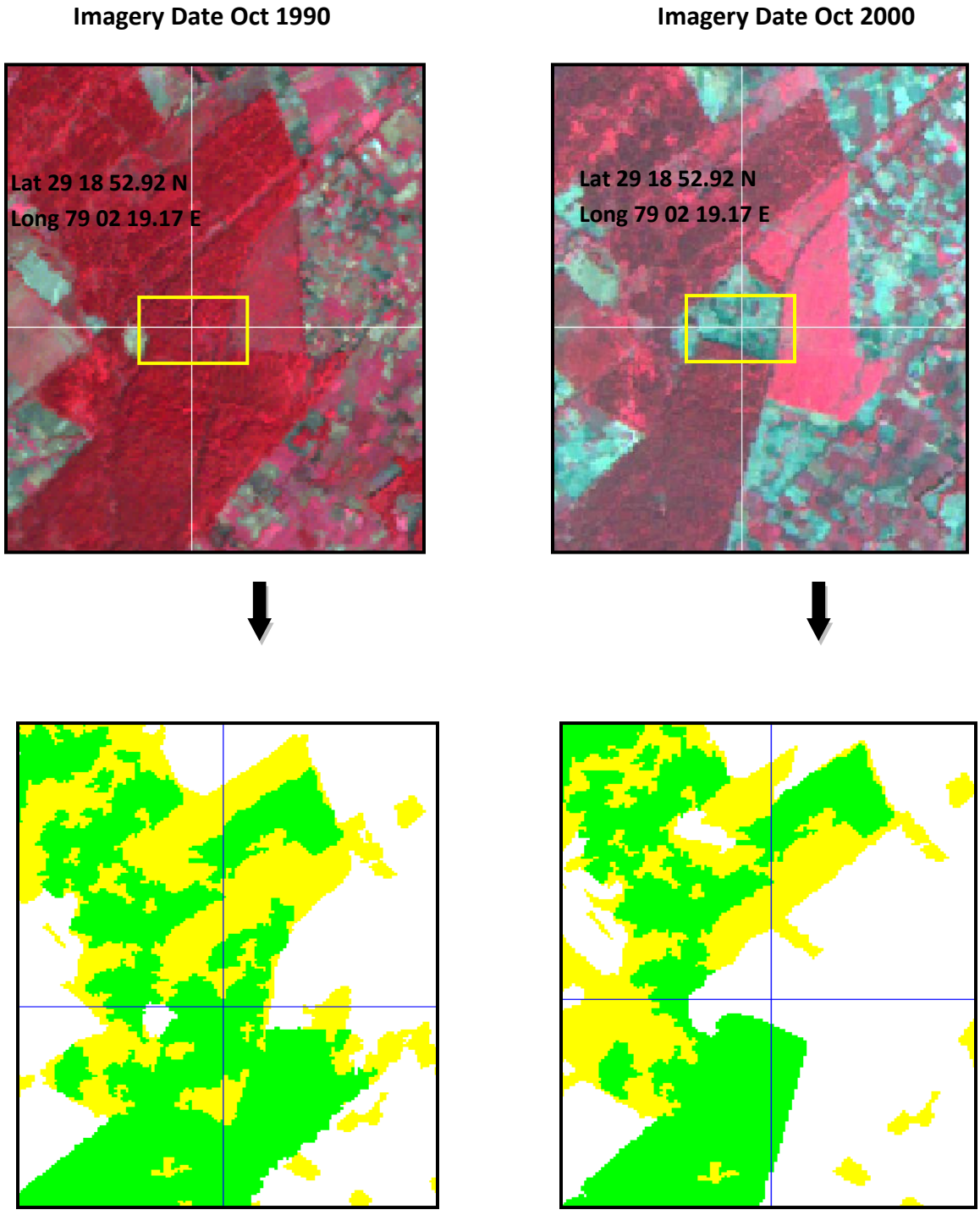


Fig. 8: **Area showing in maps falling in AUTKBTR of the reserve**

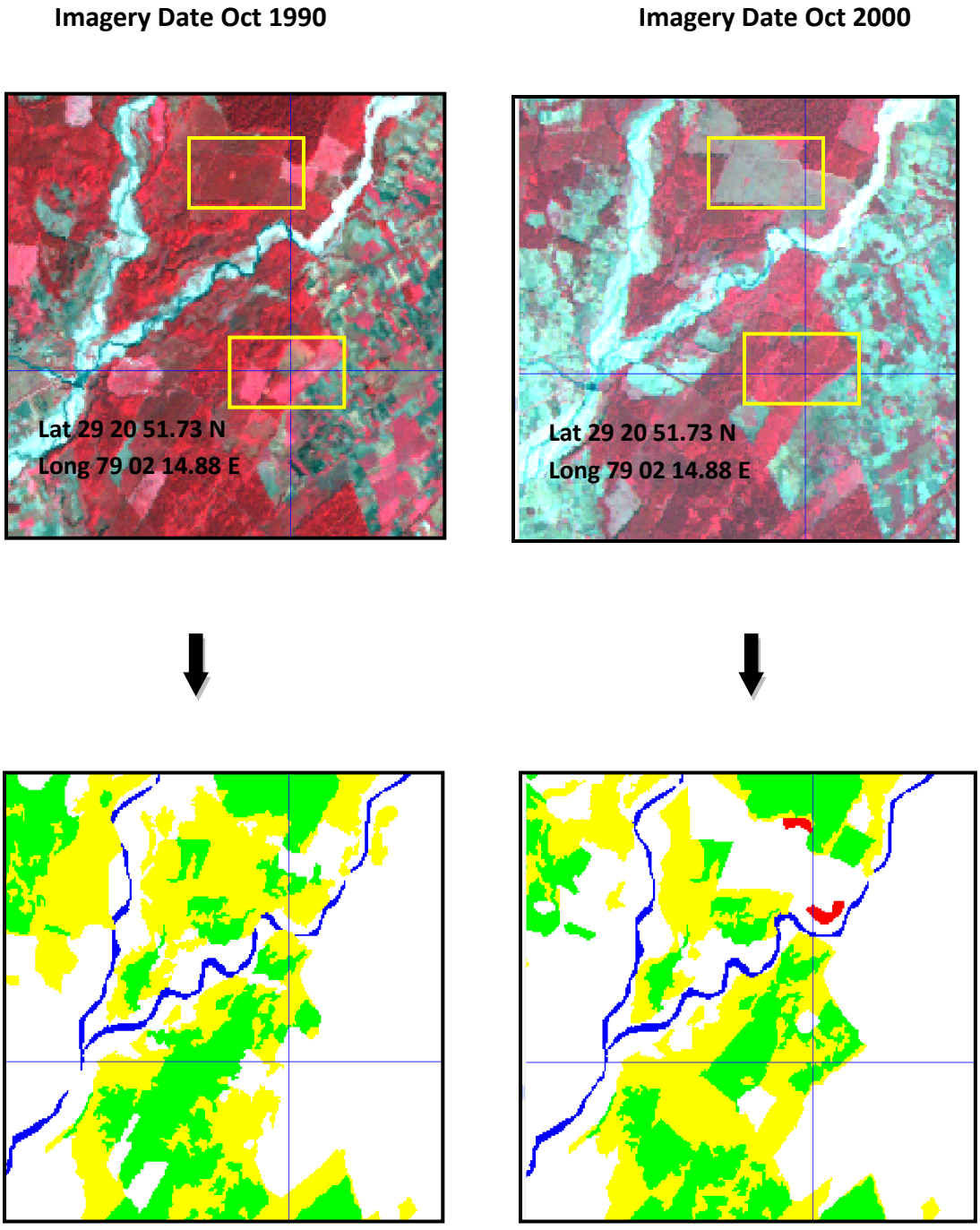


Fig.9: **Area showing in maps falling in AUTKBTR of the reserve**

2.3.2 Changes in Forest Cover during 2000-2010

- **Core Area:**

During the period of 2000 to 2010 total forest cover decreased by **2.22 sq km** in the core area of Corbett Tiger Reserve. It reveals that very dense forest in 2000 was **380.63 sq km** and in 2010 it has been increased up to **380.78 sq km**. Moderately dense forest shows a positive change from **277.82 sq km** to **277.91 sq km** during 2001 to 2010 .Open forest cover have also been decreased from **50.50 sq km** to **48.04 sq km** during that period of time. The net change shows that very dense forest, moderately dense forest and open forest have a positive change of **0.15 sq km**, **0.09 sq km** sequentially and open forest have a negative change of **2.46 sq km** at that period of time.

During the study it was found that the overall negative change in the forest cover of core area of the tiger reserve is mainly due to flood in the year 2010 in Ramganga River which caused damaged to the shisham plantation near Khinanauly. The other reasons in the decrease in forest cover are due to changes in river course of Ramganga and increase in its flood plain area. There is positive enhancement in the quality of very dense forest and moderately dense forest in core area.

Table2.3.2a: Forest Cover changes in Core Area of Corbett Tiger Reserve (2000-2010)

(Area in sq km)

Category	Assessment Year		Change
	2000	2010	
Very Dense Forest	380.63	380.78	0.15
Moderately Dense Forest	277.82	277.91	0.09
Open Forest	50.50	48.04	-2.46
Total Forest	708.95	706.73	-2.22
Scrub	0.10	0.10	0.00
Non Forest	112.94	115.16	2.22

- **Buffer Area:**

The Buffer area of Corbett Tiger Reserve is distributed in two state, **466.32 sq km** is falling in Uttarakhand **and 80.60 sq km** is falling in Uttar Pradesh.

During the period of 2000 to 2010 total forest cover decreased by **3.07 sq km** in the buffer area of Corbett Tiger Reserve. It reveals that very dense forest in 2001 was **208.43 sq km** and in 2010 it has been decreased down to **208.17 sq km**. Moderately dense forest shows a negative change from **249.13 sq km** to **247.37 sq km** during 2000 to 2010 .Open forest cover have also been decreased from **55.13 sq km** to **54.08 sq km** during that period of time.

The net change shows that very dense forest, moderately dense forest and open forest have a negative change of **0.26 sq km**, **1.76 sq km**, **and 1.05 sq km** consecutively at that period of time. During the study it was observed that the overall negative change in the forest cover of buffer area of the tiger reserve is mainly due rotational felling, flood and changes in river course of Ramganga, Mandal and Kosi river flowing through the Reserve.

Table2.3.2b: Forest Cover changes in Buffer Area of Corbett Tiger Reserve (2000-2010)

(Area in sq km)

Category	Assessment Year		Change
	2000	2010	
Very Dense Forest	208.43	208.17	-0.26
Moderately Dense Forest	249.13	247.37	-1.76
Open Forest	55.13	54.08	-1.05
Total Forest	512.69	509.62	-3.07
Scrub	0.95	0.99	0.04
Non Forest	33.28	36.31	3.03

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

During the period of 2000 to 2010 total forest cover decreased by **7.95 sq km** in the AUTKBTR of Corbett Tiger Reserve. It reveals that very dense forest in 2000 was **260.46 sq km** and in 2010 it has been increased up to **260.61 sq km**. Moderately dense forest shows a negative change from **538.83 sq km** to **531.82 sq km** during 2000 to 2010. Open forest cover has also been decreased from **234.60 sq km** to **233.51 sq km** during that period of time.

The net change shows that very dense forest has a positive change of **0.15 sq km**; moderately dense forest and open forest have a negative change of **7.01 sq km**, **1.09 sq km** sequentially at that period of time. The causes for negative changes observed in forest cover are mainly due to rotational felling, increase in the flood plain area and changes in the river course of Kosi, Dabka, Khoh and Pikha river. The other important factors in decrease in forest cover are mainly due to the anthropogenic activities like felling of trees, human intervention and increase in the collection of fuel wood.

Table2.3.2c: Forest Cover changes in AUTKBTR of Corbett Tiger Reserve (2000-2010)

(Area in sq km)

Category	Assessment Year		Change
	2000	2010	
Very Dense Forest	260.46	260.61	0.15
Moderately Dense Forest	538.83	531.82	-7.01
Open Forest	234.60	233.51	-1.09
Total Forest	1033.89	1025.94	-7.95
Scrub	1.19	4.02	2.83
Non Forest	1047.34	1052.46	5.12

CHANGES OF FOREST COVER DURING 10YEARS (2000-2010)

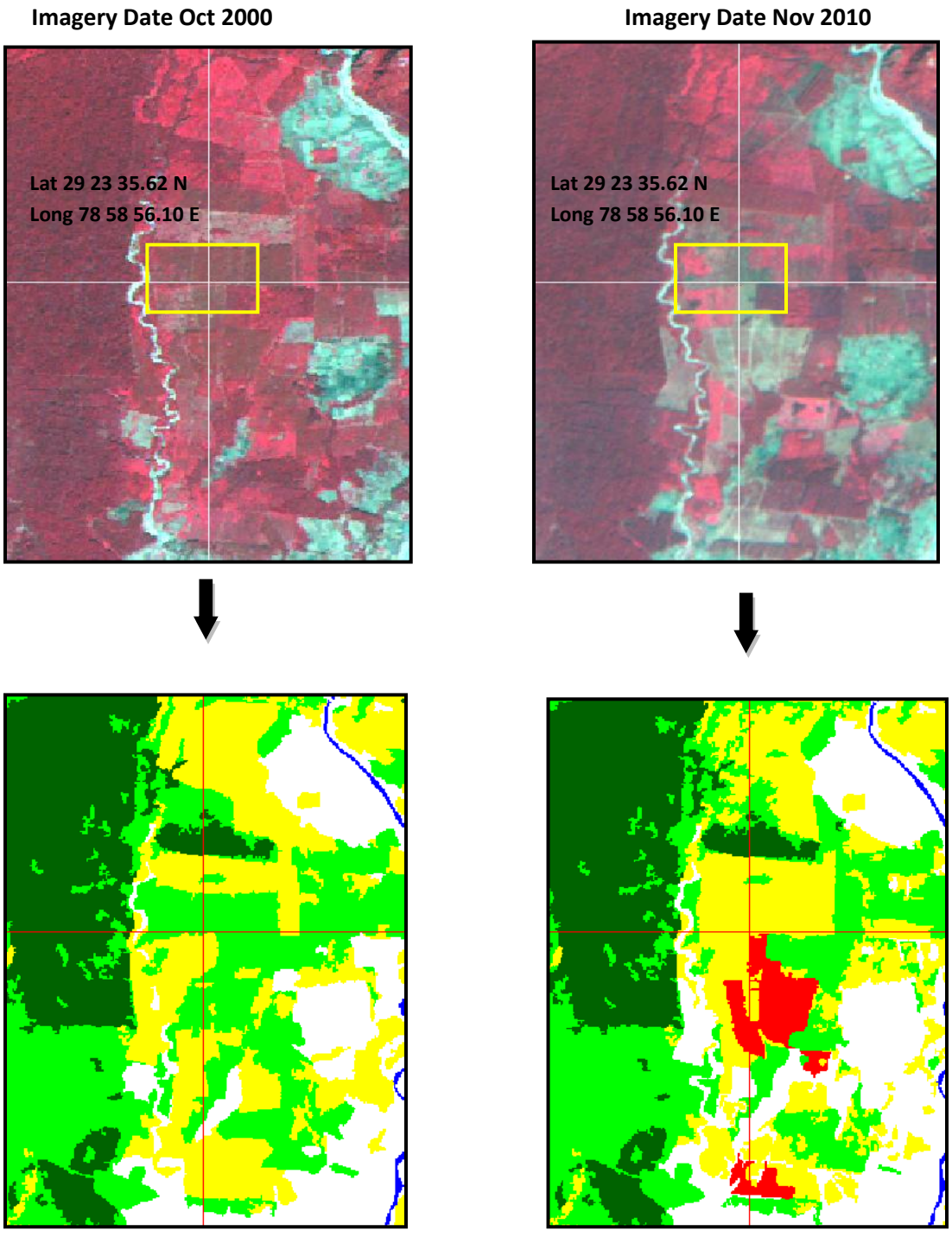


Fig. 1: **Area showing in maps falling in Buffer area (Dhela Range) of the reserve**

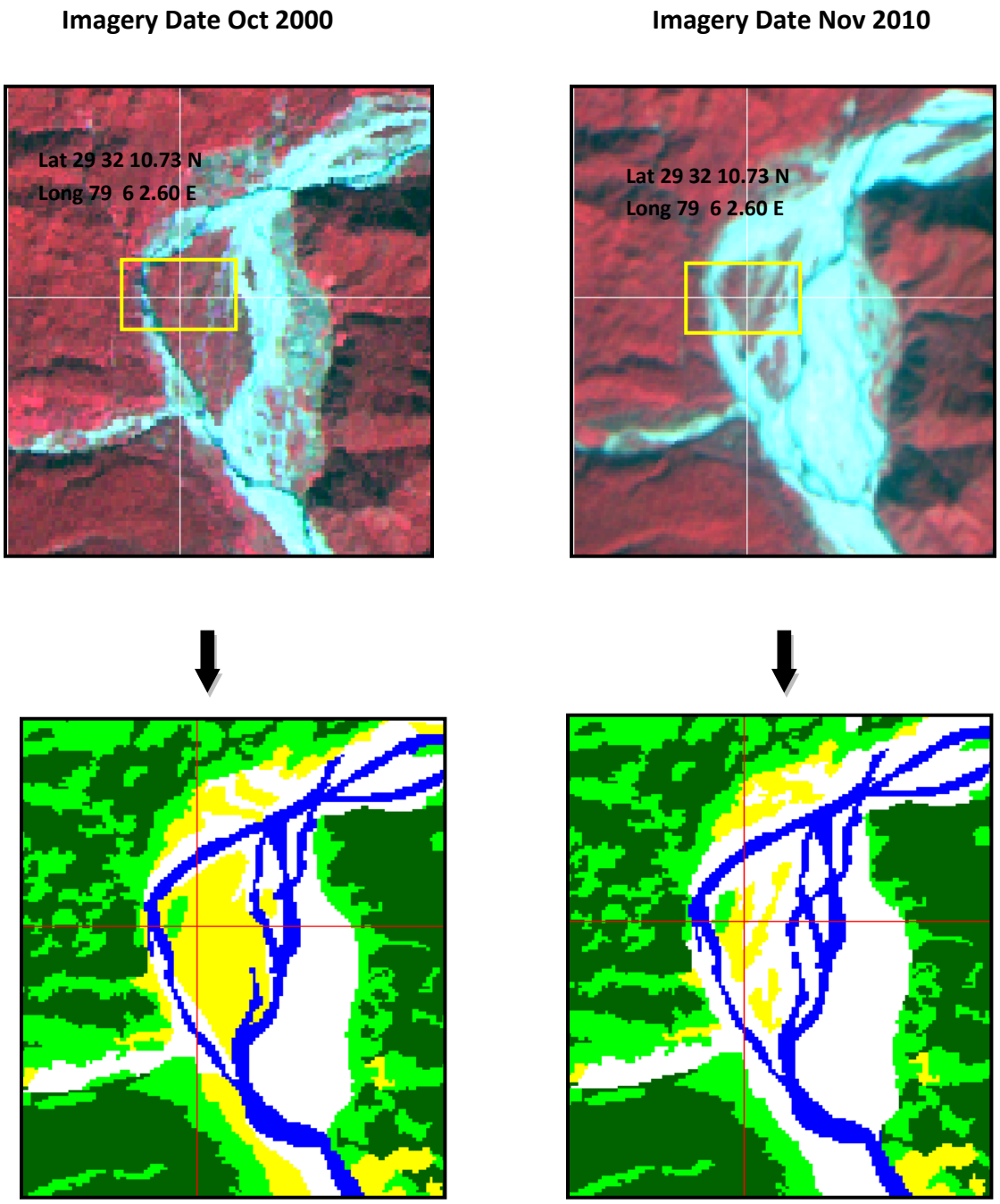


Fig. 2: **Area showing in maps falling in AUTKBTR of the reserve**

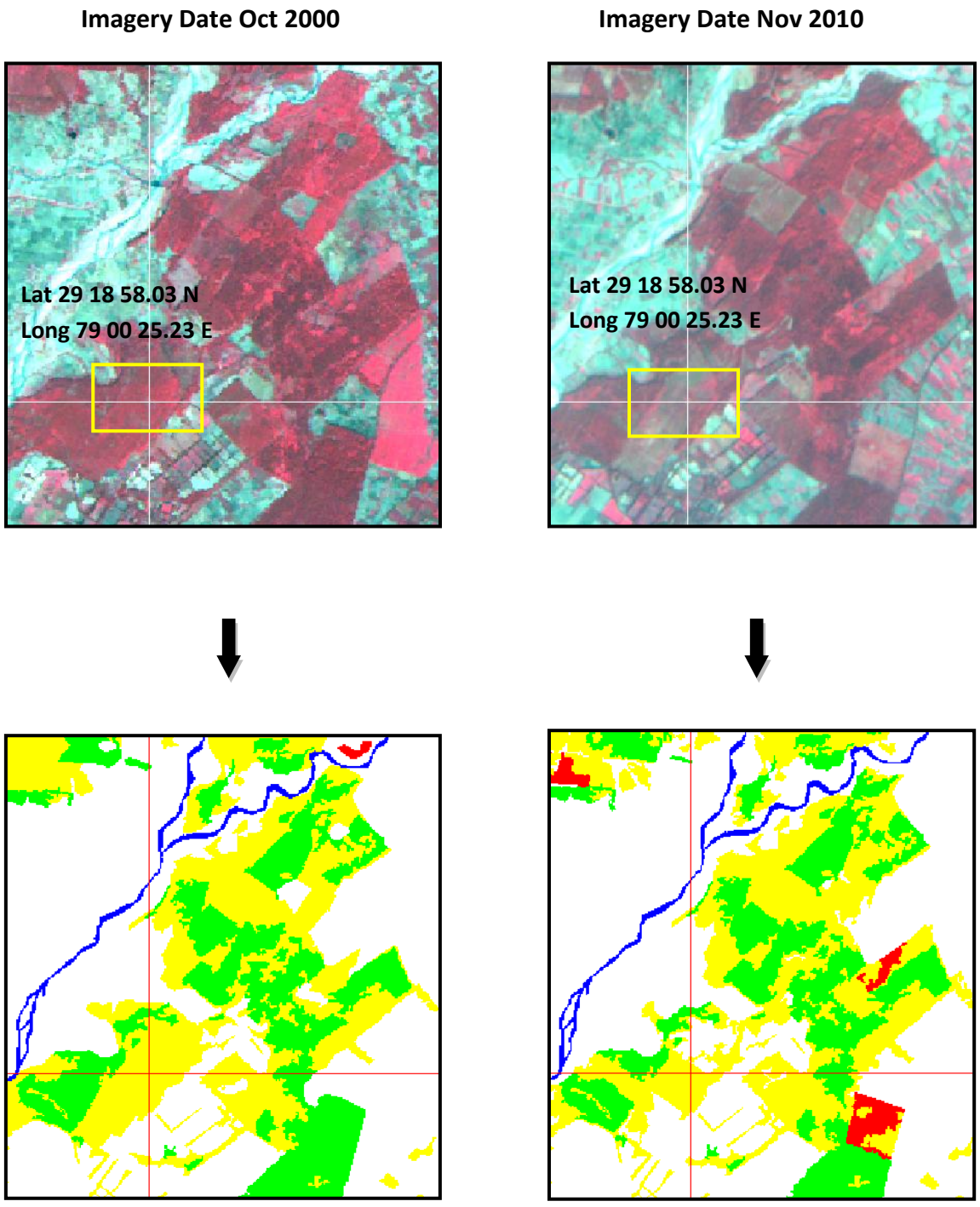


Fig.3: **Area showing in maps falling in AUTKBTR of the reserve**

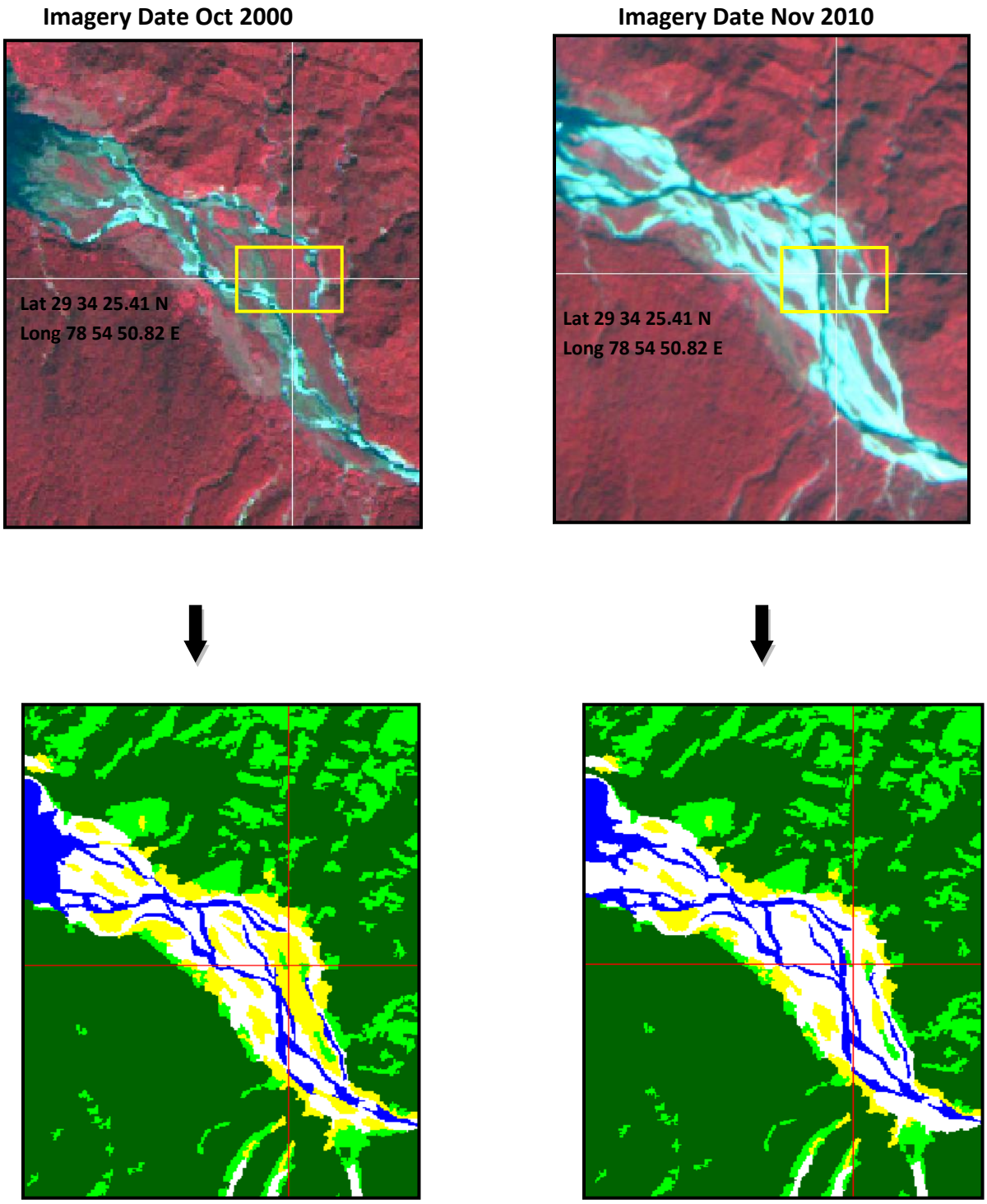


Fig. 4: **Area showing in maps falling in Core area (Dhikala Range) of the reserve**

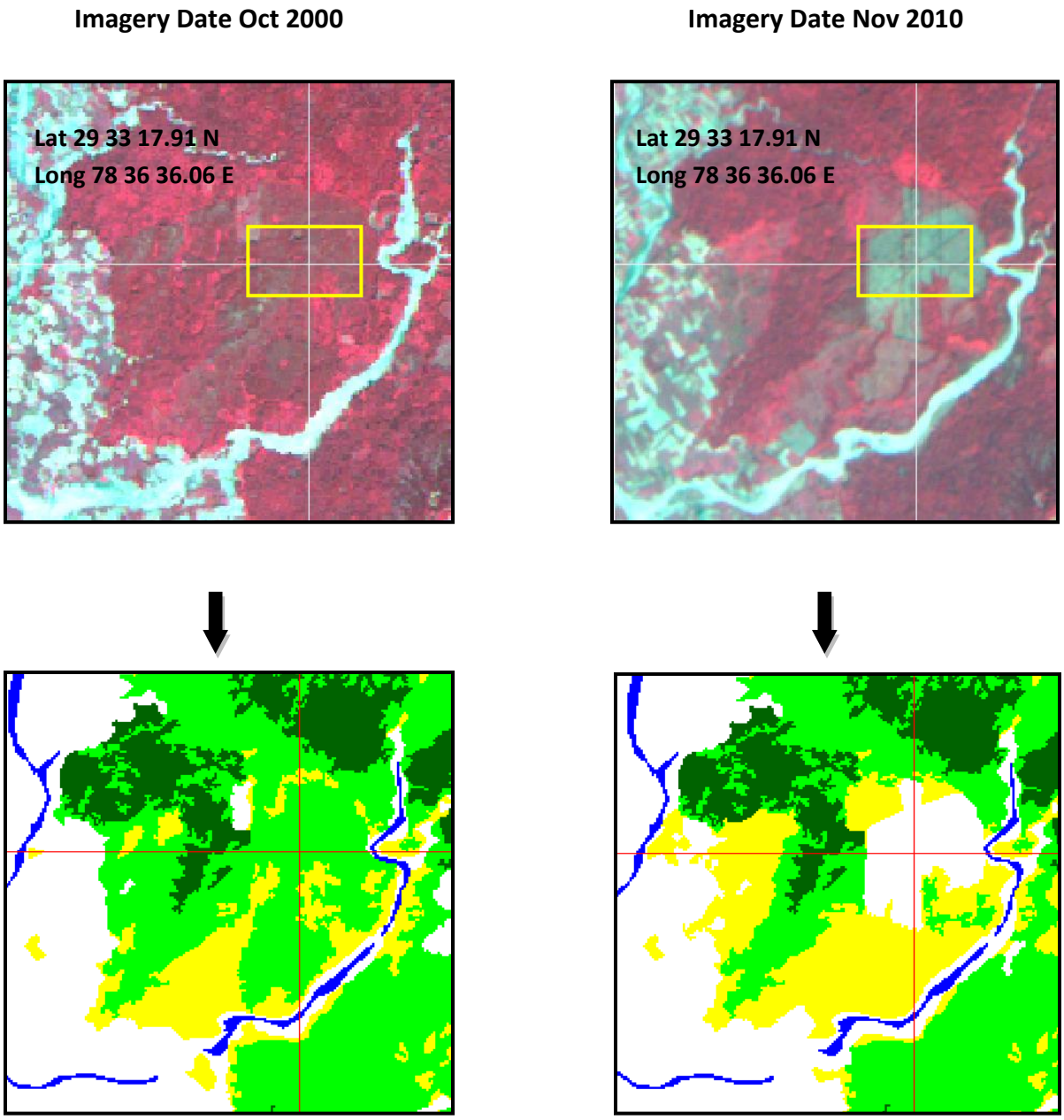


Fig. 5: **Area showing in maps falling in AUTKBTR of the reserve**

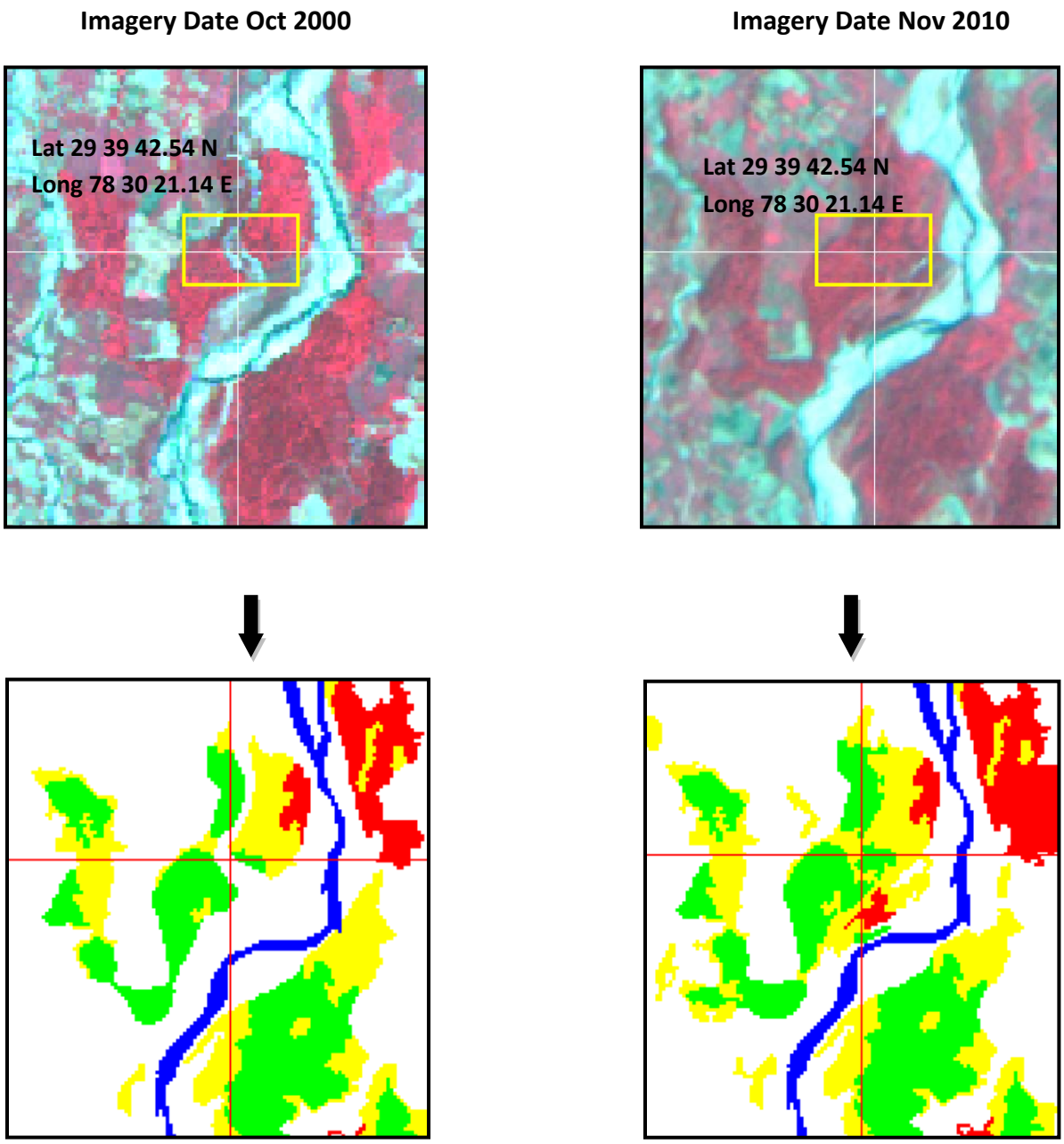


Fig. 6: **Area showing in maps falling in AUTKBTR of the reserve**

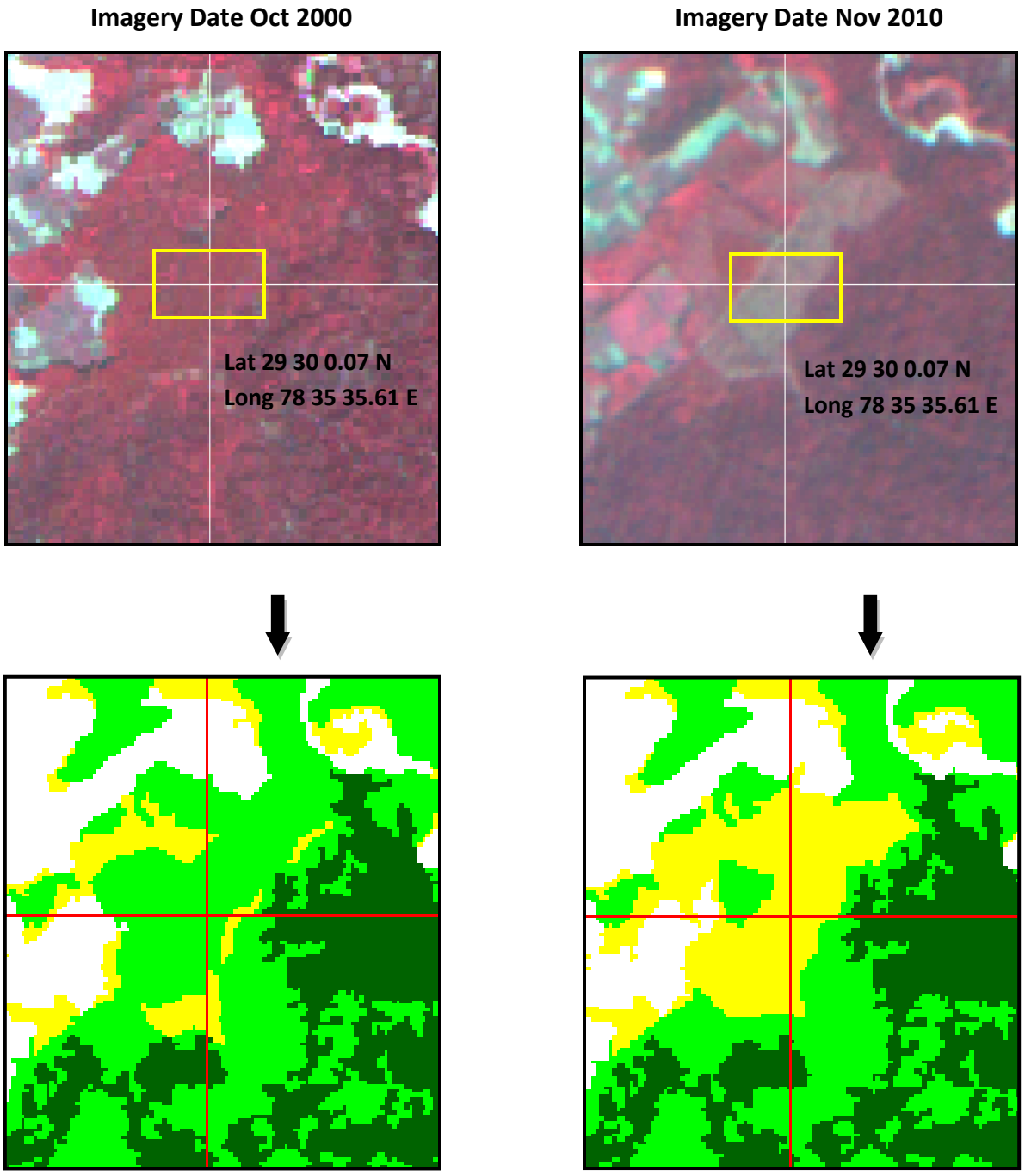


Fig. 7: **Area showing in maps falling in AUTKBTR of the reserve**

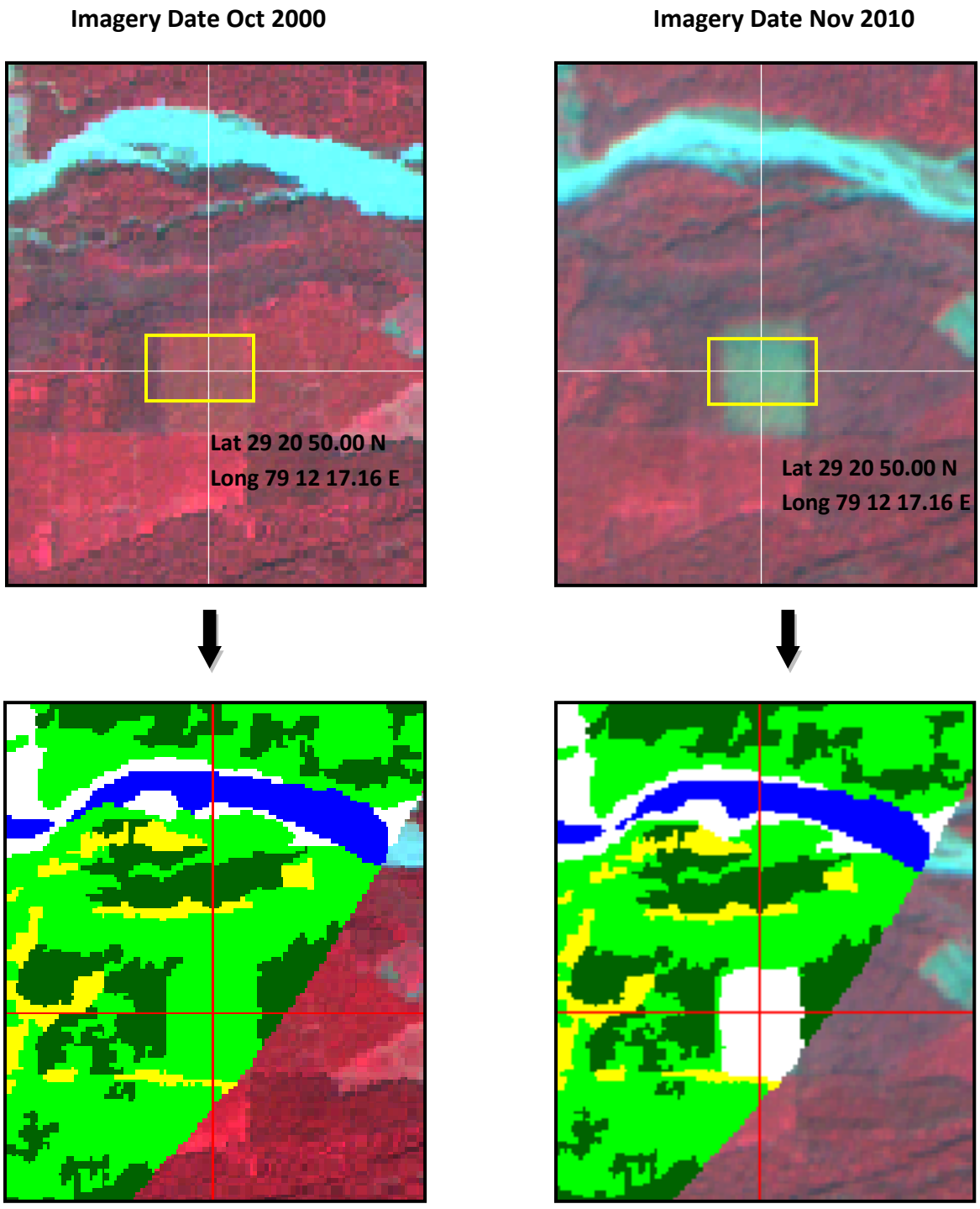


Fig. 8: **Area showing in maps falling in AUTKBTR of the reserve**

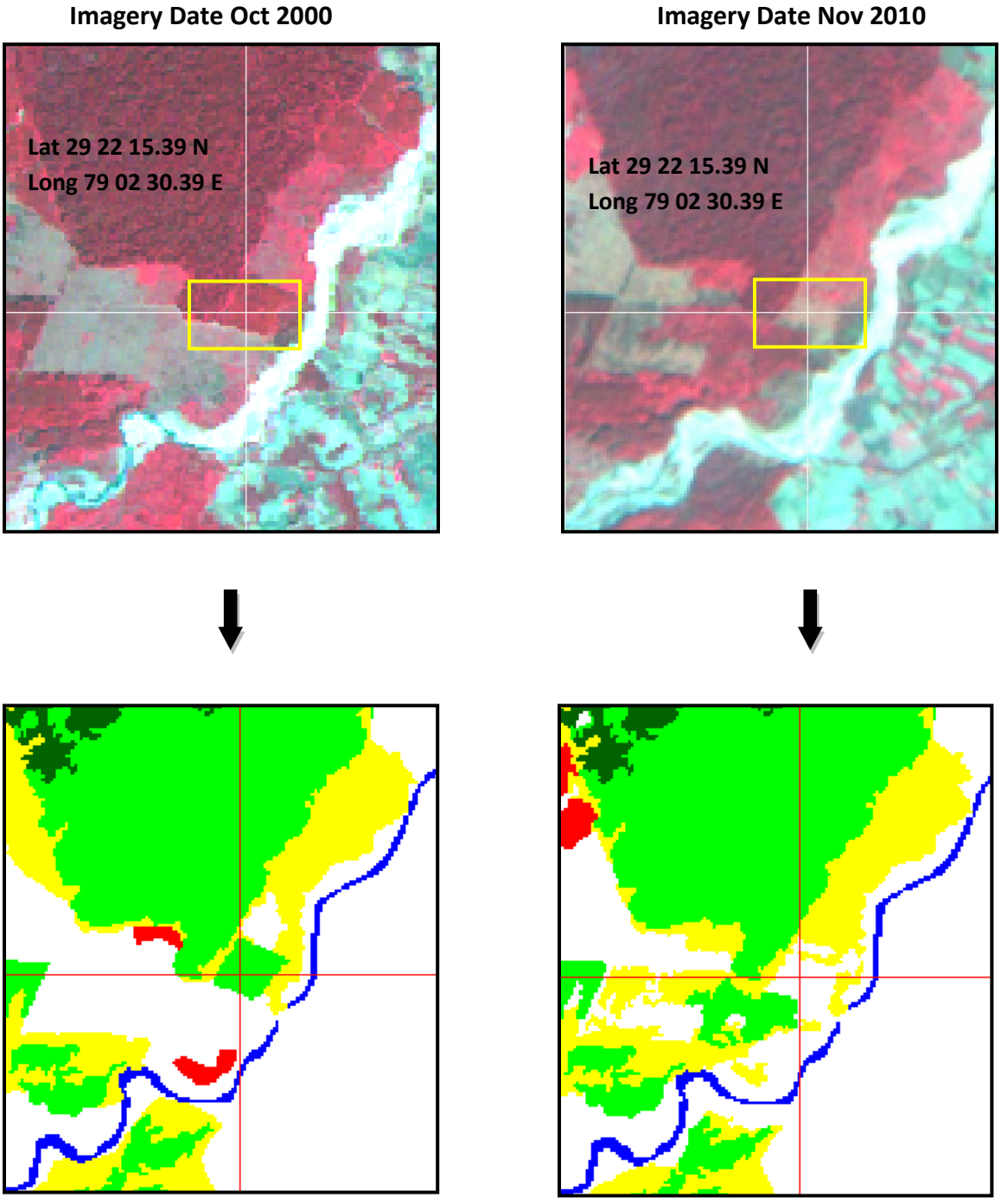


Fig. 9: **Area showing in maps falling in Buffer area of the reserve**

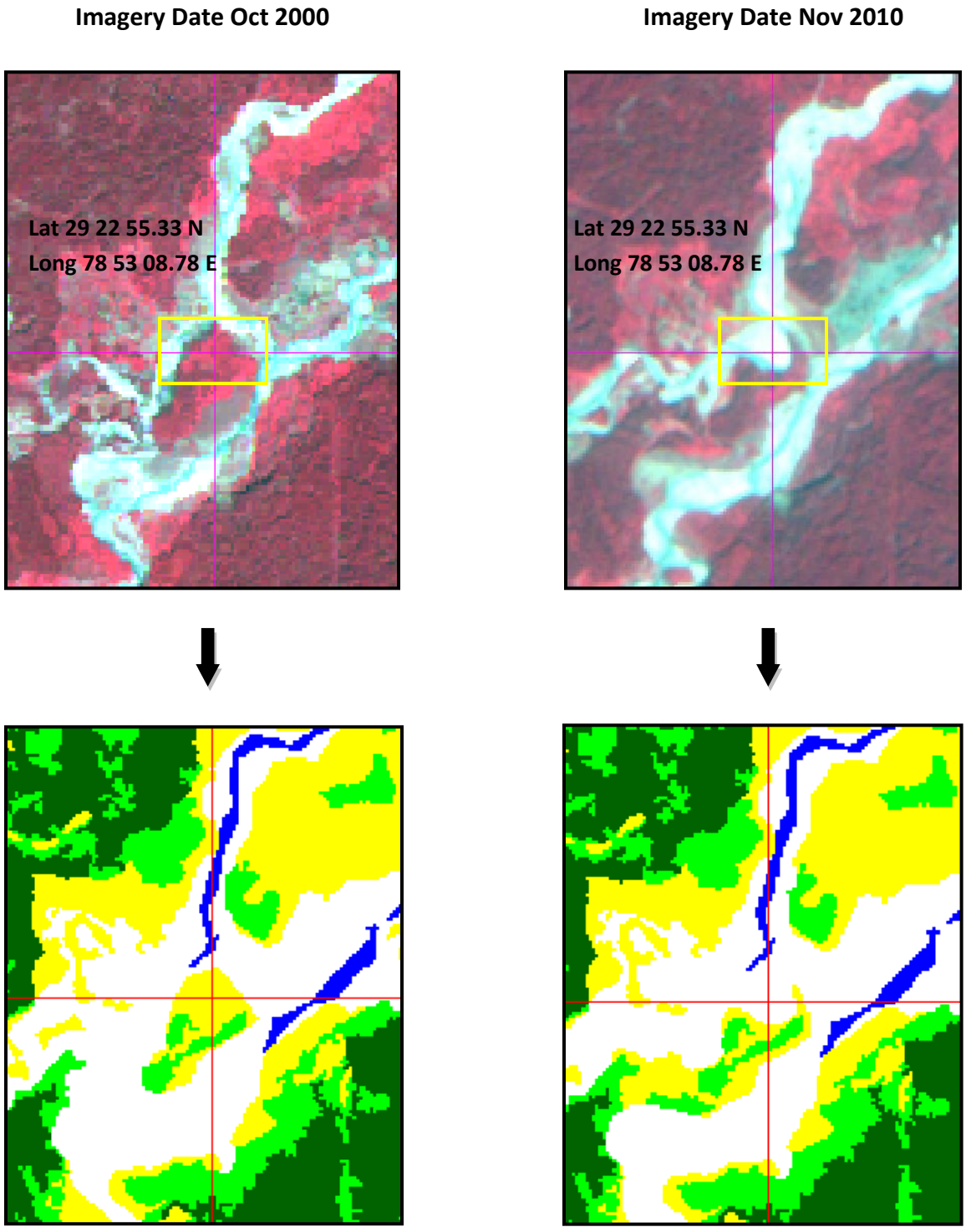


Fig. 10: **Area showing in maps falling in Buffer area of the reserve**

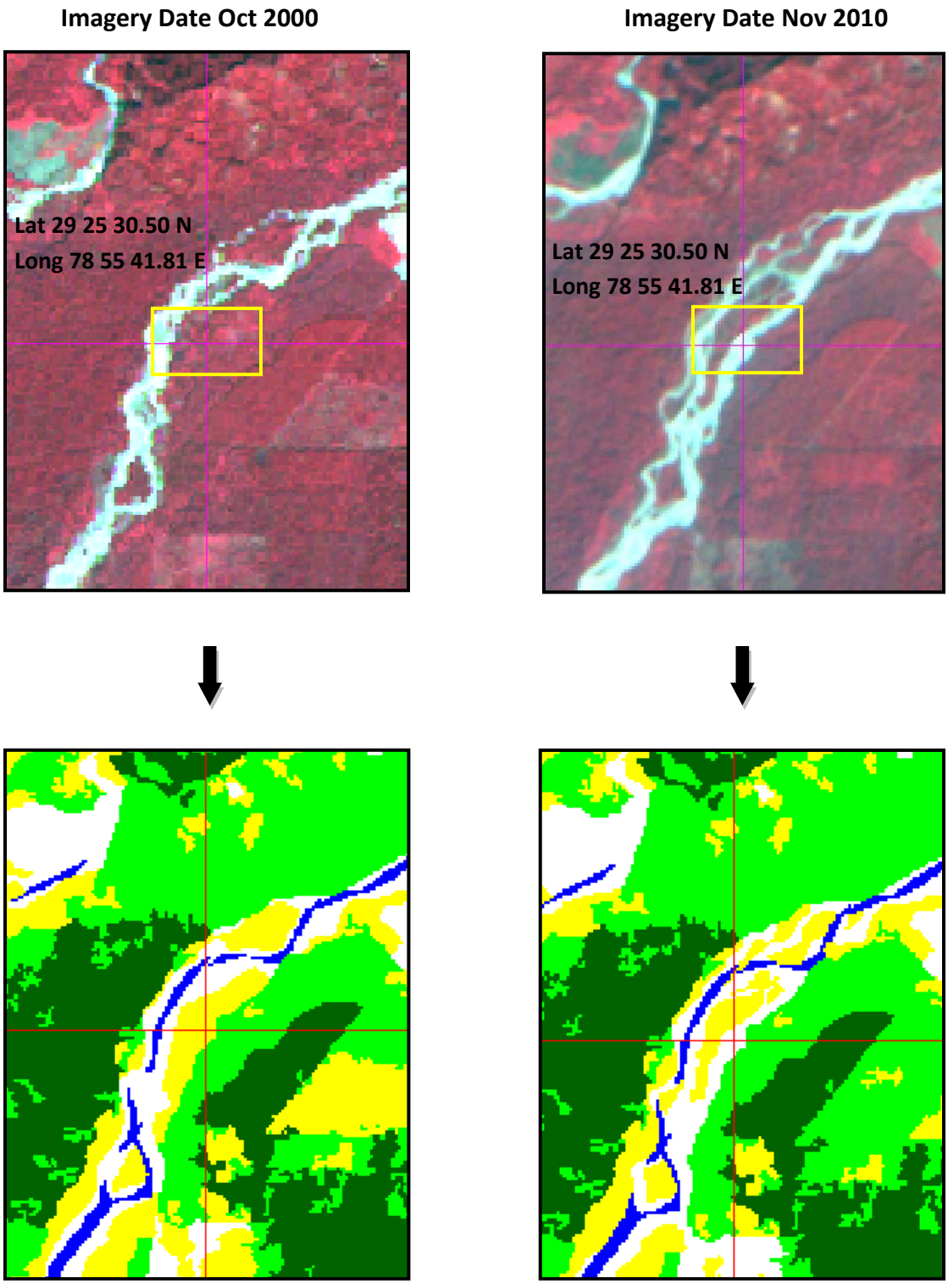


Fig. 11: **Area showing in maps falling in Buffer area of the reserve**

2.3.3 Changes in Forest Cover during 1990-2010

- **Core Area:**

During the period of 1990 to 2010 total forest cover decreased by **2.16 sq km** in the core area of Corbett Tiger Reserve. It reveals that very dense forest in 1990 was **380.22 sq km** and in 2010 it has been increased up to **380.78 sq km**. Moderately dense forest shows a positive change from **276.67 sq km** to **277.91 sq km** during 1990 to 2010. Open forest cover has been decreased from **52.00 sq km** to **48.04 sq km** during that period of time. The net change shows that very dense forest and moderately dense forest have positive change of **0.56 sq km**, **1.24 sq km** sequentially and open forest has a negative change of **3.96 sq km** at that period of time.

The positive change or improvement in very dense forest and moderately dense forest in core area of the reserve signifies qualitatively and quantitatively enhancements in the forest cover. This is a result of better habitat management, protection & conservation strategies by the Park authority and lesser human intervention. The overall negative change in the total forest cover is mainly due to flood in the year 2010 in Ramganga River which caused damaged to the shisham plantation near Khinanauly. The other reasons in the decrease in forest cover are due to changes in river course and increase in its flood plain area.

Table2.3.3a: Forest Cover changes in Core Area of Corbett Tiger Reserve (1990-2010)

(Area in sq km)

Category	Assessment Year		Change
	1990	2010	
Very Dense Forest	380.22	380.78	0.56
Moderately Dense Forest	276.67	277.91	1.24
Open Forest	52.00	48.04	-3.96
Total Forest	708.89	706.73	-2.16
Scrub	0.11	0.10	-0.01
Non Forest	112.99	115.16	2.17

- **Buffer Area :**

The Buffer area of Corbett Tiger Reserve is distributed in two state, **466.32 sq km** is falling in Uttarakhand **and 80.60 sq km** is falling in Uttar Pradesh.

During the period of 1990 to 2010 total forest cover has a change of **0.01sq km** in the buffer area of Corbett Tiger Reserve. It reveals that very dense forest in 1990 was **208.69 sq km** and in 2010 it has been decreased down to **208.17 sq km**. Moderately dense forest shows a positive change from **246.02 sq km** to **247.37 sq km** during 1990 to 2010 .Open forest cover have been decreased from **54.90 sq km** to **54.08 sq km** during that period of time.

The net change shows that very dense forest and open forest have negative change of **0.52 sq km**, **0.82 sq km** sequentially and moderately dense forest has a positive change of **1.35 sq km** at that period of time. The study shows the stability in the forest cover of buffer area over two decades. This is a result of better management practices and habitat management which yielded a positive result which is evident with increase in MDF and overall stability in total forest area. It has been observed that the negative changes are a result of rotational felling, flood and changes in river course flowing through the reserve.

Table2.3.3b: Forest Cover change in Buffer Area of Corbett Tiger Reserve (1990-2010)

(Area in sq km)

Category	Assessment Year		Change
	1990	2010	
Very Dense Forest	208.69	208.17	-0.52
Moderately Dense Forest	246.02	247.37	1.35
Open Forest	54.90	54.08	-0.82
Total Forest	509.61	509.62	0.01
Scrub	1.40	0.99	-0.41
Non Forest	35.91	36.31	0.40

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

During the period of 1990 to 2010 total forest cover decreased by **13.38 sq km** in the AUTKBTR of Corbett Tiger Reserve. It reveals that very dense forest in 1990 was **261.02 sq km** and in 2010 it has been decreased down to **260.61 sq km**. Moderately dense forest shows a negative change from **541.67 sq km** to **531.82 sq km** during 1990 to 2010. Open forest cover has also been decreased from **236.63 sq km** to **233.51 sq km** during that period of time.

The net change shows that very dense forest, moderately dense forest and open forest have a negative change of **0.41 sq km, 9.85 sq km**, **and 3.12 sq km** sequentially at that period of time. The causes for negative changes observed in forest cover are mainly due to rotational felling, increase in the flood plain area and changes in the river course of Kosi, Dabka, Khoh and Pikha river. Anthropogenic activities like felling of trees, human intervention and increase in the collection of fuel wood also played important role in decrease in forest cover.

Table2.3.3c: Forest Cover changes in AUTKBTR of Corbett Tiger Reserve (1990-2010)

(Area in sq km)

Category	Assessment Year		Change
	1990	2010	
Very Dense Forest	261.02	260.61	-0.41
Moderately Dense Forest	541.67	531.82	-9.85
Open Forest	236.63	233.51	-3.12
Total Forest	1039.32	1025.94	-13.38
Scrub	1.03	4.02	2.99
Non Forest	1042.07	1052.46	10.39

CHANGES OF FOREST COVER DURING 20 YEARS (1990-2010)

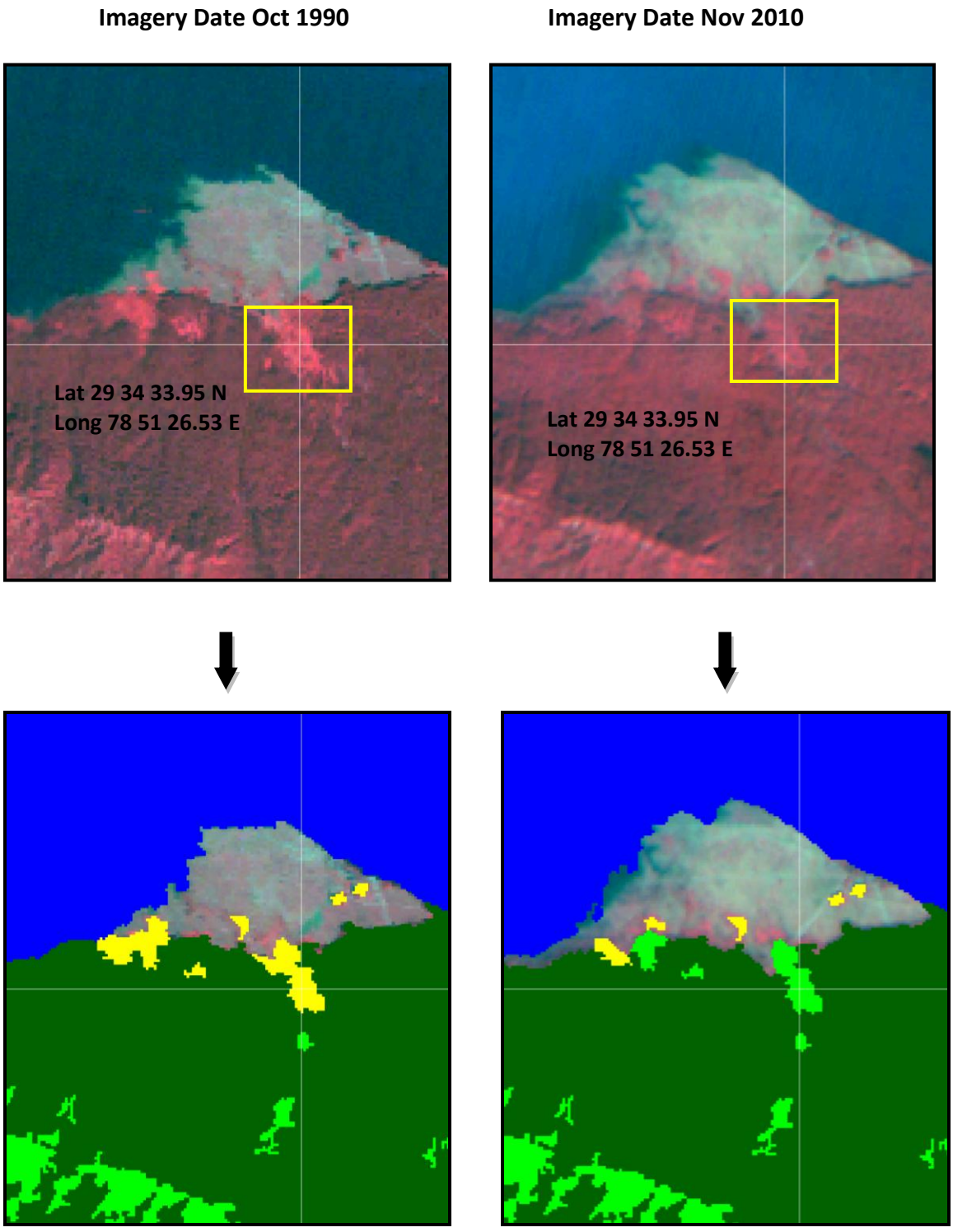


Fig. 1: **Area showing in maps falling in Core area (Dhikala Range) of the reserve**

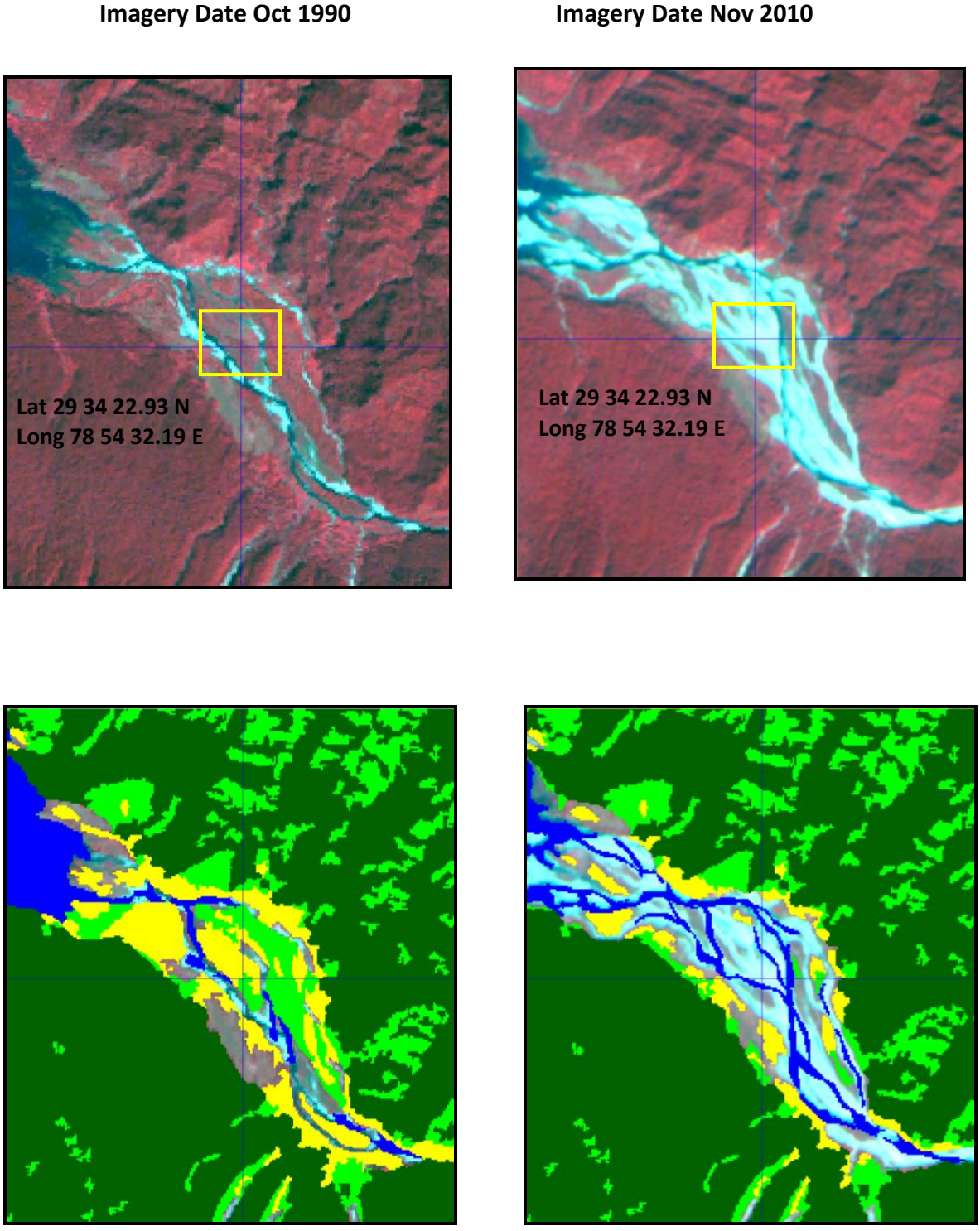


Fig. 2: **Area showing in maps falling in Core area (Dhikala Range) of the reserve**

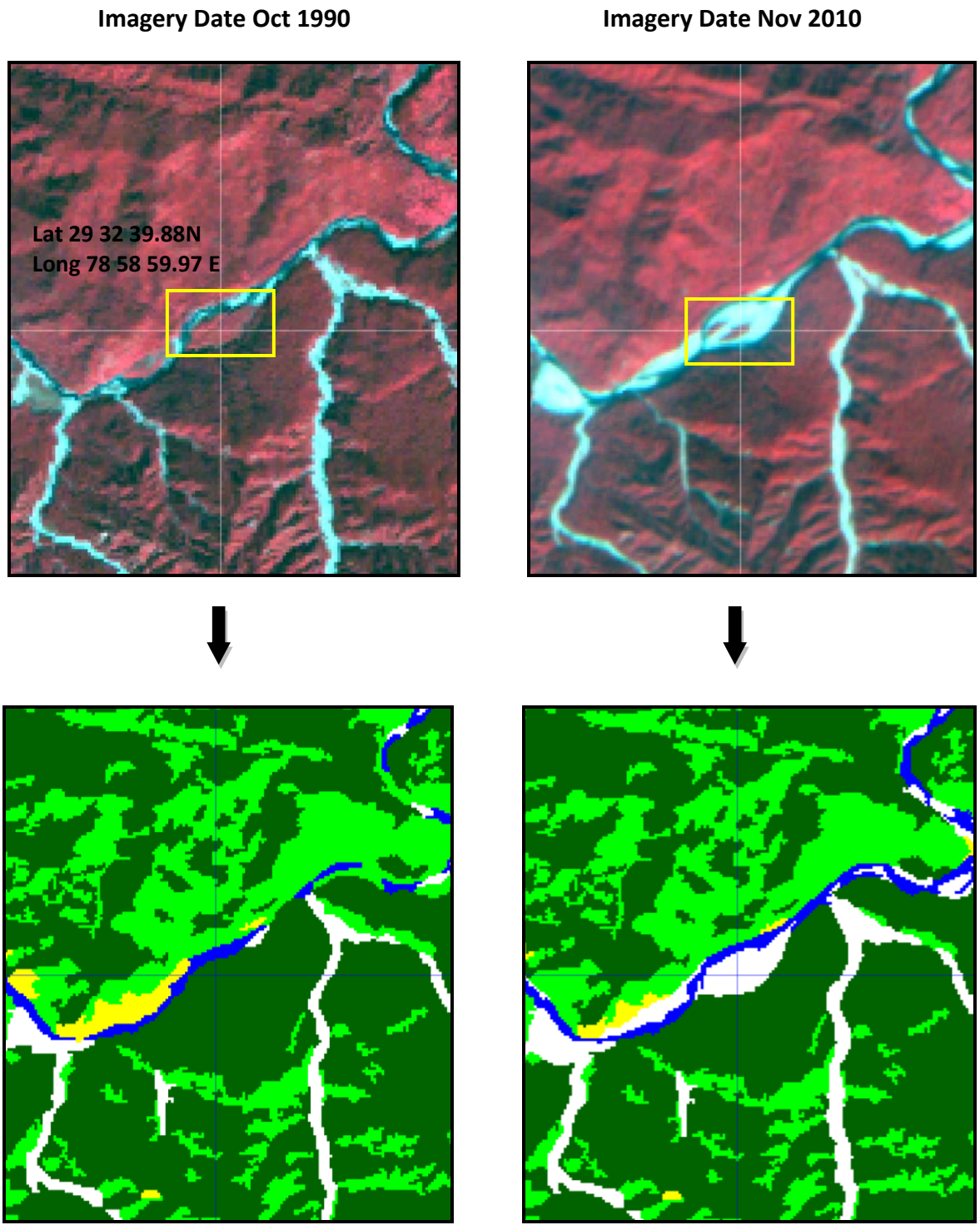


Fig. 3: **Area showing in maps falling in Core area (Sarpduli Range) of the reserve**

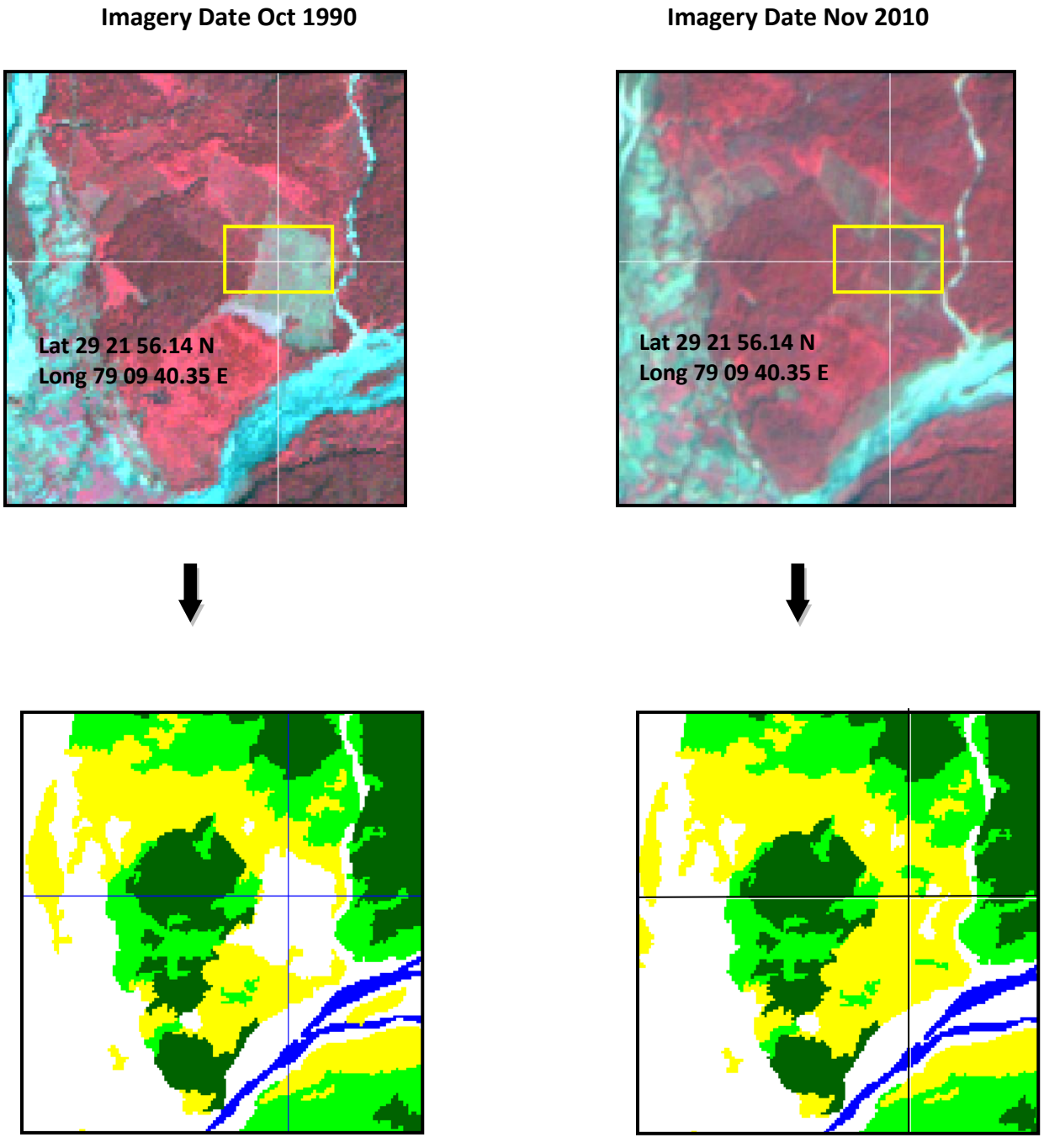


Fig.4: **Area showing in maps falling in AUTKBTR of the reserve**

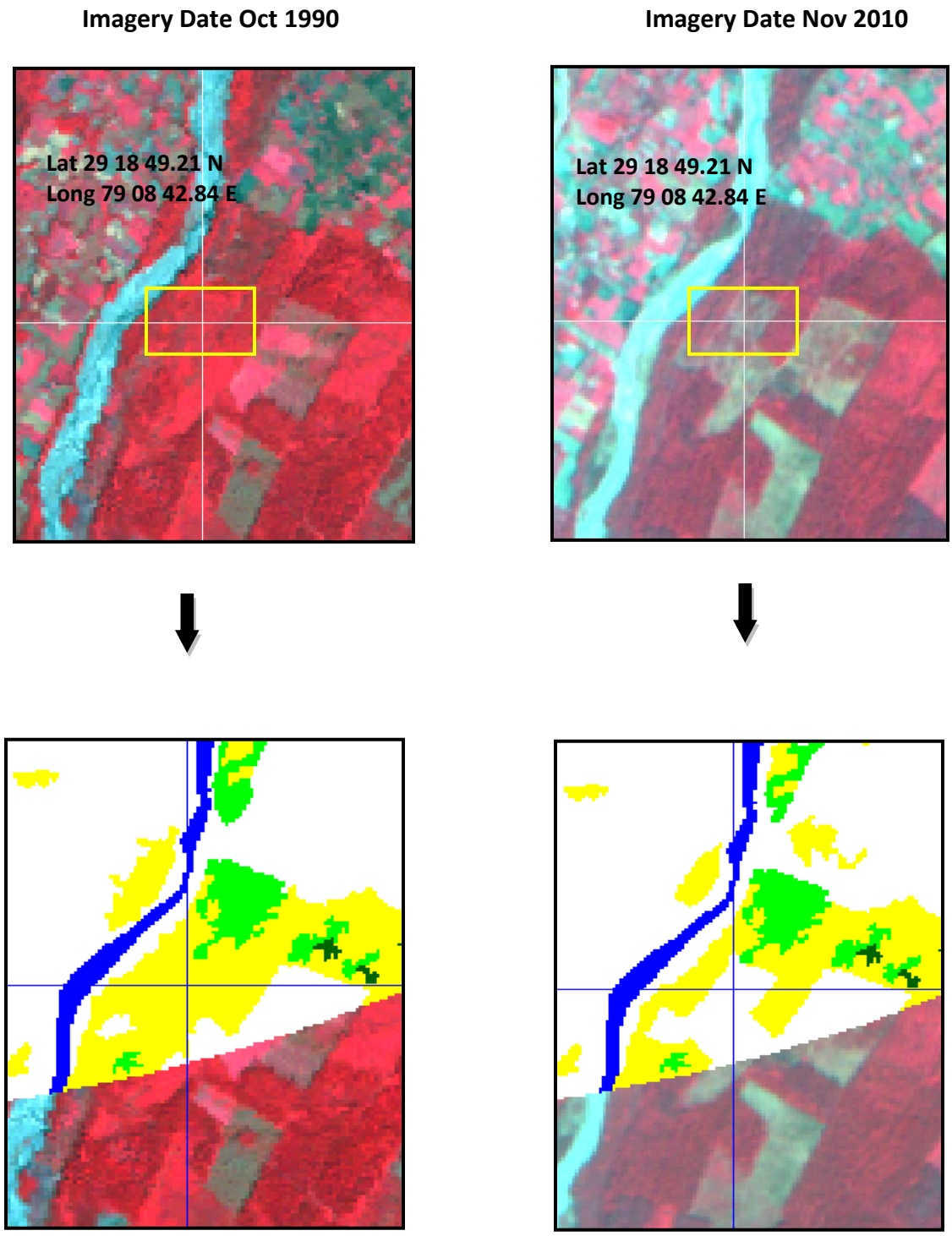


Fig. 5: **Area showing in maps falling in AUTKBTR of the reserve**

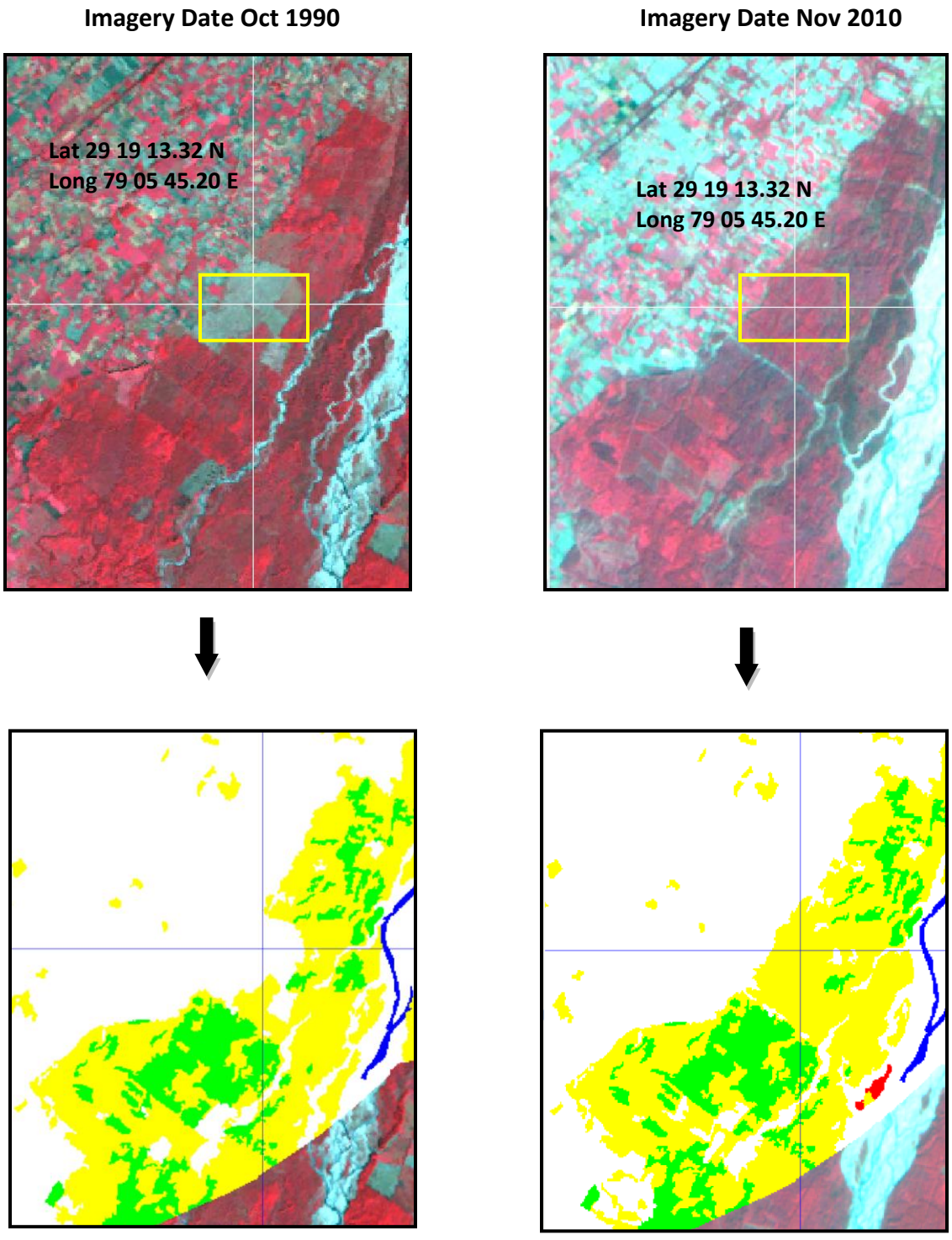


Fig. 6: **Area showing in maps falling in AUTKBTR of the reserve**

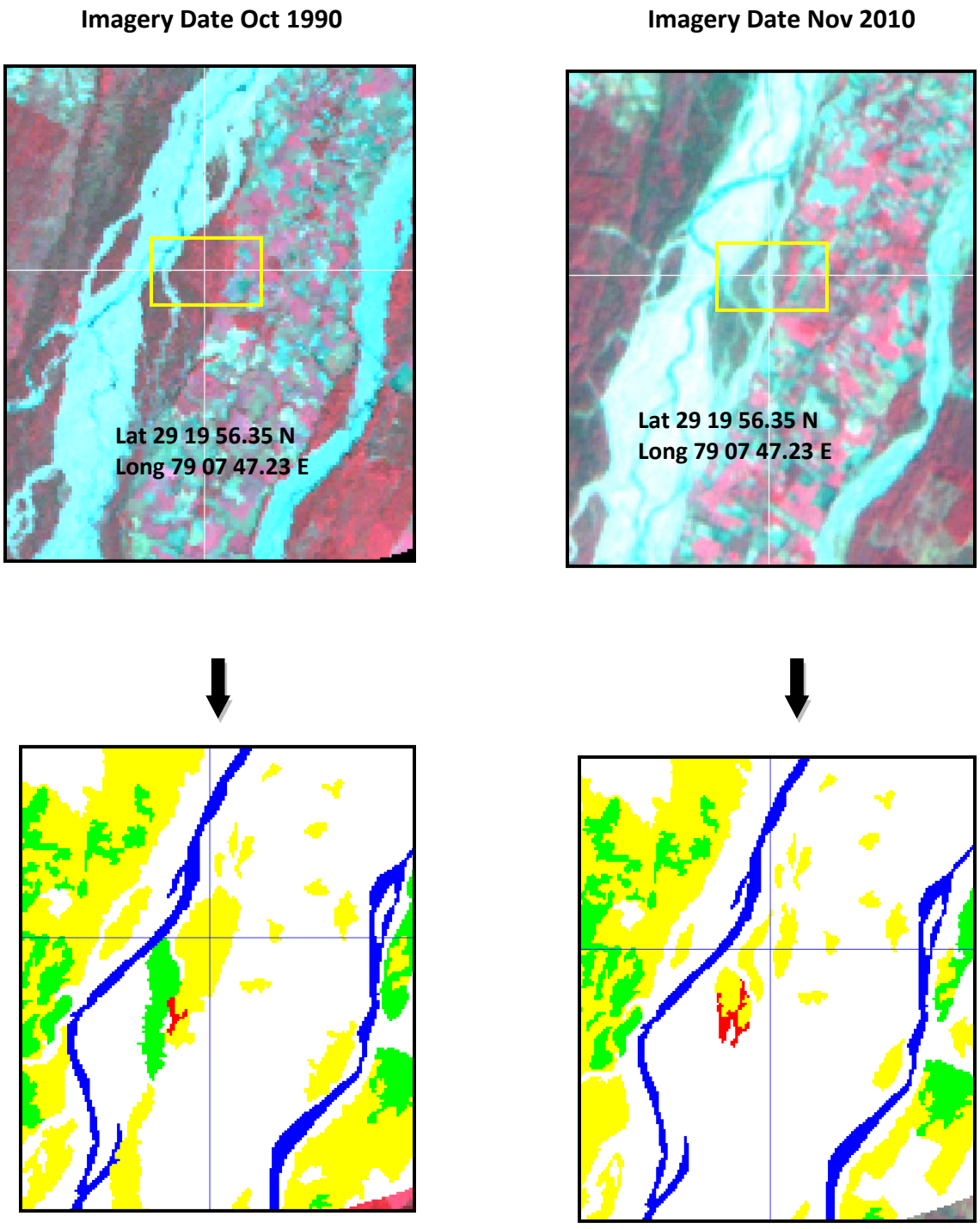


Fig. 7: **Area showing in maps falling in AUTKBTR of the reserve**

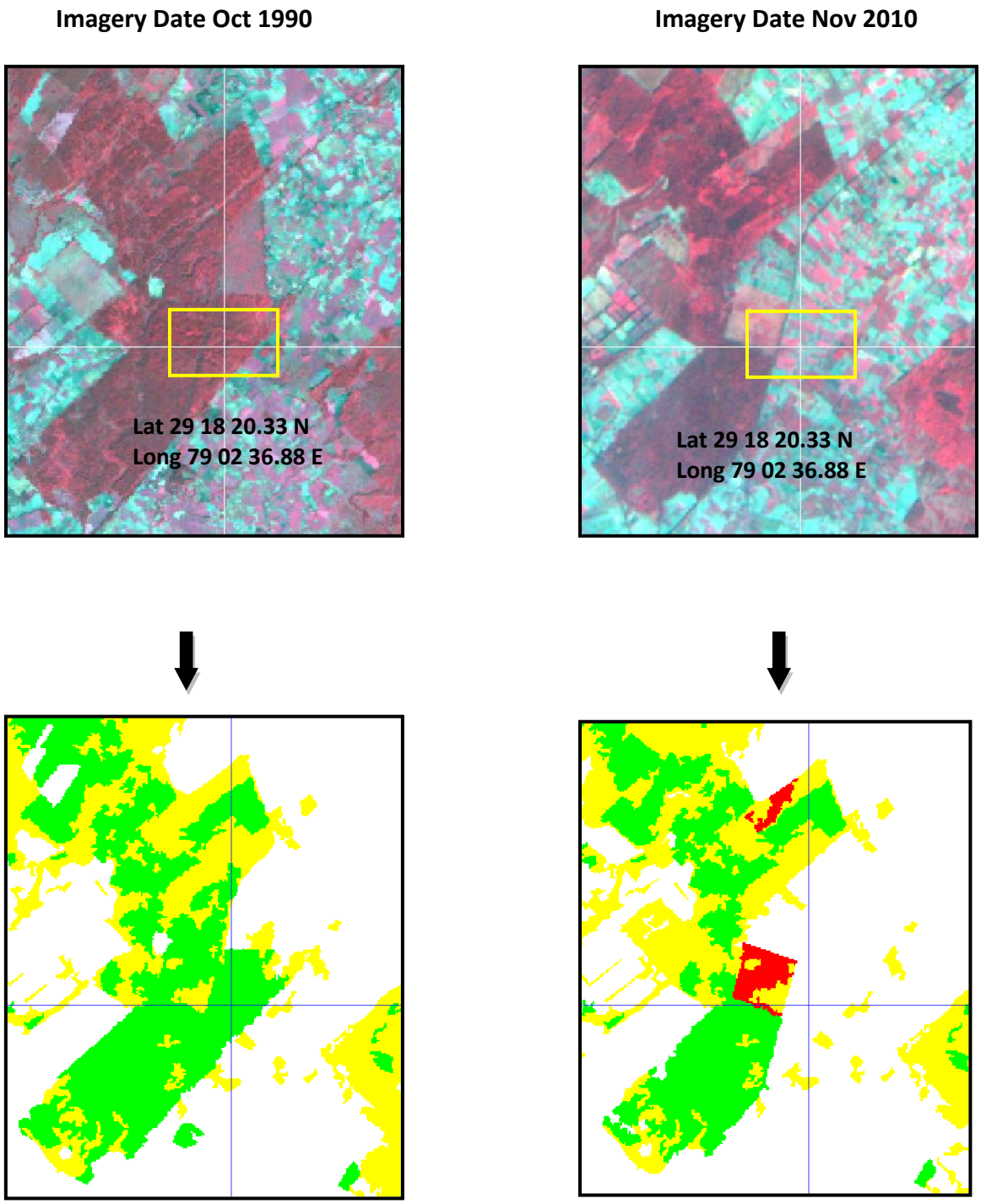


Fig. 8: **Area showing in maps falling in AUTKBTR of the reserve**

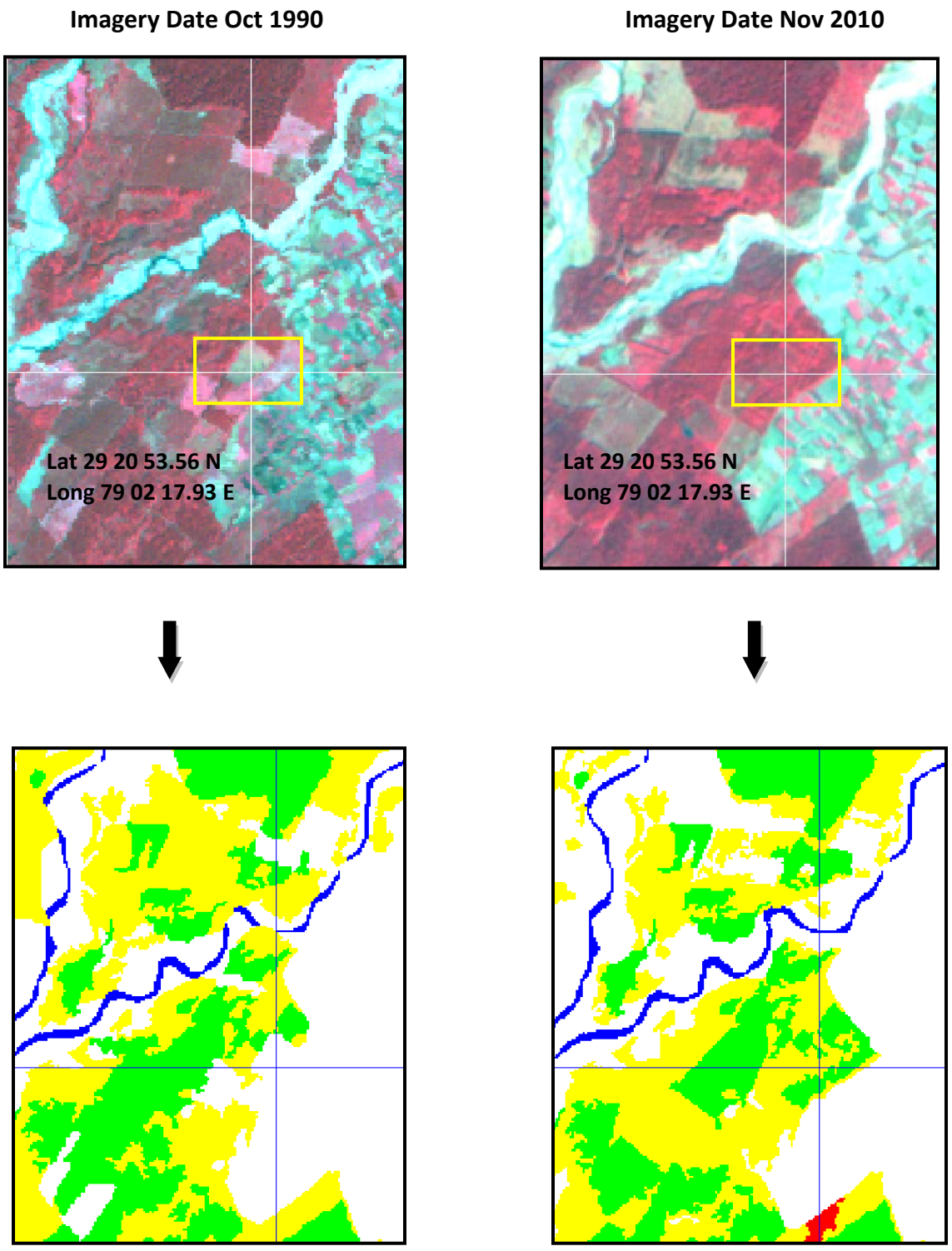


Fig. 9: **Area showing in maps falling in AUTKBTR of the reserve**

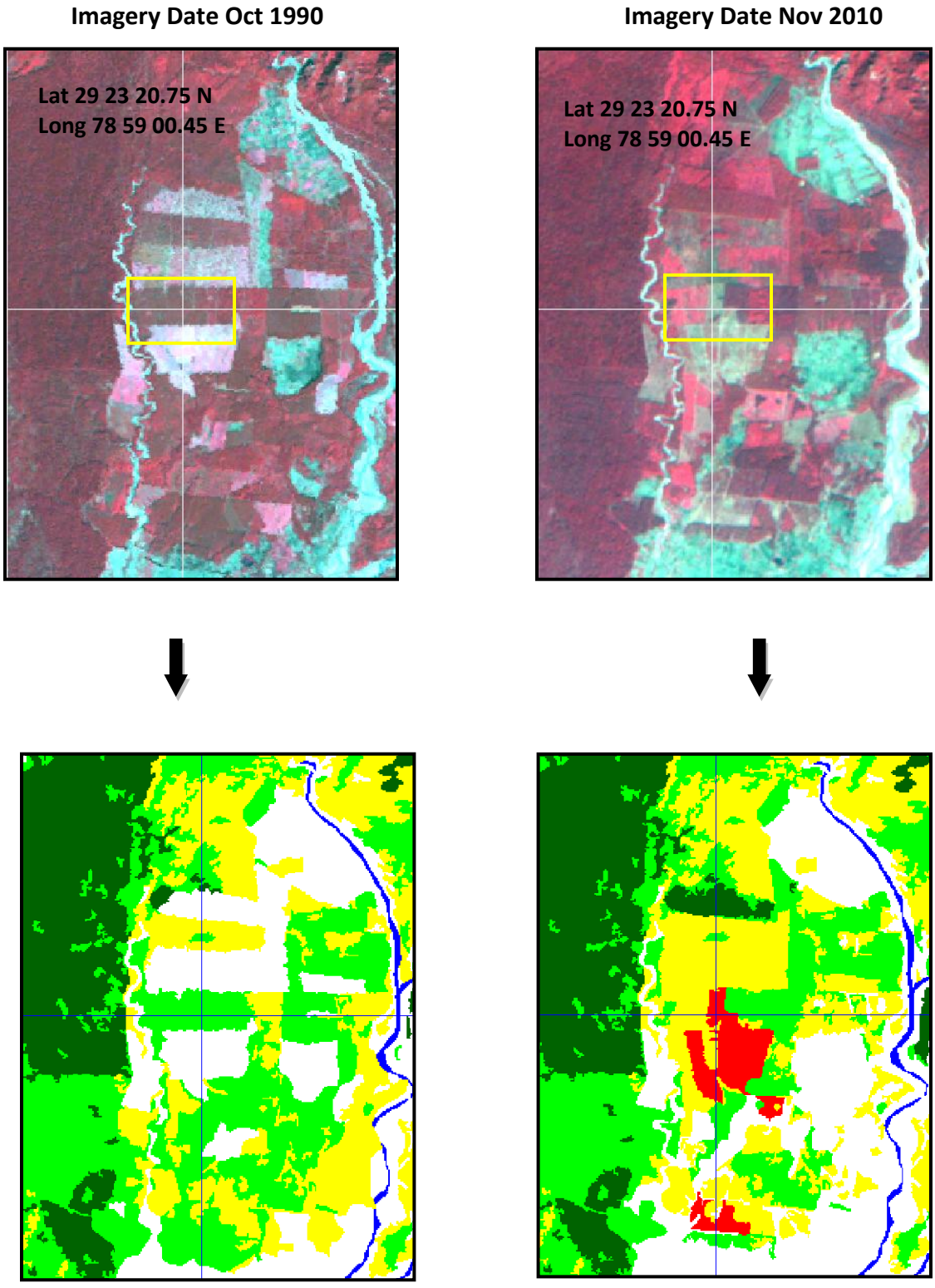


Fig. 10: **Area showing in maps falling in AUTKBTR of the reserve**

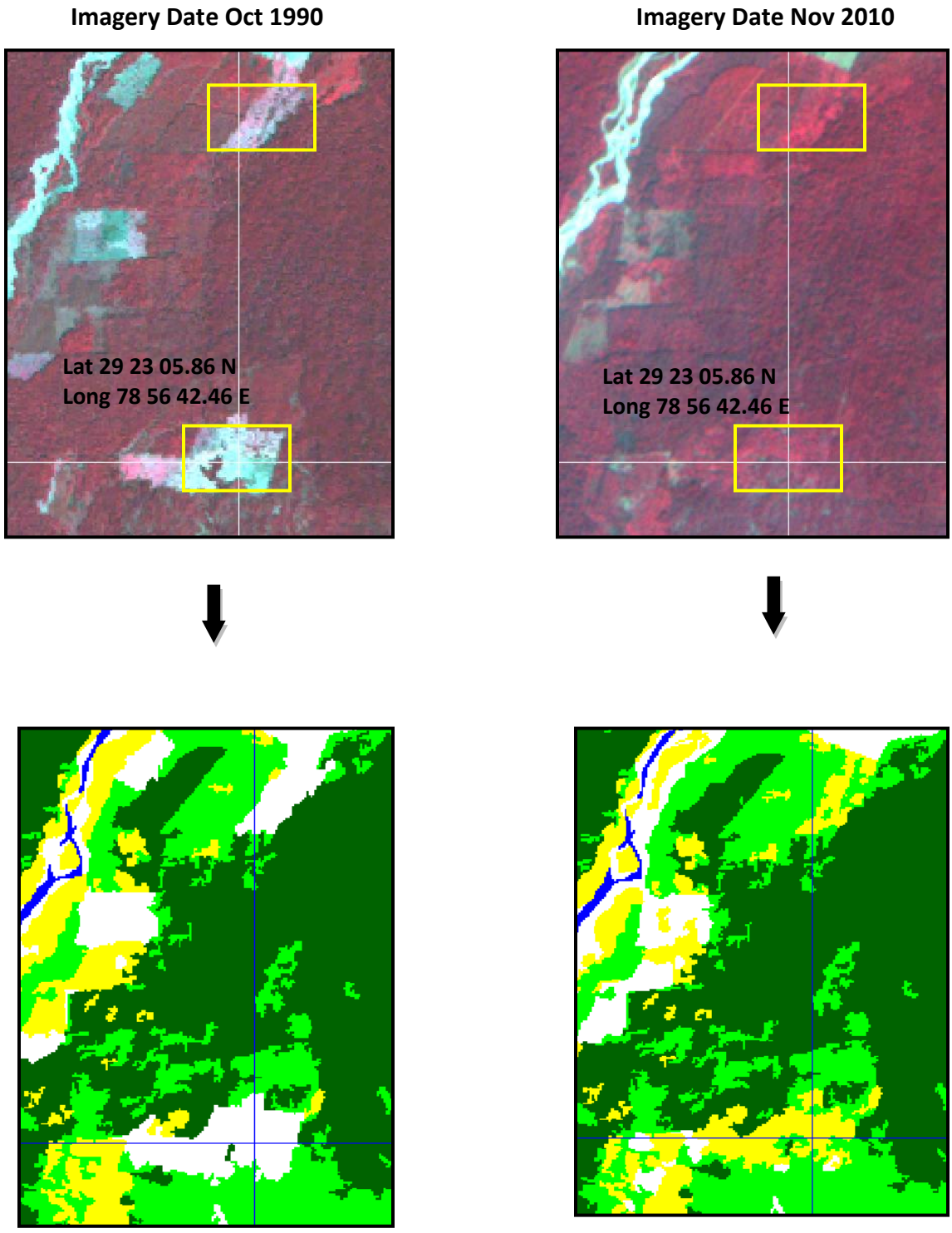


Fig. 11: **Area showing in maps falling in Buffer area of the reserve**

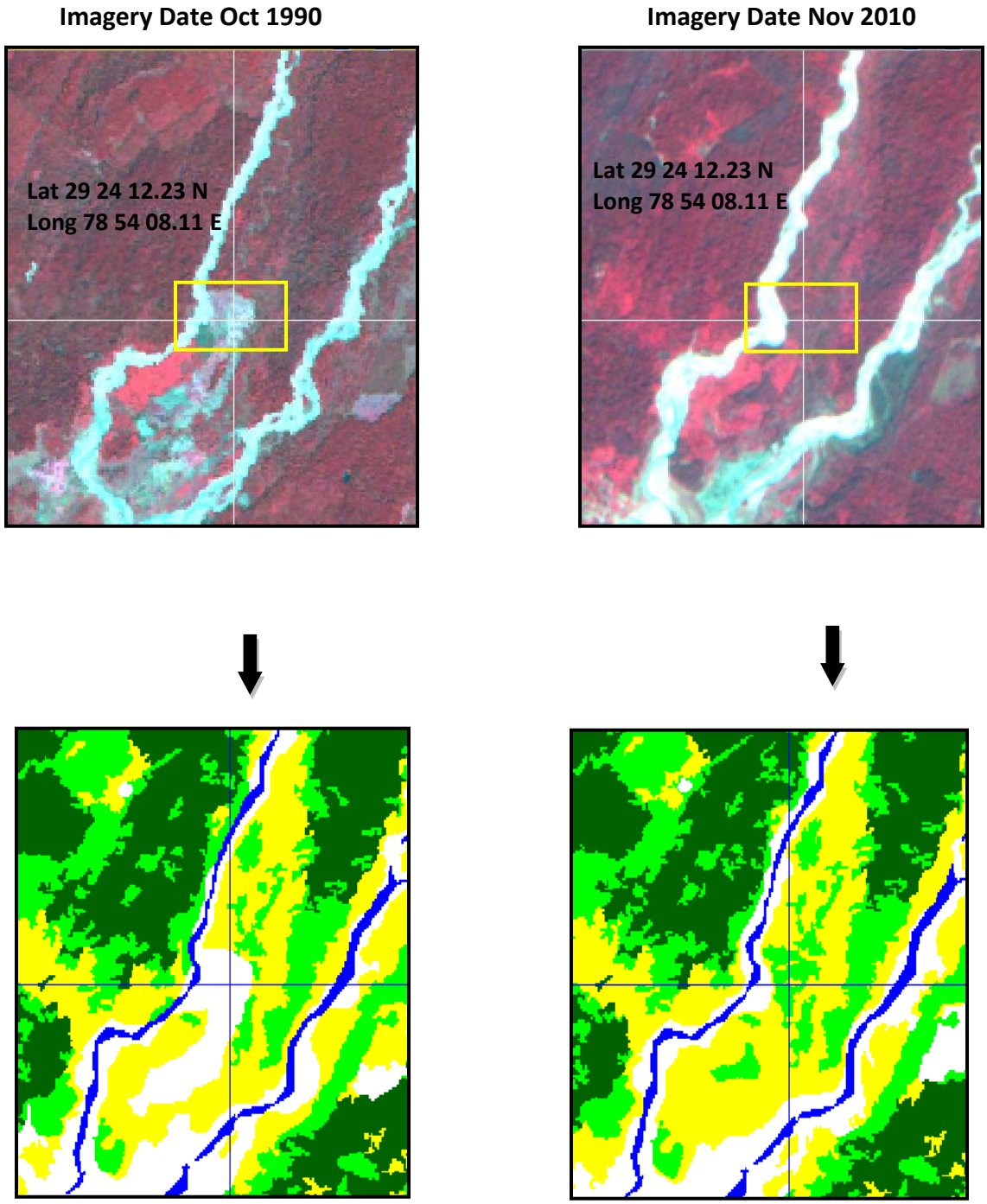


Fig. 12: **Area showing in maps falling in AUTKBTR of the reserve**

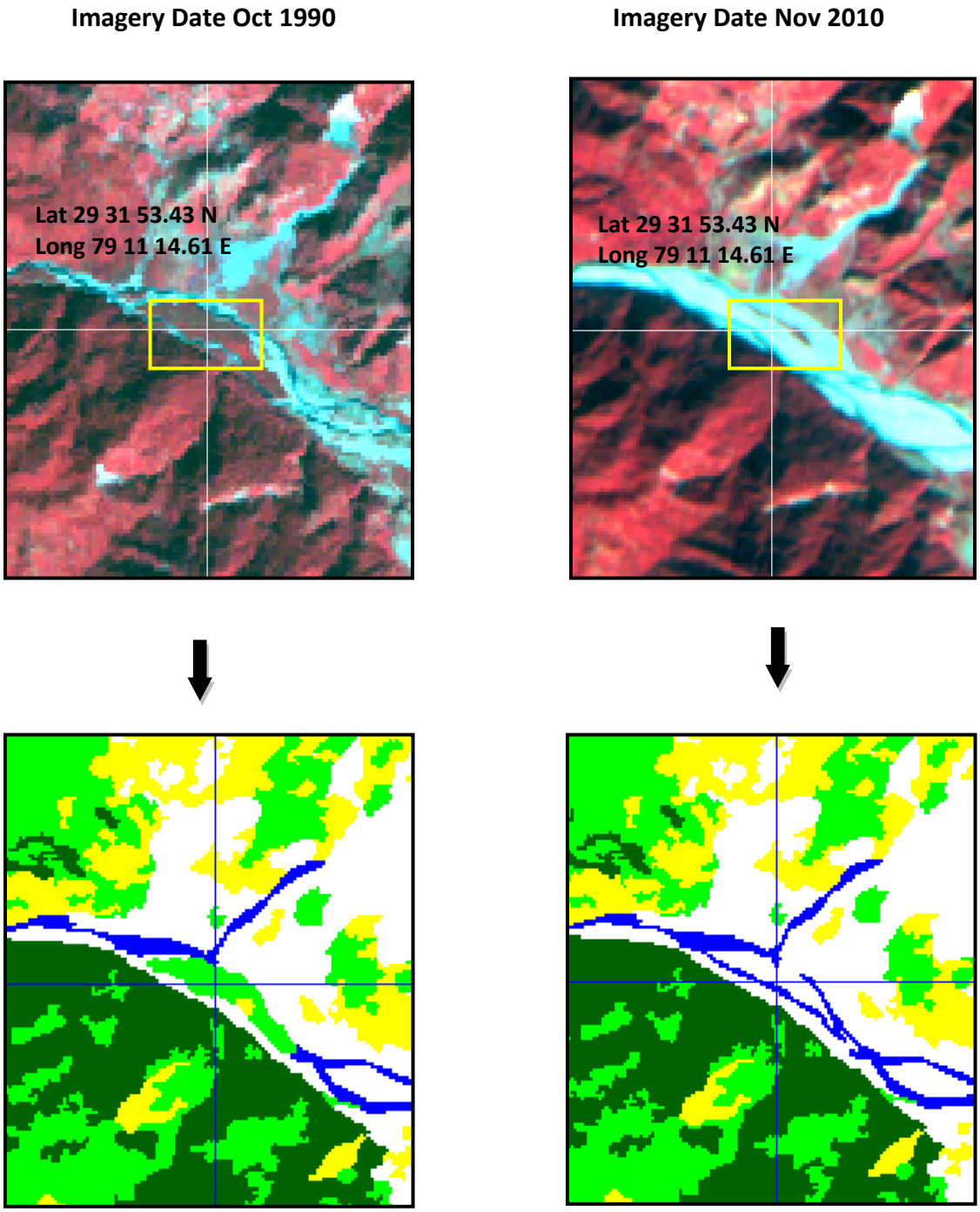


Fig. 13: **Area showing in maps falling in AUTKBTR of the reserve**

COMPARATIVE BAR DIAGRAMS SHOWING FOREST COVER AREA IN CORBETT TIGER RESERVE

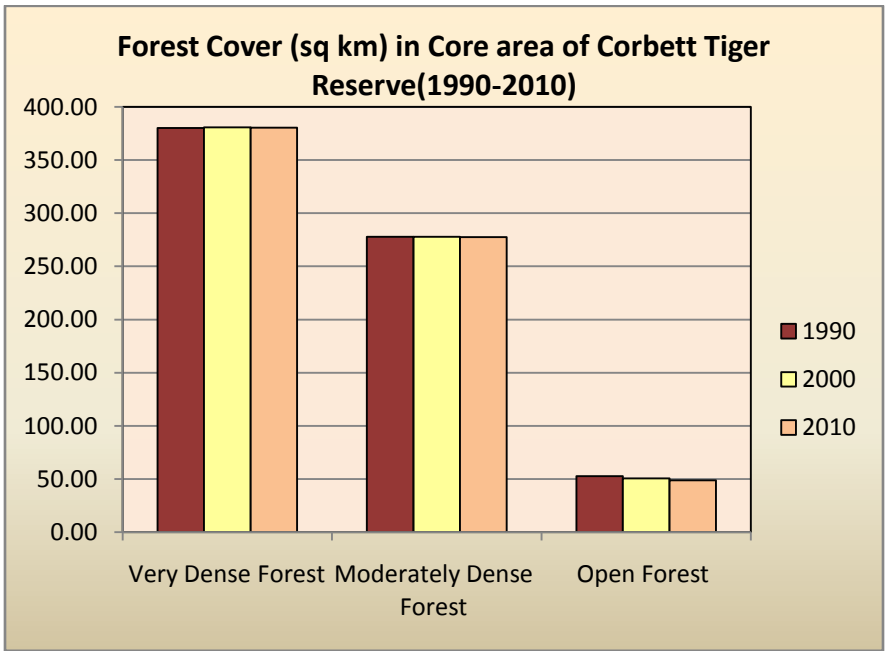


Fig 2.3 a: Comparative Bar diagram showing Forest Cover Area in CorbettTiger Reserve (Core Area)

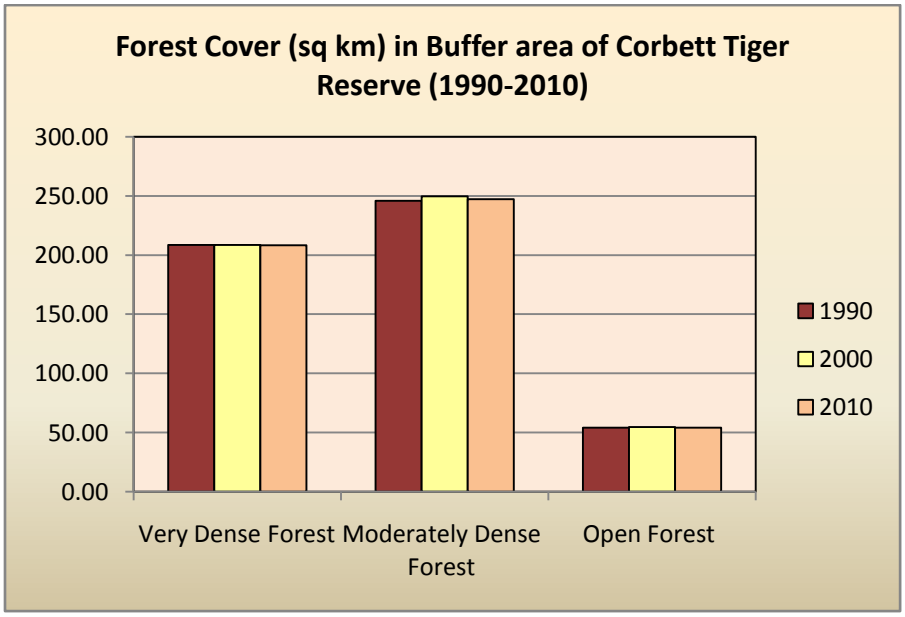


Fig 2.3 b: Comparative Bar diagram showing Forest Cover Area in Corbett Tiger Reserve (Buffer Area)

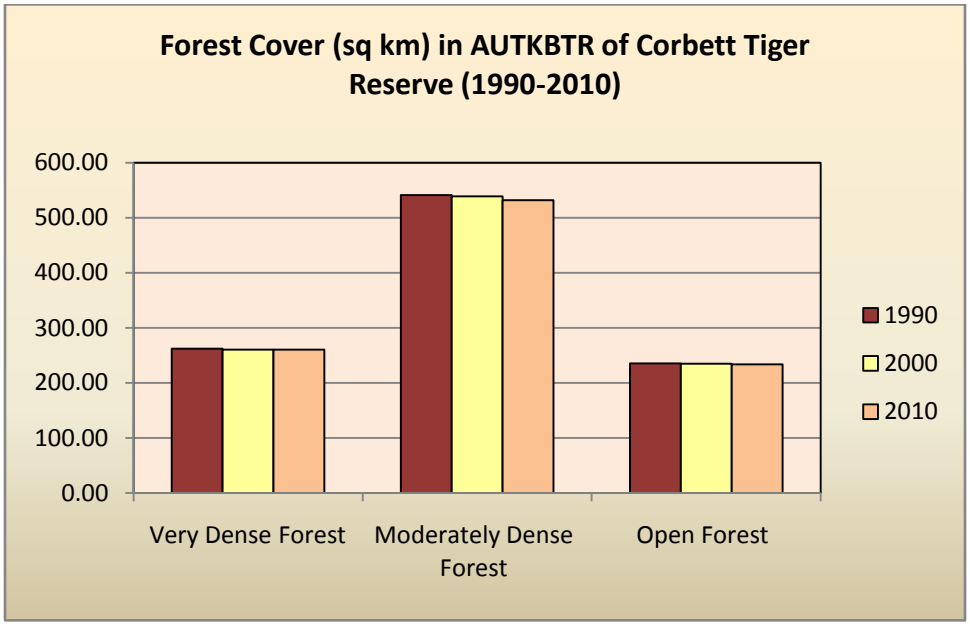
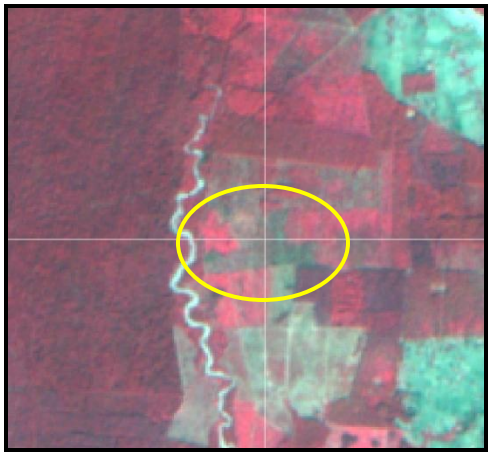


Fig 2.3 c: Comparative Bar diagram showing Forest Cover Area in Corbett Tiger Reserve (Area upto 10km from the boundary of Tiger Reserve)

Plates showing satellite images and corresponding ground photos captured during ground truth verification of Corbett Tiger Reserve

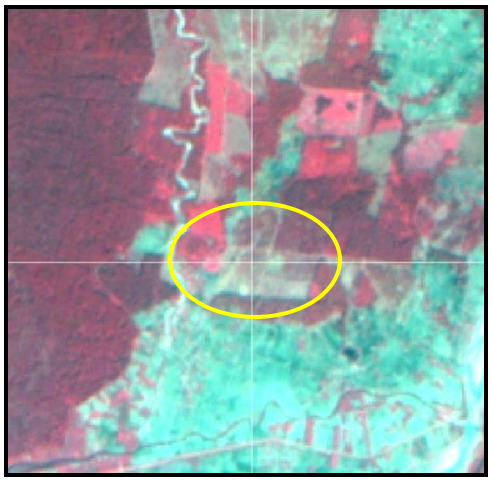


IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 29 23 43.73 N; Long 78 58 52.42 E)

Dhela Range (Puthrava East-I Beat)

(Eucalyptus Plantation)



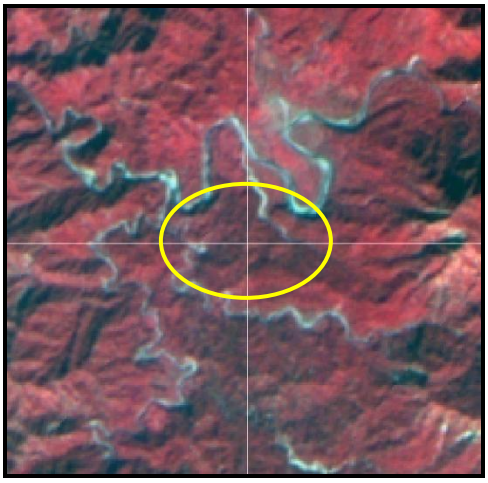
IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 29 21 39.21 N; Long 78 59 0.22 E)

Amphokara Range(West Shivnathpur Beat)

(Teak Plantation)

Plate 1

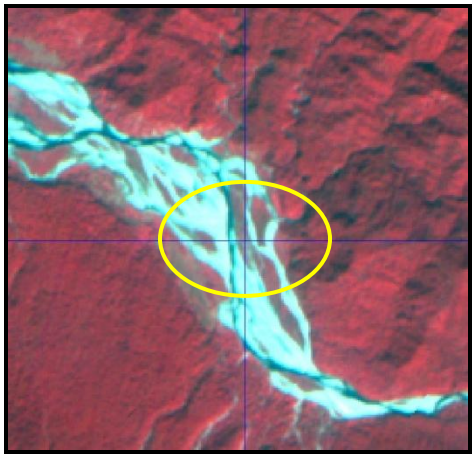


IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 29 41 56.98 N; Long 78 34 49.28 E)

South Kotdi (Compartment No.6)

(Miscellaneous Forest)



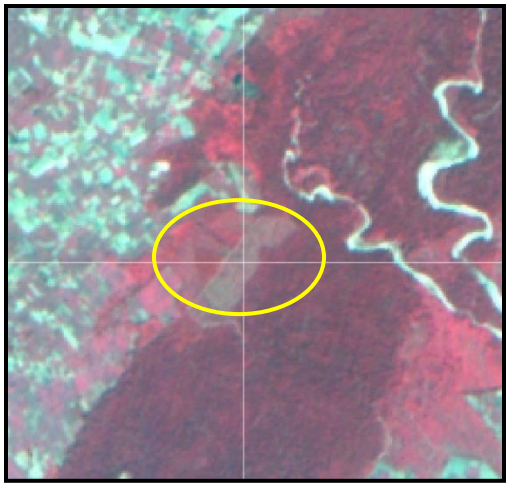
IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 29 34 15.81 N; Long 78 54 50.66 E)

Dhikala Range (Corbett National Park)

(Dead Sal Forest)

Plate 2

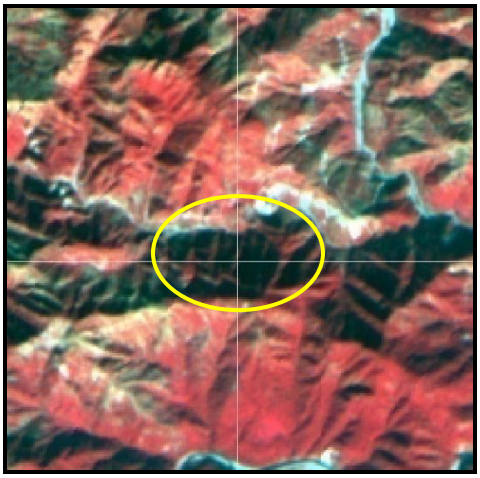


IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 29 30 5.12 N; Long 78 35 39.85 E)

Sahuwala (Compartment 1B)

(Miscellaneous Foret:Teak , Eucalyptus, Khair, sal)



IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 29 37 28.04N; Long 79 3 54.57 E)

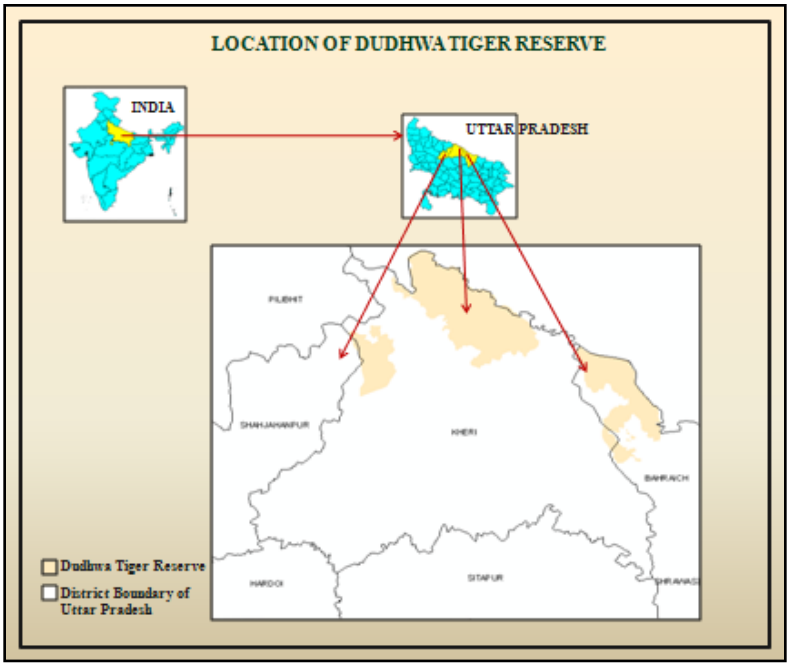
Shankarpur

(Sal Forest)

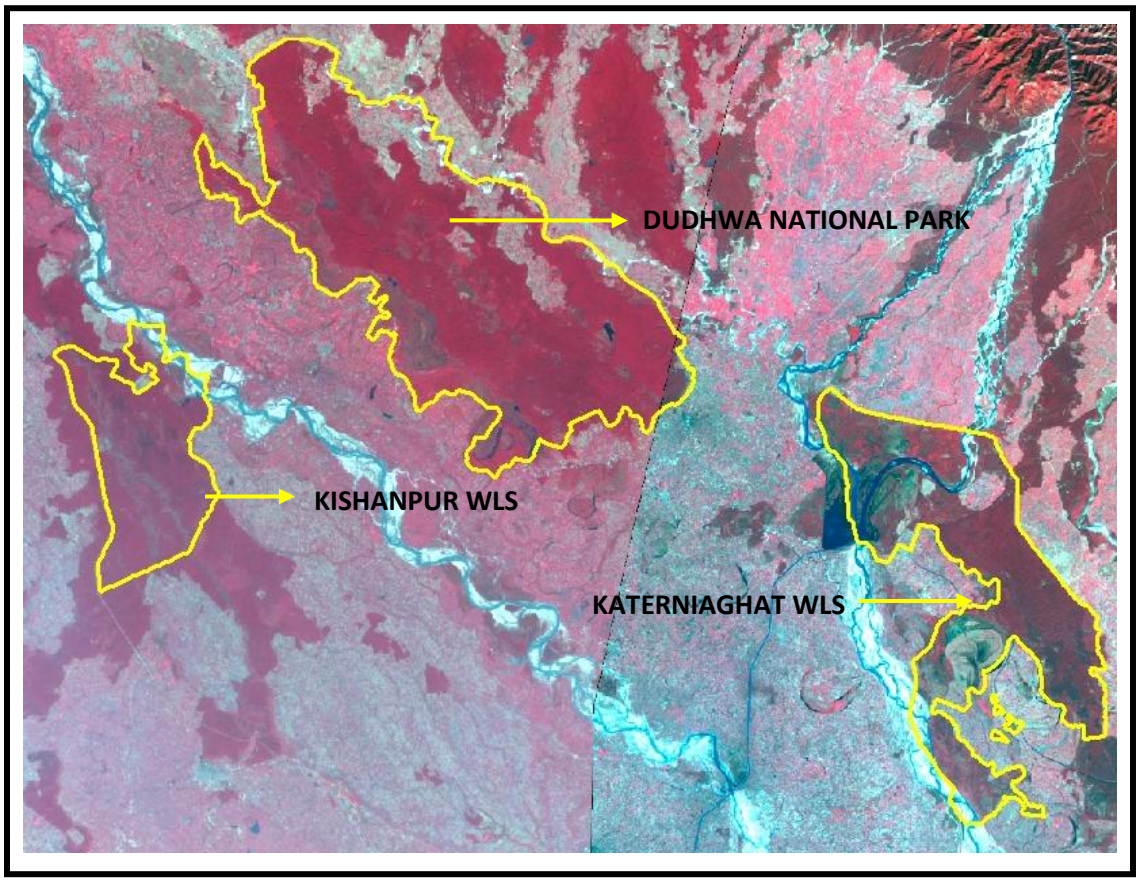
Plate 3

DUDHWA TIGER RESERVE

DUDHWA TIGER RESERVE



DUDHWA TIGER RESERVE BOUNDARIES OVERLAID ON IRS 1C/1D LISS III DATA



INTRODUCTION

3.1 INTRODUCTION:

Dudhwa Tiger Reserve represents the part of Terai ecosystem in the foothills of the Himalaya. Dudhwa Tiger Reserve consists three Core areas-Dudhwa National Park, Kishanpur Wildlife Sanctuary and Katerniaghat Wildlife Sanctuary ,along with forests of North Kheri,South Kheri and Shahjahanpur forest division which are separated from each other.Dudhwa National Park and Kishanpur WLS was created in 1987-88 and in 1999-2000 Govt of India extended this reserve by including Katerniaghat WLS. As per the notification under the Wildlife (Protection) Act 1972, amended in 2006 ,area of the Core of Dudhwa Tiger Reserve is 1093.79 sq km(as on 03.09.2014) and area of Buffer is 1107.98 sq km. The legal status of the Reserve is as follows:

i) Dudhwa National Park with an area of 490.29 sq.km as core area

ii) The Kishanpur WLS having an area of 203.41 sq. Km as core area

iii) Katerniaghat WLS with an area of 400.09 sq. Km as core area

iv) An area of 190.0371 sq km buffer area under Dudhwa Tiger reserve division, 493.9032 sq km of North Kheri Forest Division as buffer to Dudhwa national Park, 247.7950 sq km of South Kheri Forest Division and 26.2220 sq km of Shahjahanpur Forest Division as buffer area to Kishanpur Wildlife Division and 150.0275 sq km of Katerniaghat Wildlife Division as buffer to Katerniaghat Wildlife Sanctuary.

The Dudhwa National Park is close to the Indo-Nepal border in the Palia and Nighasan tehsil of district Lakhimpur-kheri.The Kishanpur Sanctuary is stretched over Gola and Powayan tehsil of Lakhimpur and Shahjahanpur district respectively. The Katerniaghat Santuary is located in the Nanpara Tehsil of district Bahraich,with the Indo-Nepal border constituting its northern boundary.

3.1.2 LOCATION

The entire Reserve lies between lat. 28^0 00’ N to 28^0 42’ N and long 80^0 00’ E to 81^0 19’ E.

Dudhwa National Park- Lat- 28^0 18’ N to 28^0 42’ N

Long - 80^0 28’ E to 80^0 57’ E

Kishanpur WLS- Lat- 28^0 00’ N to 28^0 42’ N

Long - 80^0 00’ E to 80^0 50’ E

Katerniaghat WLS- Lat- 28^0 06’ N to 28^0 24’ N

Long - 81^0 02’ E to 81^0 19’ E

The area of the Reserve is a vast alluvial plain and is the doab of Mohana and Suheli rivers.Ghaghra river flows in between Dudhwa and Katerniaghat WLS.Sharda river flows in between Dudhwa national Park and Kishanpur WLS. There are a number of rivers and rivulets in the habitat.

3.1.3 SOIL AND RIVER SYSTEM

- **Dudhwa National Park:**

The area of the Park is a vast alluvial plain, the doab of the Mohana and Suheli rivers. The under-lying soil of the area consists of the alluvial formation of the Gangetic Plains, showing a succession of beds of sand and loam. These vary in thickness and depth according to the configuration of the ground. The subsoil has, at depths of 12m to 21m, a layer of hard clay with narrow shingle beds.

The surface soil is sandy in the more elevated portions and along the high banks of the rivers, loamy in the level uplands and clayey in the depressions. However, these are prone to variations. Wherever the ground slopes appreciably, as along the damars, the soil is poor; wherever clay has been deposited on the surface, as in the case of depressions formed by former waterways, the ground is Swampy. The rapidity with which the wells in the area silt-up, indicates that below spring level sand is more or less universal.

- **Kishanpur Wild Life Sanctuary:**

The soil of the reserved forests consists of the alluvial formations of the Gangetic plains, showing a succession of beds of sand and loam and varying in depth according to the configuration of the ground. The soil of the low alluvium is recent. The soil of the high alluvium is mostly loamy sand varying in depth and composition within short distances. Generally speaking, the sandy constituent is coarser in the north as compared to the south. The following broad types of soil with their characteristic vegetation may be seen:

1.Low Alluvium- (i) Pure Sand- This is in fact the bed of the Sharda and Ull rivers and is generally under water during the rains. (ii) Recent loamy sand- The sand is much coarse and

shallower than that found in the high alluvium. The subsoil is micaceous. At times small boulders of quartzite, gneiss and other Himalayan rocks are found embedded in the sand at depths of 3-4.5m. This type of soil is found in portions of Sharda block.

2. High and Middle Alluvium- (i) A rich loamy sand with a variable proportion of clay. This supports the best forests and is found in the Sal areas. The soil has a fair amount of humus.

(ii) A moist sandy loam mixed with a fair amount of decaying vegetable matter is met with in depressions and watercoarses covered with grasses. The depth of this soil varies from 0.6 to 0.9m. It is usually quite stiff when dry. Due to prolonged submergence it usually does not support tree growth but in areas where its thickness has increased due to deposition of silt from adjoining high grounds, it supports a good crop of Sal and sain.

(iii) A micaceous sand with little or no clay and marked by an almost complete absence of humus is the typical soil of the Sal chandars. It is exceedingly poor, containing particles of manganese dioxide, which bind it and render it stiff and hard during the greater part of the year.

(iv) A stiff clay with a large amount of decayed and partly decayed vegetative matter is the soil type found in the lower parts of the Ull River. This type of soil is characterized by extremely poor aeration of the surface soil and water-logging conditions.

The depth of the soil varies from a few cm. in the chandars to about 2.4m elsewhere. In most of the areas, the soil varies from 1.2 to 2.4m in depth. The portion rich in humus never exceed 0.9m and are usually limited to 0.3 to 0.6 m under trees and only a few cm. under grassy patches.

- **Katerniaghat WLS:**

The whole tract lies on the alluvium of the Gangetic plain, in which two main types of soil are found:

(a)The low alluvium consisting of large areas in the north and along the eastern boundary of the WLS.

(b)The middle alluvium in the south of the WLS.

(c)The high alluvium consisting of the rest of the WLS.

In the low alluvial tracts of the Kauriala and Saryu rivers, the soil is almost pure river sand, enriched in many places by a deposit of fine silt, and in these localities, Sissoo (Dalbergia sissoo), Khair (Acacia catechu), Semal (Bombax ceiba) and various other miscellaneous species of a similar habit of growth are found in varying quantities . Tree growth rapidly becomes established on the coarses of the rivers wherever the soil conditions are suitable. Practically, throughout the northern portions of the Kauriala basin, a stratum of shingle and water worn boulders occur at variable depths.

In the middle alluvium, which is of earlier origin than the low alluvium, the soil is sandy but has a certain admixture of vegetable matter.

In the high alluvium, the following types of soil are found:

(a)A light sandy loam, rich, moist, and containing vegetable moulds to a depth of two feet or more. This type supports the best tree growth and on it occurs the best quality Sal forests.

(b)A heavier loam with varying proportions of clay and a fair amount of vegetable mould. This type of clayey loam is fairly fertile, but is inferior to the light loamy soils, and where there is a large proportion of clay, Asna (Terminalia alata) is the predominant species.

(c)A Stiff infertile clay containing manganese dioxide and with reefs of kankar from place to place, many of which have become exposed as a result of erosion. These infertile tracts are scattered indiscriminately throughout the areas of better soil and either merge into the latter through increasing degrees of fertility, or frequently abruptly change from one type to the other, being clearly defined by the sudden change in the forest crop.

RIVER SYSTEM:

The Reserve is bestowed with a number of rivers, canals and perennial water sources which are the life line of the Dudhwa Tiger Reserve. The Suheli and Mohana rivers, Kauriala, Gerva, Ull, Barauchha, Joraha, Nagrol, Nakua and Neora nalas (streams), are the major rivers and streams of the Tiger Reserve. In all the rivers and streams are associated with the Reserve. The Suheli and Mohana river flow roughly along the southern and northern boundaries of the Dudhwa National Park. Gerva river and Kauriala river intersects the Katerniaghat forests and they are the life line of Katerniaghat WLS. Sharda river constitutes the northern boundary of Kishanpur WLS and Barauchha and Ull river passes through Kishanpur WLS. The Neora and Nagrol have their origins in Nepal. After

flowing separately for some distance the Nagrol merges with the Neora which ultimately merges with the Suheli. The Joraha flows for considerable distance almost across the Park.

There are also a large number of perennial *taals* or lakes such as the Bankey, Kakraha, Chhedia, Bhandara, Chhapra, Amaha, Bhadi, Mutna, Churaila, Puraina, Laudaria, Nagra, Khajua, Chaitua, Dhanghari, Bhadraula, Terhia etc. located variously in the Park. These contribute significantly in making the habitat of the Park unique. Many areas have depressions that retain rainwater for some time after monsoon and provide drinking water to wild animals.

The major rivers of the Kishanpur Sanctuary are the Sharda and Ull. The Sharda forms a part of the boundary of the Sanctuary. The Ull river traverses a large portion of the Sanctuary. Jhadi Tal is the most important lake in the Sanctuary. Mahadeva Tal is an important Swamp in Katerniaghat WLS and there are numerous other Swamps which are a good wildlife habitat of migratory birds and other aquatic species.

3.1.4 CLIMATE

The climate of the area is tropical monsoon type and is characterized by a dry hot summer and a pleasant cold season. The cold season or winter lasts from about the end of November to the end of February, followed by the summer season from March to the third week of June. The climate of the Reserve is characterized by temperatures ranging from 3^0 C during winter to 45^0 C in summer. The rainy season generally begins in the middle of June and lasts up to September. The day and night temperatures during the months of July/August are between 37.2°C and 19.8°C respectively. This period accounts for about 90% of total annual rainfall. The total annual rainfall is about 223cm. Annual rainfall varies from 1000mm to 1200 mm.

3.1.5 FLORA

There are near about 75 species of trees,21 species of shrubs,77 species of grasses and 179 species of aquatic plants. According to Champion and Seth classification following forest types have been recognized -

- **Northern Moist Deciduous Forest**

  1. **3C/C2b(ii) - Damar Sal Forests:**

  This type comprises the best Sal forests of the Tiger Reserve. This type is met with in Amargarh 2-10b, 10d-13b, Belghat 1-4a, 4c, 5, Dingania 2b, 4, Kiratpur1-9a, 9c-10b,

11a-12, Chandpara 1-2, 3a, 4-9a, 10-11a,11c, Bhadraula 1a, 2,4,5, Masankhamb 2, 3a, 3c, 4a, 7, 11a, Sarota 1a, 1b, 2a, 3-10b, Sohnaha 2a, 5a, 5c, Chota Palia 1a, 2-9, Lauki 2a, 3-8, Tehri 2a, 2c, 3a-5, 8-10, Rehta 6, Bhadi 1a-3a, 5a, 6a, 7a-7b, Ludaria 1a-3a, 5-8, 10-12c, Mahadewa 2a-3c, 5a-5c, Mohrania 3a,3b, 6a-6c, 7 and Nagra 4a, 5a, 5b, 6a.

2. **3C/C 2b(ii) / 3C/C 2d(i) - Damar Sal Forests / Western Light Alluvium Plains Sal Forests:**

The Sal forests of this type are met with in Amargarh 1, Dingania 5a, 5b, 8b, Bhadraula 3a, Masankhamb 8, 9, Sohnaha 5a, 5b, 6a, 6b, 7a and 10, Barbatta 2a, 2b, Lauki 1a, 1c, 9a,10a, 10b, Rehta 2a, 3-5, Bhadi 4a, 4b, 6b, Ludaria 4a, 4c, Mohrania 1 and Nagra 4b. The crop in these forests is variable with well-stocked patches intermixed with under stocked patches. Sal is the predominant species with an admixture of Terminalia tomentosa whose percentage increases in the less well drained areas. Besides Sal and Terminalia tomentosa the other species of the overwood are Terminalia bellerica, Lagerstroemia parviflora, Kydia calycina, Stereospermum suavolens, Schleichera oleosa and various species of figs.

Teak has been introduced by gap planting in Dingania 5a and Lauki 1a and by clear felling in Lauki 10 and Bhadi 6b. The plantations are successful and teak has started regenerating in Lauki 1a.

3. **3C/C2b–C2d(i) – Moist Bhabar Sal / Western Light Alluvium Plains Sal:**

The forests have characteristics intermediate between the two sub-types C2b and C2d(i). The Sal crop is very dense. The middle storey consists of rohini. The undergrowth is composed mostly of grasses such as Ulla (*Themeda arundinacea), Erianthus ravennae, Saccharum spontaneum* and *Imperata cyclindrica* along with *Pogostemon plectranthoides, Clerodendrum viscosum, Glycosmis pentaphylla,* jamun etc. This type is found in Mailani Central 3 and 8 and Mailani South 3a, 4, 5, and 8.

4. **3C/C 2d(i) - Western Light Alluvium Plains Sal Forests:**

These forests generally occur on sandy alluvium with a dry sub-soil. These forests are met with in Dingania 2a, 9, Masankhamb 4b,10, Sohnaha 3, 4a, 7b, and 9, Barbatta 1, 4a, 6a, 7, Rehta 1a, 1d, Ludaria 9a-c, Mohrania 2, 4a, 5, 8a, 9a-c, and Nagra 2. The proportion of miscellaneous species is significantly higher in these forests as compared to other areas. The over-wood consists of scattered old Sal trees with a few middle aged trees. Most of the old trees are hollow and crooked. Regeneration of Sal is absent over most of the area. *Terminalia tomentosa* makes up about 15% of the crop being more profuse on the edges of damars and the banks of nalas. The other species of the top canopy are *Terminalia bellerica, Lagerstroemia parviflora, Adina cordifolia, Kydia calycina, Schleichera oleosa* and various species of figs.

Teak has been introduced by gap planting in Mohrania 2, 5a, 5b, and by clear felling in Rehta 1a, Ludaria 9a, 9c, and Mohrania 2, 8a and 9b. The plantations are successful.

The South Kheri Type of Western Light Alluvium Plains Sal occurs in Kishanpur Sanctuary – Mailani Central 4, 5 & 6.

5. 3C/C2d(i)-5B/C1b – Western Light Alluvium Plains Sal – Dry Plains Sal:

The forests are essentially of the former type but are considerably open due to heavy Sal mortality or frost damage. Recurring mortality is characteristic reducing the forest to a mixed dry deciduous type. This type occurs in Mailani North 6, Bhira North 6a, and 11.

6. 3C/C2d (i) App. – Chandar Sal:

This type is encountered in the Sanctuary e.g., in Bhira North 4-6 and 10, Kishanpur West 10, 12, 15, 18, and Kishanpur East 17. The peculiar feature of the chandars is the severe frost that affects them in most years. The frost is sufficient at times to kill back all Sal growth under 5m or so in height. Despite the adverse frost conditions the Sal saplings have, at many places, managed to establish and fairly dense pole crop can be seen. The Sal Chandars can be considered as a special type of Savannah land, representing a sub-climax, in which frost is, for the time being, the chief limiting factor.

7. 3C/C2/DS1- Moist Sal Savannah:

This type is characterized by the occurrence of grassy blanks or ‘phantas’ inside the moist Sal forests. Such areas are met with in Amargarh 10c, Kiratpur 9b, 10c, Dingania 1a-c, 3a, 6, 7, 8, Sohana 1 and 8, Masankhamb 1, 5a, 6b, Sarota 2b, 10c, 10d, Chandpara 3b, 9c, 9d, 11b and 12, Tehri 1, 6, 7, Mahadewa 1 and 4, and the whole of Sathiana, Phersaia, Kakraha, Gulra, Maholi and Sumerpur, Mailain North 4 and in some parts on both sides of the Ull river.

8. 3C/1S1 – Low Alluvial Savannah Woodlands:

This type occurs on the more stable riverine flats that get flooded during the rainy season but remain dry during the rest of the year. Such areas are met along the banks of the Suheli and Mohana rivers. In Kishanpur Sanctuary this type is met with in Sharda 4a, 4b, 4c, 5, 6a, and 6c to the north and east of Jhadi Taal.

- **Tropical Seasonal Swamp Forests:**

1. **4D/SS3 – Syzygium cumini Swamp Forests**:

These forests consist of pure belts of jamun along various nalas and streams.The crop is usually dense with long clean boles. At places *Barringtonia acutangula* and *Trewia nudiflora* are also seen. Underwood is usually absent. The undergrowth is usually devoid of grasses but ferns are almost always present.

- **Northern Tropical Dry Deciduous Forests:**

1. **5B/C1b – Dry Plains Sal Forests:**

Most of the forests placed in this category were at one time average forests of the type 3C/C2d(i) (Western Light Alluvium Plains Sal) but recurring drought mortality has resulted in creation of large gaps with scattered trees of Sal. The forests have changed to dry deciduous type with poor soil conditions. This type is met with in Mailani Central 8, 9, Marha 6a, 8a and 9a.

2. **5B/1S2 Khair – Sissoo Forests:**

These occur on new sandy alluvium of streams and rivers. These are met with along the Suheli, Mohana and Sharda rivers. Khair and sissoo are mixed with heavy growth of grasses. Regeneration of both species is scarce as the areas are prone to fire. Due to flooding and prolonged water logging the quality of the sissoo and khair is poor and growth stunted.

The forest is mainly moist deciduous, dominated by the most valuable Sal (*Shorea robusta*) forest of India. Pure Sal and Sal dominated forest occupy major area of the reserve. Some of the best Sal forests occur on higher alluvial terraces with loamy soil.Sal is the most dominated species in the landscape .Prominent co associates area *Mallotus Philippensis,Terminalia alata,Lagerstroemia Parviflora,Trewia nudiflora and Mitragyna parvifolia.Profuse growth of Syzygium cumini* and *Schleichera oleosa* occures along stream.Teak was planted in several places by clear felling as well as gap planting.Prominent grasses observed in Sal forest area are *Desmostachya bipinnata, Themeda arundinacea, Saccharum bengalense,Saccharum spontaneum,*and *Impereta cylindrica*.

Beside Sal forest, Moist mixed Deciduous Forests having prominence of miscellaneous species and conspicuous absence of Sal occur on sandy alluvium. *Terminalia alata,Haldina cordifolia* and *Milusa velutina* are main constituent trees.Once the landscape was famous for its Khair(*Acacia catechu*) and Sissoo (*Dalbergia sissoo*) type forest.Flooding and prolonged water logging resulted poor and stunted growth of Khair and Sissoo.The area is also popular for extensive plantation of Khair,Shisham,*Ailanthus excelsa*,Teak and *Eucalyptus citridora*.

Table 3.1a: Area according to Forest Types of the Core Area of Dudhwa Tiger Reserve

Forest Types	Area In (%) Assessment Year 2004
3C/C2 d (i) Western Light Alluvial Plain Sal	41.70
3C/C3 a West Gangatic Moist Mixed Deciduous Forest	0.25
3C/2S1 Northern Secondary Moist Mixed Deciduous Forest	10.65
3/1S1 Low Alluvial Savannah Woodland(Salmalia - Albizzia)	6.84
4D/SS3 Syzygium cumini Swamp Low Forest	1.96
4D/2S1 Eastern Wet Alluvial Grassland	4.54
5/1S2 Khair Sissoo Forest	3.43
Plantation/TOF	3.21

Table 3.1b: Area according to Forest Types of the AUTKBTR of Dudhwa Tiger Reserve

Forest Types	Area In (%) Assessment Year 2004
3C/C2 d (i) Western Light Alluvial Plain Sal	7.60
3C/C3 a West Gangatic Moist Mixed Deciduous Forest	0.70
3C/2S1 Northern Secondary Moist Mixed Deciduous Forest	1.64
3/1S1 Low Alluvial Savannah Woodland(Salmalia - Albizzia)	2.19
4D/SS3 Syzygium cumini Swamp Low Forest	0.29
4D/2S1 Eastern Wet Alluvial Grassland	1.40
5B/C2 Northern Dry Mixed Deciduous Forest	0.26
5/1S2 Khair Sissoo Forest	1.28
Plantation/TOF	1.37

Lantana camara is one of the prominent exotic weed.*Cassia tora* and *Parthenium sp.* are common in excessive grazed and village peripherial areas.Grassland occur in openings with woodland.

The grasslands are a prominent feature of both the National Park and the Sanctuary. They constitute about 19 % of the National Park and 21% of the Sanctuary. The buffer areas have 31.50% under grasslands. Thus in all 22.30% of the Reserve is covered by grasslands. These make the habitat unique. In the National Park, the grasslands are categorized into two prominent types:

(a) Upland areas of phantas - Narenga Savannah type
(b) Low lying phantas - Wet Savannah

Plantations:

1) National Park and Buffer :

Plantation of a variety of species was tried from time to time. With the advent of five year plans, there was an increase in plantation activity. Plantations of several species of shisham, khair, semal, tun, eucalyptus and teak have been raised under Plan Schemes. Poplar was also tried on experimental basis.

- **Teak Plantation :**First plantations were raised in 1924 in Belghat 7. The plantation of 20 ha. also contained sissoo and semal. Very few teak trees are surviving. Later teak was introduced in the gaps within Sal forest in Sohnaha 4a, Lauki 1a and Mohrania 5 from 1927 to 1931. Here it has come out very well with the best ones in Mohrania 5. Teak has regenerated naturally in Mohrania 7 and Lauki 1a with the result that the area under teak has increased.
- **Mulberry (*Morus alba*) :** Mulberry plantations were tried for the first time in 1950 in Masankhamb 12, in Saunaha 3 and Masankhamb 3b in 1951 and Sarota 10a in 1952. It was raised with other species such as semal, siris, mahua, haldu and teak etc., but it failed. Later it was tried again in 1954 & 1955 in plantations along with tun, sissoo in Nagra 5b, but it failed. It was never tried again.
- **Paper Mulberry (*Braussonetia papyrifera*) :** It was introduced in 1962 when it was planted in Maholi 2 &3 along with pula (*Kydia calycina*). It was planted in subsequent years in Maholi 4 in 1963, in Kakraha 2 in 1964 and in Tehri 11 in 1965. Presently it survives only in Maholi 4.
- **Eucalyptus hybrid :** The first *Eucalyptus* plantations were raised in Maholi 3 in 1962. Since then it was planted regularly till creation of the National Park. Extent of Eucalyptus plantation was greatly reduced during 1971 and 1972. It has been raised pure or mixed with teak. *Eucalyptus* plantations have been successful in areas where the soil is good.

2) Kishanpur Wildlife Sanctuary:

- **Teak :** The planting technique was similar to that adopted in the Park with under planting of existing gaps or artificially created gaps in Sal forests. In Mathur's Plan, The old method of gap planting was abandoned in favour of planting clear felled areas, with 10-15 trees/ha left to serve as frost cover. However the results were poor. Later Teak plantations were raised only in gaps. Since 1964 Teak plantations were raised in Bhira South 4a & 8, Bhira North 7 pure or mixed with *Eucalyptus* either by taungya or mechanised means in conjunction with agricultural crops in between the lines of trees.
- **Ailanthus excelsa :** Some trees of this species are encountered in the Sanctuary. These were raised in plantations up to 1960 along with species such as Khair, Sisham, Semal, Teak.
- **Mulberry (*Morus alba*) :** Mulberry was planted along with other species in several areas but they did not survive. Hence planting of Mulberry was discontinued in mid-seventies.
- **Eucalyptus :** The earliest plantations date back to 1964 when Eucalyptus was mixed with Teak and planted in Bhira South 4a and Kishanpur East 12. It has been raised by taungya method and as mechanized plantation. Growth of Eucalyptus has not been very good. Its planting was discontinued in 1978.

3) Katerniaghat Wildlife Sanctuary :

The planting technique was similar to that adopted in the Park with under planting of existing gaps or artificially created gaps in Sal forests. In Mathur's Plan, the old method of gap planting was abandoned in favour of planting clear felled areas, with 10-15 trees/ha left to serve as frost cover. However the results were poor. Later Teak plantations were raised only in gaps. Since 1964 Teak plantations were raised in Bhira South 4a & 8, Bhira North 7 pure or mixed with *Eucalyptus* either by taungya or mechanised means in conjunction with agricultural crops in between the lines of trees.

3.1.6 FAUNA

Due to the complexity of habitat diversity and availability of sufficient food,water the reserve is very rich in fauna.The major mammals include: *Panthera pardus* (Guldar), *Panthera tigris*(Tiger), *Felis viverrina* (Fishing cat), *Macaca mulatta*(Monkey), *Presbytis entellus* (Langur),*Herpestes edwardsi* (Mongoose),*Canis aureus*(Jackal), *Axis axis*(Spotted Deer), *Cervus unicolor* (Sambhar),*Rhinocerous unicornis*(Great Indian Rhino),*Elephant maximus*(Asian Elephant) and *Lepus nigricollis*.Tiger (Panthera tigris), Asian elephant(Elephant maximus), Rhinocerous(Rhinocerous unicornis),Swamp deer(Cervus duvauceli duvauceli),Bengal florican (Hubraopsis bengalensis) are threatened species as endangered. Five deer species viz. Sambhar, Swamp deer, Spotted deer, Hog deer, Barking deer have been found here easily.

The Reserve has a good tiger status owing to its connectivity with other tiger habitats like Pilibhit and tiger bearing forests of Nepal. The density of tiger for the reserve is 5.4 tigers per 100sq km as assessed during the 2010 country level assessment.

There are about 423 species of birds including resident and migratory ones have been observed in the habitat such as *Podiceps ruficollis* (Dabchick), *Pelicnus philipensis*(spotbilled pelican), *Phalacrocorax carbo* (Large cornorant), *Phalacrocorax niger*(Little cormorant), *Threskiornis aethiopica*(White lbis),*Gyps indicus*(India Longbilled Vulture), *Gallus gallus*(Red vjungle Fowl),*Ninox scutulata* (Brown Hawk owl) etc.

There are several fishes which include Rohu,Singhi and Kacehala have been identified, and Mugger,Ghariyal,Python,Sandboa,Rat snake,Monitor lizard and King Cobra etc are few reptiles have also been found in reserve.

3.2 FOREST COVER IN DUDHWA TIGER RESERVE

3.2. 1 Forest Cover in the year of 1990

- **Core Area:**

As per the List of Core and AUTKBTR of the Tiger Reserves in India published by **National Tiger Conservation Authority/ Project Tiger**, notified under the Wildlife (Protection) Act1972, amended in 2006 , area of the Core of Dudhwa Tiger Reserve is **1093.79 sq km**(as on 03.09.2014).

The assessment of forest cover in the core area of Dudhwa Tiger Reserve is **892.16 sq km** which is about **81.57%** of the core area of reserve. The study of 1990 image interpretation is based on the satellite data of Landsat-5 TM. The study reveals that **402.66 sq km** of forest falls in Very Dense Forest category, **367.58 sq km** of forest lie in Moderately Dense Forest category and **121.92 sq km** forest is in Open Forest category.

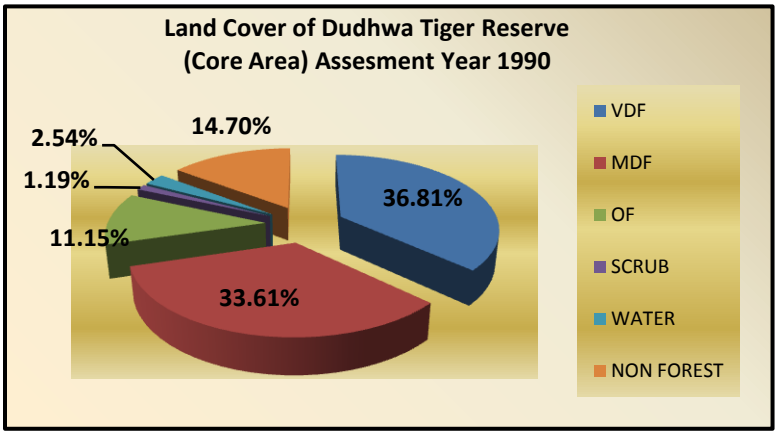


Fig 3.2.1a Pie chart showing percentage of Land Cover of Dudhwa Tiger Reserve(Core in 1990)

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

The outer surround of 10km radius from the notified core boundary of the tiger reserve is defined as AUTKBTR and its area is 2734.56 sq km. Due to unavailability of notified Buffer boundary of Dudhwa Tiger Reserve we have considered area of 10km radius from the notified boundary of reserve as Extended Buffer area.

The assessment of forest cover in the AUTKBTR of Dudhwa Tiger Reserve is **375.54 sq km** which is about **13.73 %** of the reserve. For the study of 1990 image interpretation is based on the satellite data of Landsat-5 TM (1990).**168.49 sq km** of forest falls in Very Dense Forest category,**149.24 sq km** of forest lies in Moderately Dense Forest category and **57.81sq km** forest is in Open Forest category.

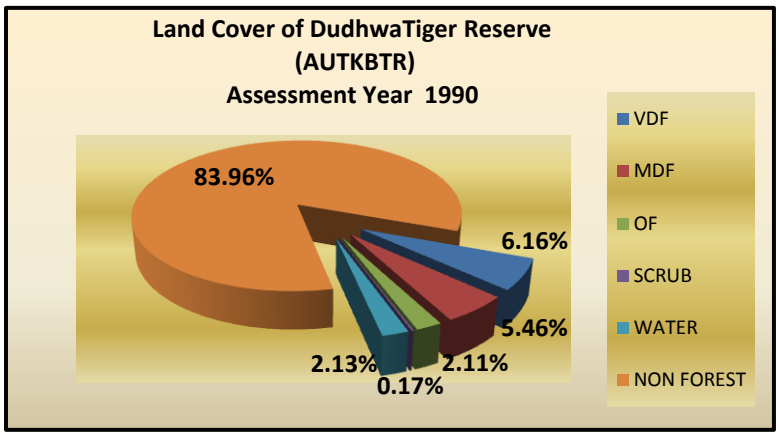


Fig 3.2.1b Pie chart showing percentage of Land Cover of Dudhwa Tiger Reserve(AUTKBTR in 1990)

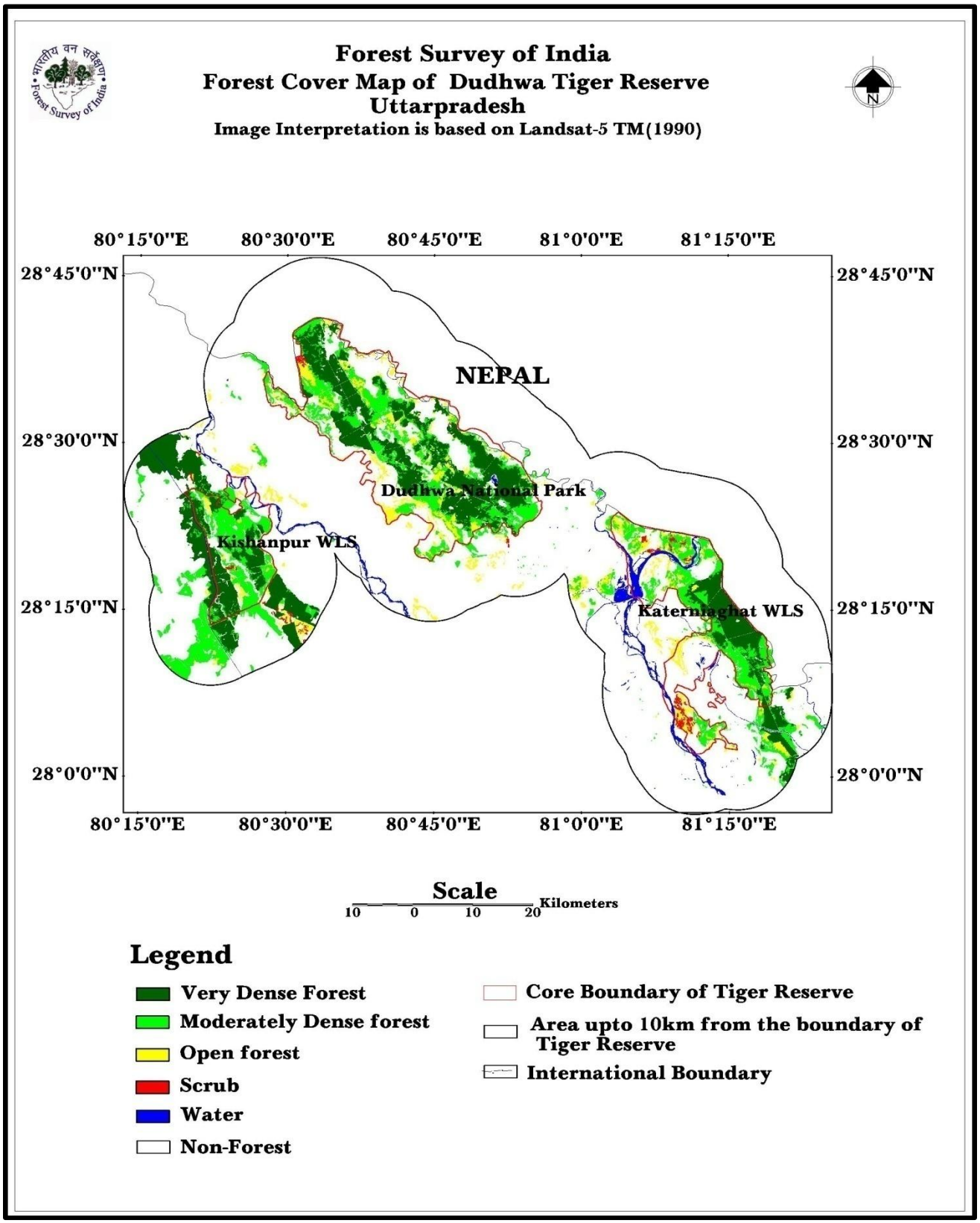


Fig.3.2.1 Forest Cover Map of Dudhwa Tiger Reserve(1990)

3.2.2 Forest Cover in the year of 2000

- **Core Area:**

The assessment of forest cover in the core area of Dudhwa Tiger Reserve is **918.72 sq km** which is about **83.99%** of the reserve. For the study of 2000 image interpretation is based on the satellite data of IRS – 1C/1D LISS III (2000).**399.62 sq km** of forest falls in Very Dense Forest category,**402.17 sq km** of forest lie in Moderately Dense Forest category and **116.93 sq km** forest is in Open Forest category.

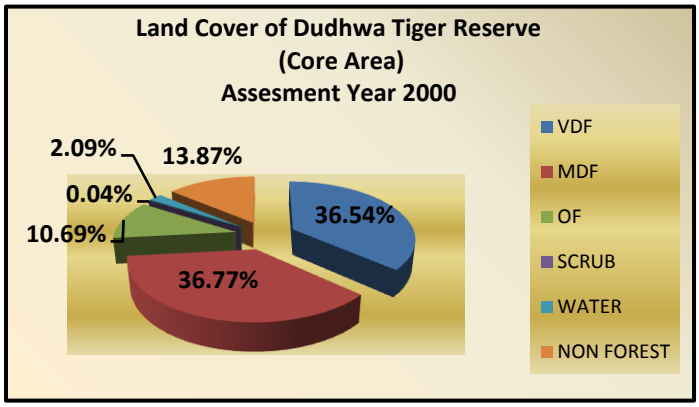


Fig 3.2. 2a Pie chart showing percentage of Land Cover of Dudhwa Tiger Reserve (Core in 2000)

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

The assessment of forest cover in the AUTKBTR of Dudhwa Tiger Reserve is **393.04 sq km** which is about **14.37%** of the reserve. The study of 2000 image interpretation is based on the satellite data of IRS – 1C/1D LISS III. The study reveals that **170.72 sq km** of forest falls in Very Dense Forest category,**165.60 sq km** of forest lie in Moderately Dense Forest category and **56.72 sq km** forest is in Open Forest category.

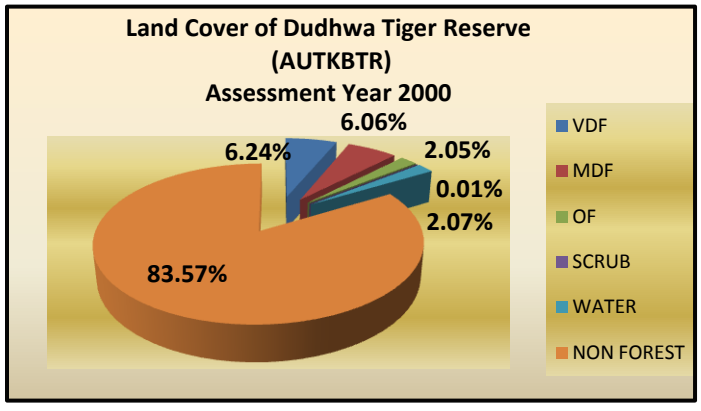


Fig 3.2. 2b Pie chart showing percentage of Land Cover of Dudhwa Tiger Reserve (AUTKBTR in 2000)

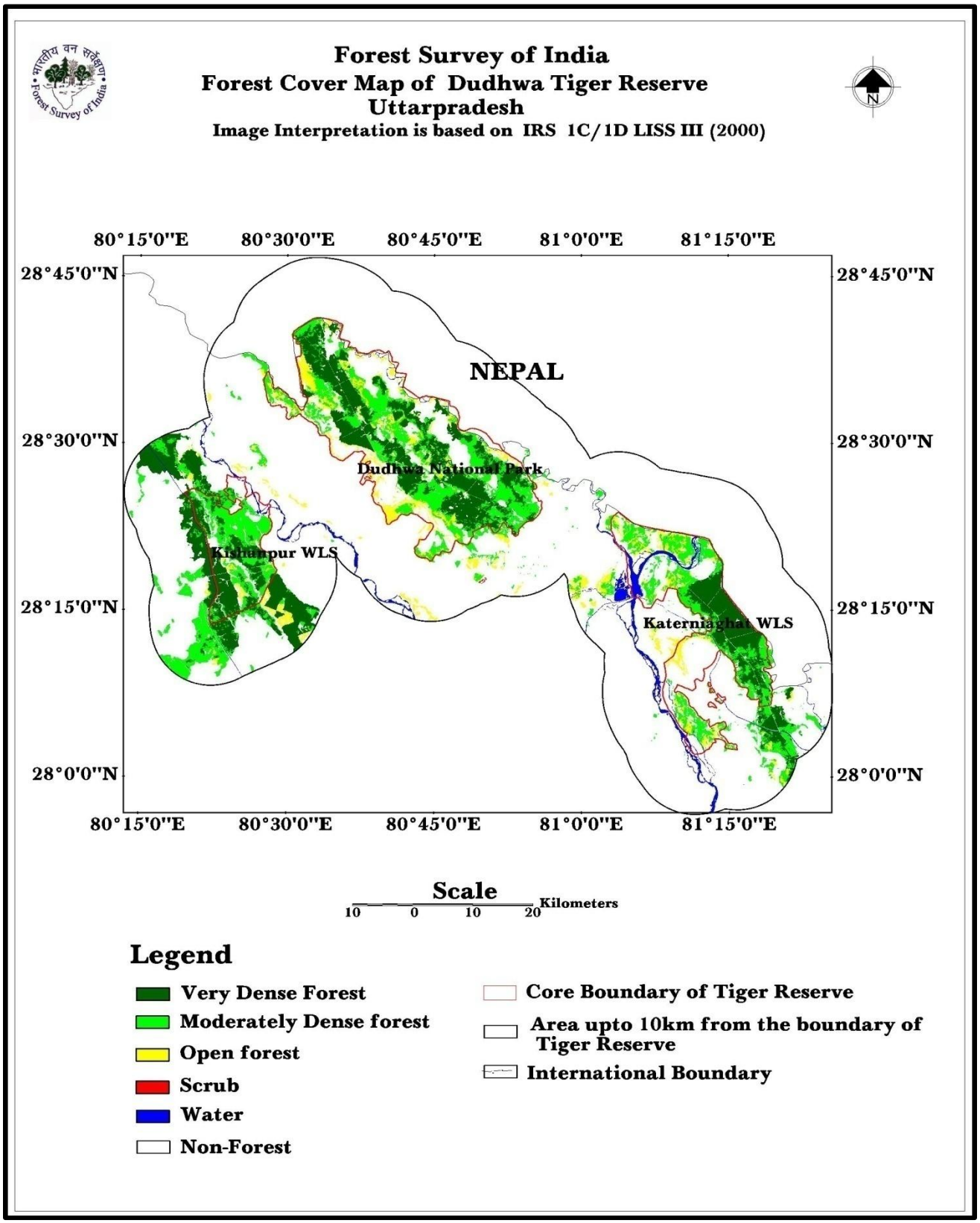


Fig.3.2.2 Forest Cover Map of Dudhwa Tiger Reserve(2000)

3.2.3 Forest Cover in the year of 2010

- **Core Area:**

The assessment of forest cover in the core area of Dudhwa Tiger Reserve is **928.71 sq km** which is about **84.91%** of the reserve. For the study of 2010 image interpretation is based on the satellite data of IRS – P6 LISS III .The study reveals that **408.30 sq km** of forest falls in Very Dense Forest category,**400.72 sq km** of forest lie in Moderately Dense Forest category and **119.69 sq km** forest is in Open Forest category.

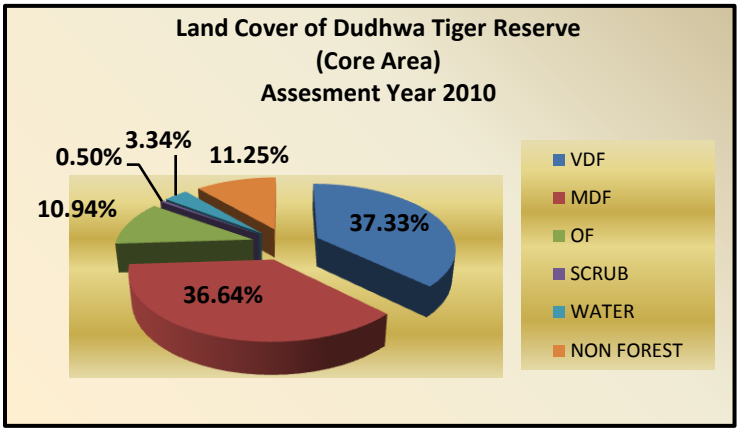


Fig 3.2.3a Pie chart showing percentage of Land Cover of Dudhwa Tiger Reserve (Core in 2010)

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

The assessment of forest cover in the AUTKBTR of Dudhwa Tiger Reserve is **392.14 sq km** which is about **14.34 %** of the reserve. For the study of 2010 image interpretation is based on the satellite data of IRS – P6 LISS III .The study reveals that **171.27sq km** of forest falls in Very Dense Forest category,**156.68 sq km** of forest lie in Moderately Dense Forest category and **64.19sq km** forest is in Open Forest category.

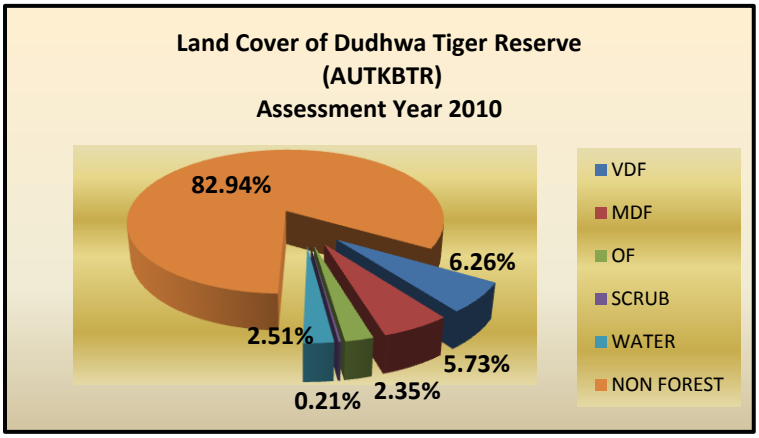


Fig 3.2.3b Pie chart showing percentage of Land Cover of Dudhwa Tiger Reserve (AUTKBTR in 2010)

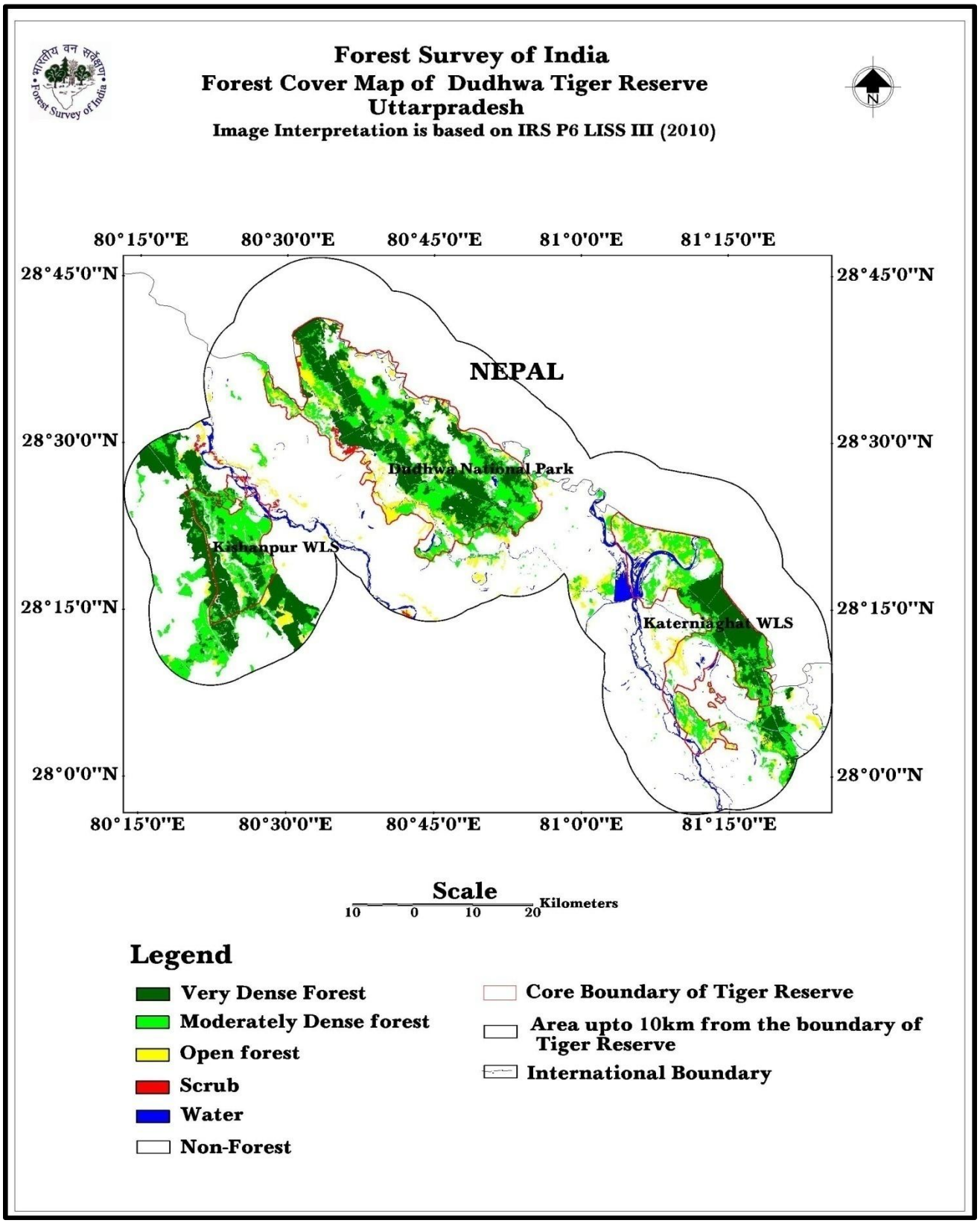


Fig.3.2.3 Forest Cover Map of Dudhwa Tiger Reserve (2010)

Table 3.2: Forest Cover Area (in sq km)in Core and AUTKBTR of Dudhwa Tiger Reserve

ASSESSMENT YEAR	TIGER RESERVE BOUNDARY	VDF	MDF	OF	TOTAL FOREST	SCRUB	WATER	NON FOREST
1990	CORE	402.66	367.58	121.92	892.16	13.00	27.82	160.81
	AUTKBTR	168.49	149.24	57.81	375.54	4.76	58.33	2295.93
2000	CORE	399.62	402.17	116.93	918.72	0.44	22.81	151.82
	AUTKBTR	170.72	165.60	56.72	393.04	0.20	55.95	2285.37
2010	CORE	408.30	400.72	119.69	928.71	5.48	36.57	123.03
	AUTKBTR	171.27	156.68	64.19	392.14	5.51	68.63	2268.28

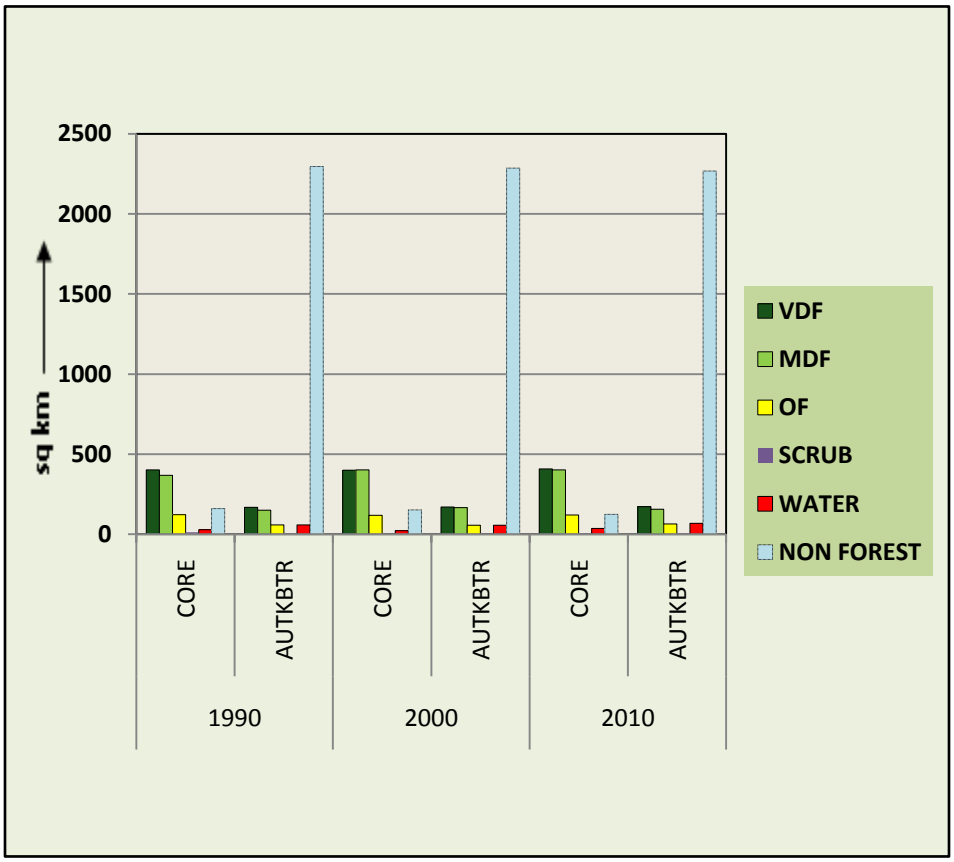


Fig 3.2 Bar diagram showing Land Cover of Dudhwa Tiger Reserve in Core and AUTKBTR (1990-2010)

3. 3 CHANGE OF FOREST COVER IN DUDHWA TIGER RESERVE DURING 1990-2010

3.3.1 Changes in Forest Cover during 1990-2000

- **Core Area:**

During the period of 1990 to 2000 total forest cover increased by 26.56 sq km in the core area of Dudhwa Tiger Reserve. It reveals that out of 402.66 sq km of very dense forest in 1990, 399.62 sq km of forest remain very dense in 2000 and rest has been converted in other category. Moderately dense forest shows a positive change from 367.58 sq km to 402.17 sq km during 1990 to 2000 but Open forest cover decreased from 121.92 sq km to 116.93 sq km during that period of time. The net change shows that very dense forest has a negative change of 3.04sq km, moderately dense forest has a positive change of 34.59sq km and open forest has a negative change of 4.99 sq km .

Positive change in forest cover in Core is due to better protection and conservation strategies deployed at local level. Subsequently lesser intervention due to anthropogenic factors has played an important role in increase in forest cover. The negative changes in Very Dense and Open forest have been observed mainly due to the changes in river course (mostly Sharda and Suheli river) flowing in the area, flood, silt deposit.

Table 3.3.1a : Forest Cover changes in Core Area of Dudhwa Tiger Reserve(1990-2000)
(Area in sq km)

Category	1990 Assessment	2000 Assessment	Change
Very Dense Forest	402.66	399.62	-3.04
Moderately Dense Forest	367.58	402.17	34.59
Open Forest	121.92	116.93	-4.99
Total Forest	892.16	918.72	26.56
Scrub	13.00	0.44	-12.56
Non Forest	188.63	174.63	-14

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

During the period of 1990 to 2000 total forest cover increased by 17.50 sq km in the AUTKBTR of Dudhwa Tiger Reserve. It reveals that very dense forest in 1990 was 168.49sq km and in 2000 it has been increased up to 170.72 sq km. Moderately dense forest shows a positive change from 149.24 sq km to 165.60 sq km during 1990 to 2000 but in case of Open forest cover area figure have been decreased from 57.81 sq km to 56.72 sq km during that period of time. The net change shows that very dense forest has a negative change of 3.04 sq km, moderately dense forest has a positive change of 34.59 sq km and open forest has a negative change of 4.99 sq km.

Although during this period of time negative changes in Open forest has been observed mainly due to flood, changes in river course(mostly Sharda) flowing in the area but better management practices and habitat management has yielded a positive result which is evident with increase in MDF and overall increase of total forest area.

Table 3.3.1b: Forest Cover changes in AUTKBTR of Dudhwa Tiger Reserve (1990-2000)

(Area in sq km)

Category	1990 Assessment	2000 Assessment	Change
Very Dense Forest	**168.49**	**170.72**	**2.23**
Moderately Dense Forest	**149.24**	**165.60**	**16.36**
Open Forest	**57.81**	**56.72**	**-1.09**
Total Forest	**375.54**	**393.04**	**17.50**
Scrub	**4.76**	**0.20**	**-4.56**
Non Forest	**2354.26**	**2341.32**	**-12.94**

CHANGES OF FOREST COVER DURING 10 YEARS (1990-2000)

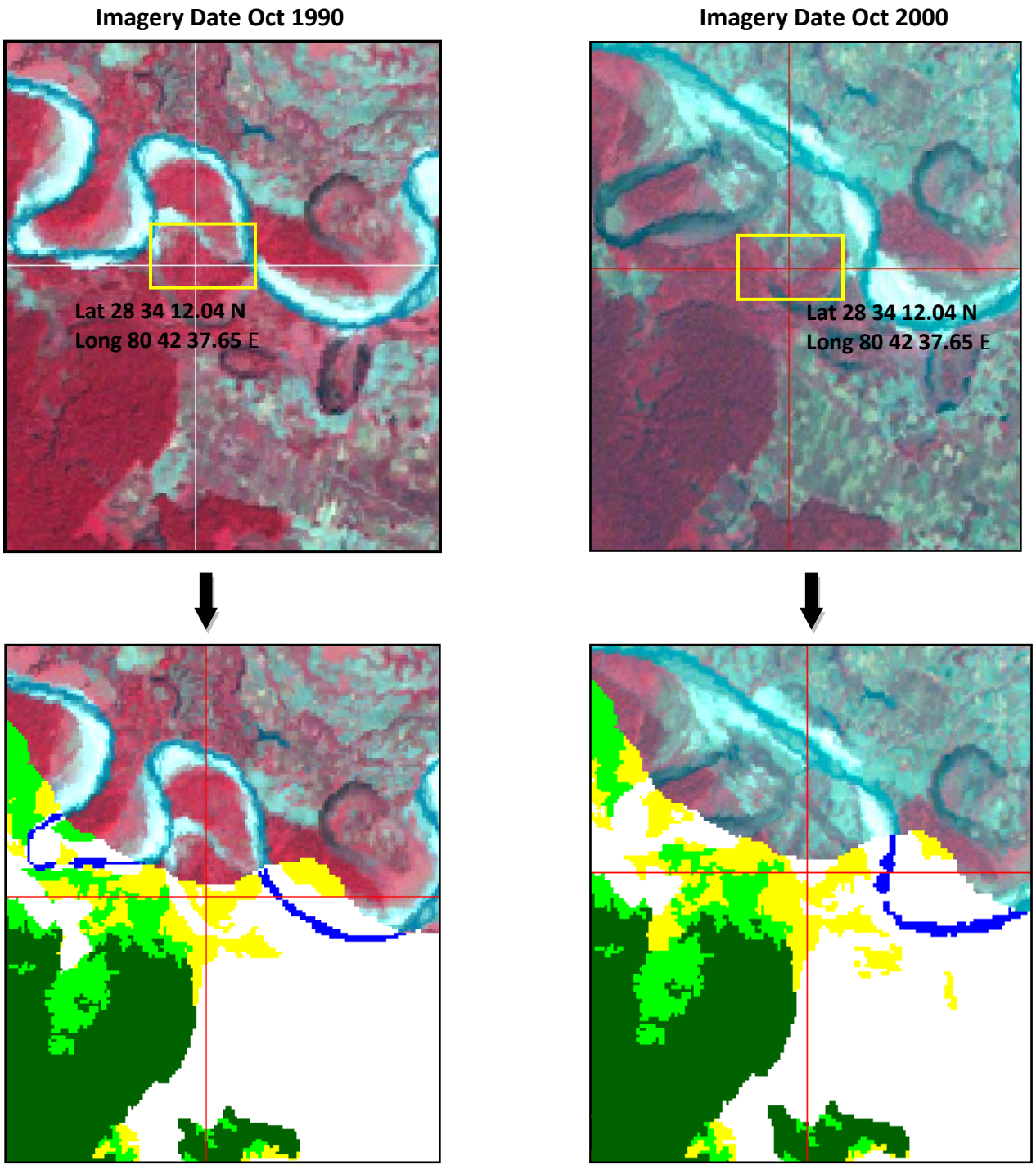


Fig. 1:**Area showing in maps falling in core area of the reserve**

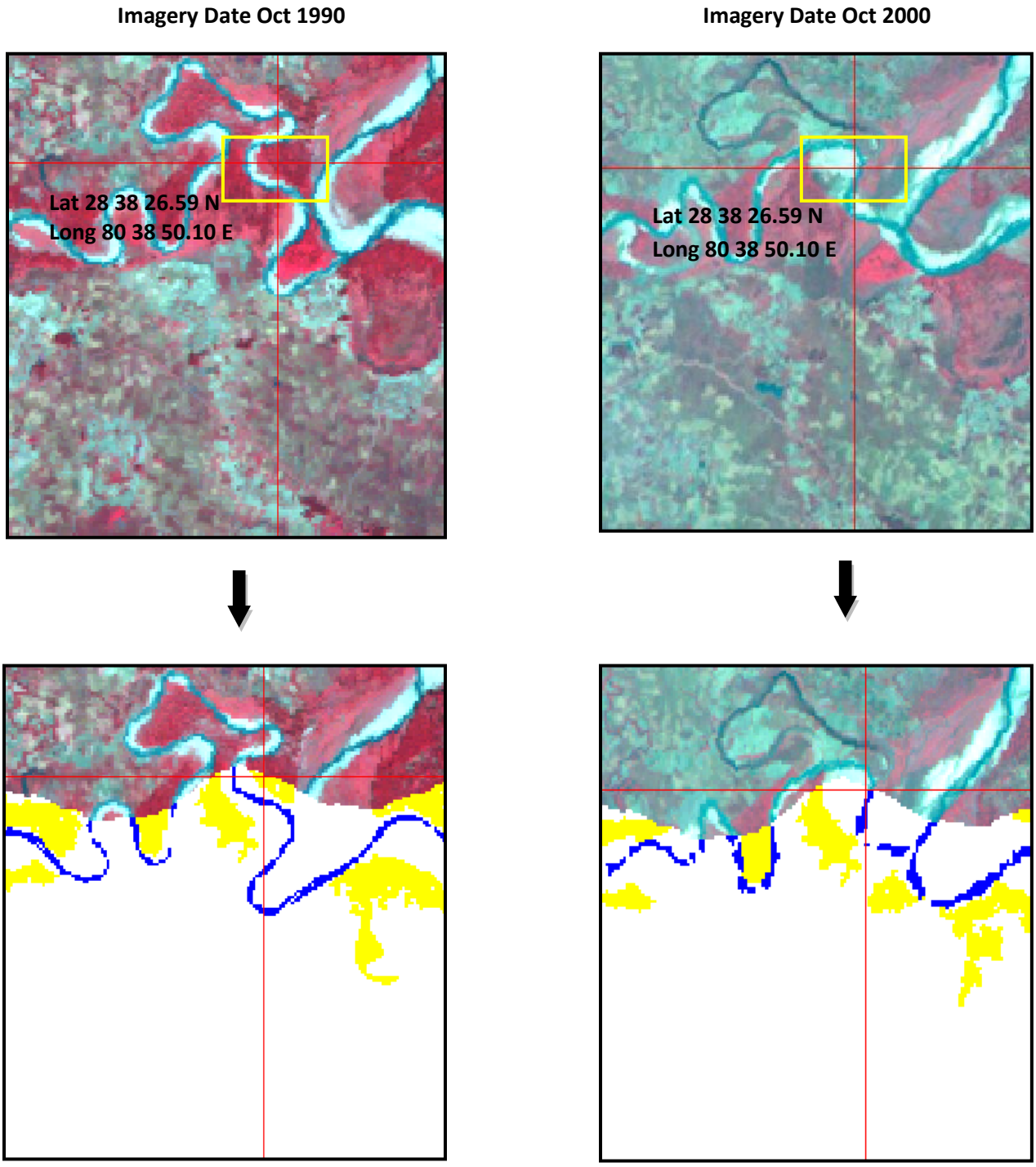


Fig. 2: **Area showing in maps falling in core area (Dudhwa Park Range) of the reserve**

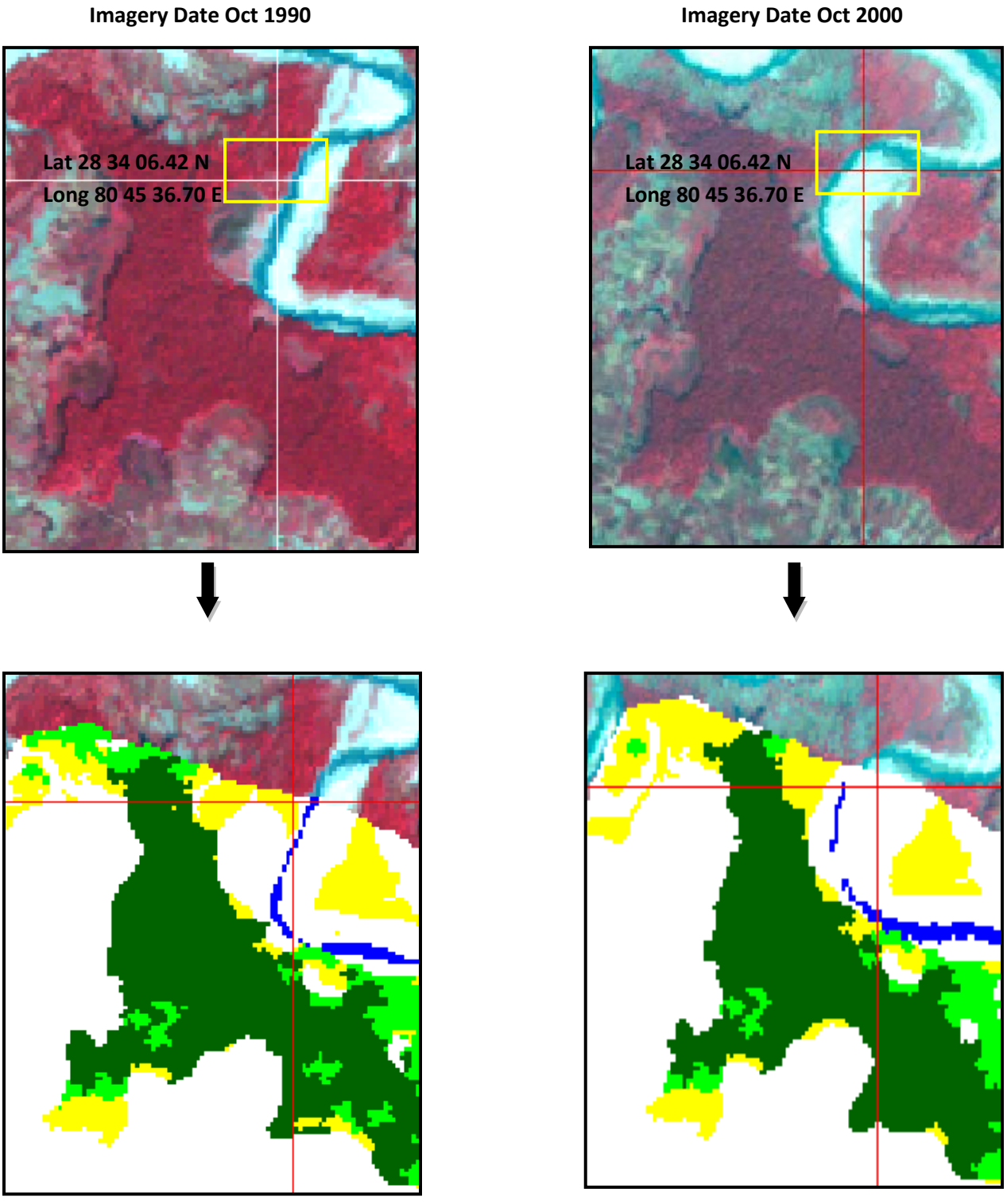


Fig. 3: **Area showing in maps falling in core area (Dudhwa Park Range) of the reserve**

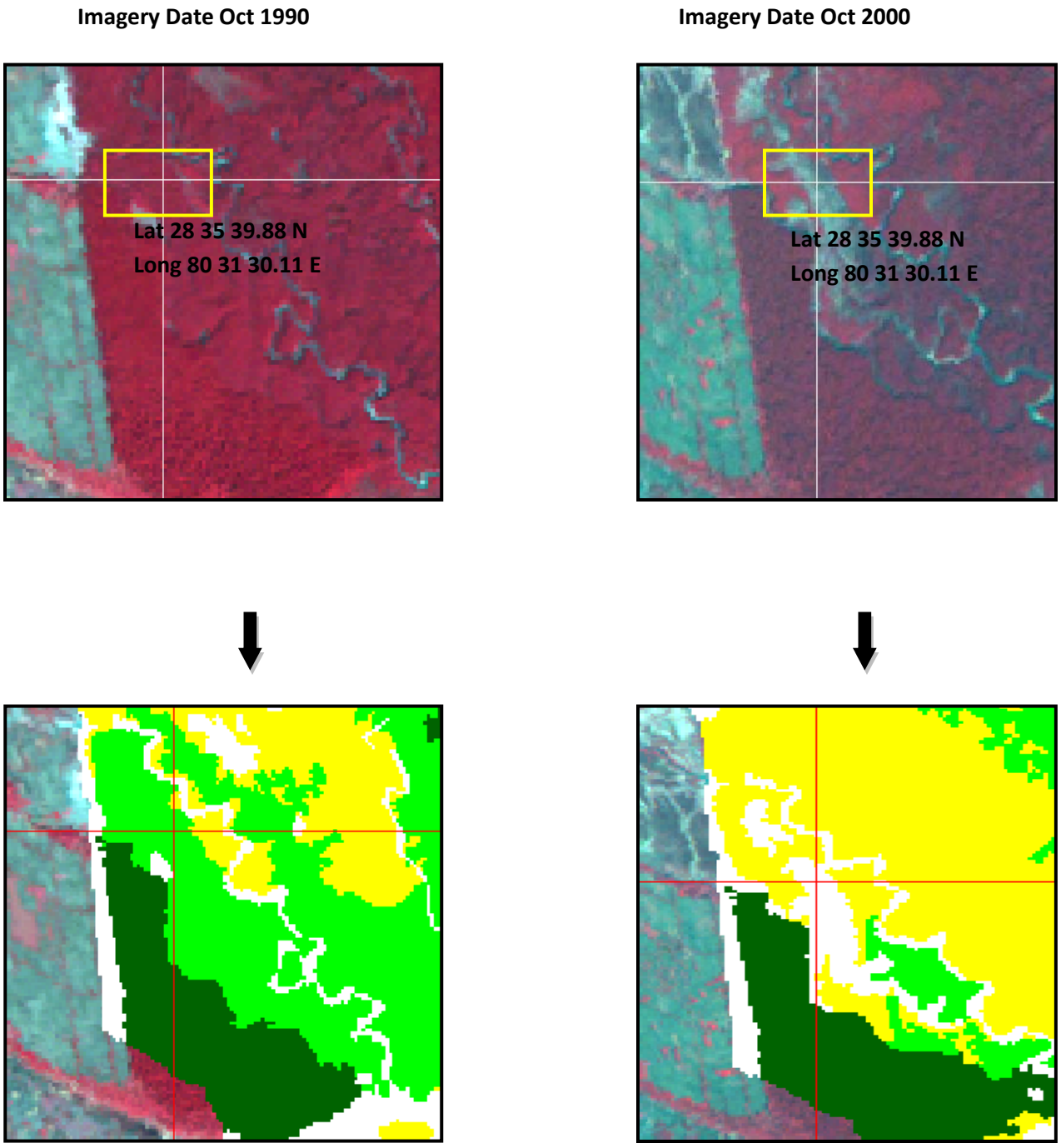


Fig. 4: **Area showing in maps falling in core area (Dudhwa Park Range) of the reserve**

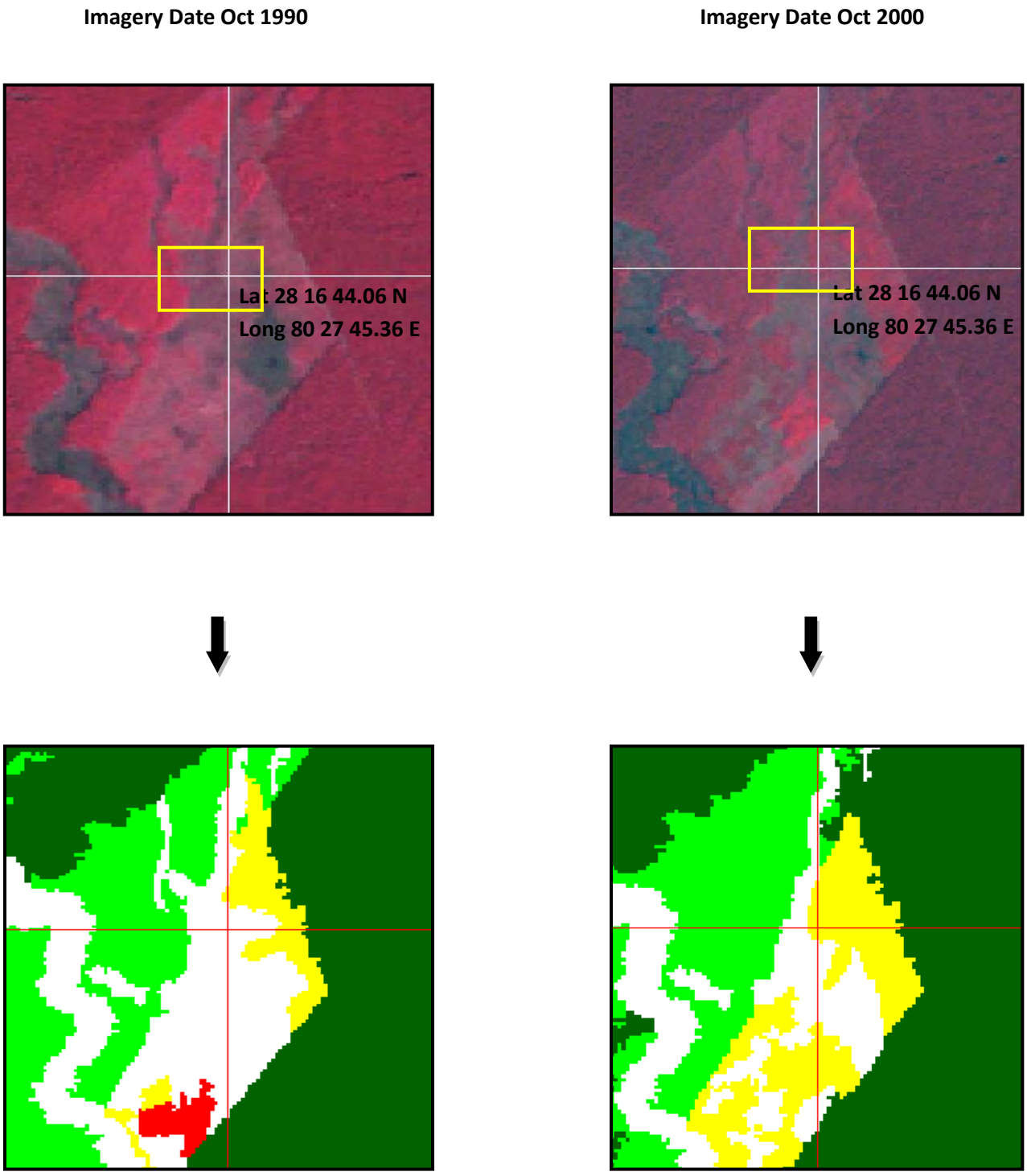


Fig. 5: **Area showing in maps falling in AUTKBTR (Bhira Range) of the reserve**

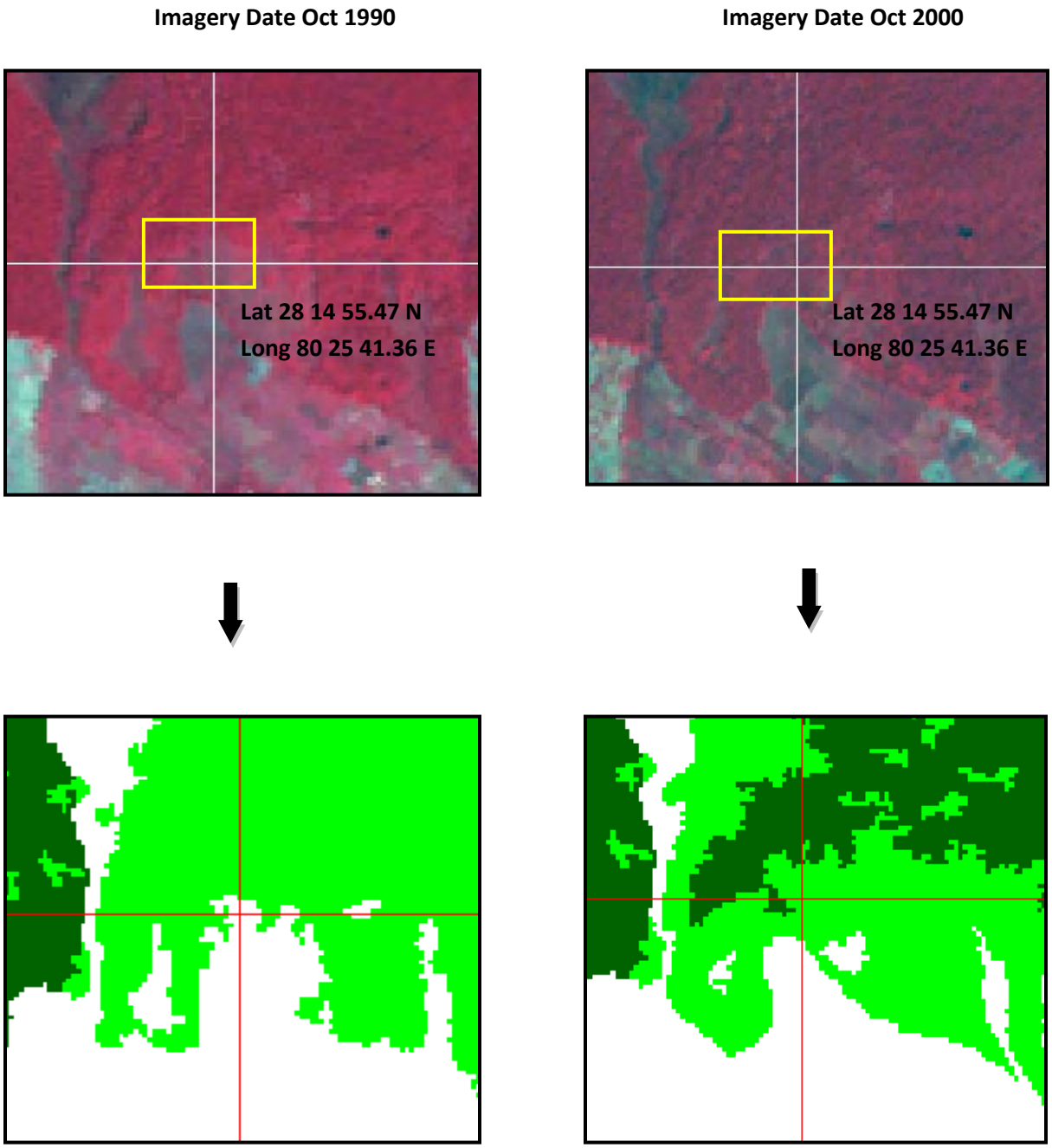


Fig. 6: **Area showing in maps falling in AUTKBTR (Mailani Range) of the reserve**

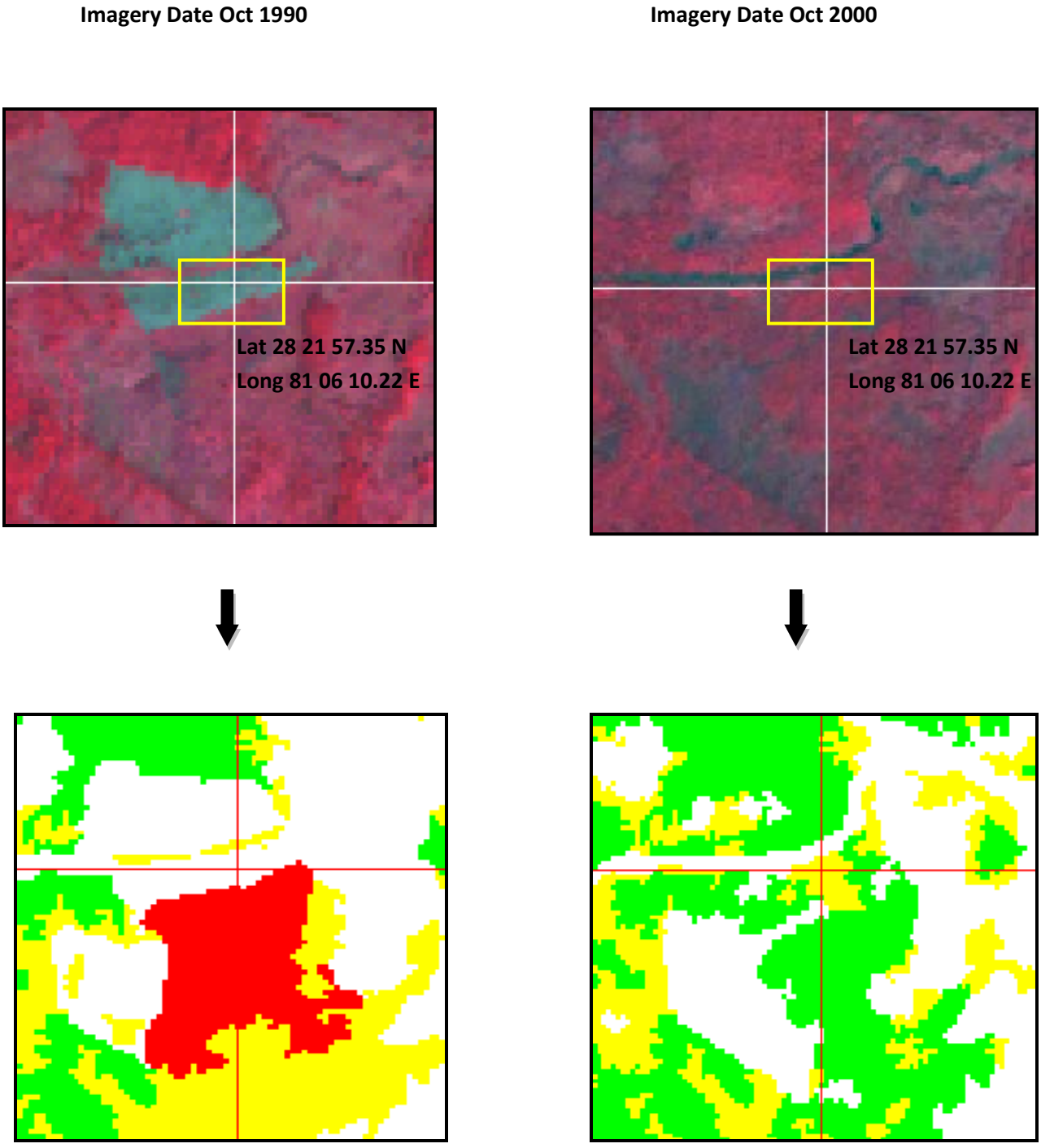


Fig. 7: **Area showing in maps falling in core area of the reserve**

3.3.2 Changes in Forest Cover during 2000-2010

- **Core Area:**

During the period of 2000 to 2010 total forest cover increased by 9.99 sq km in the core area of Dudhwa Tiger Reserve. It reveals that very dense forest in 2000 was 399.62 sq km and in 2010 it has been increased up to 408.30 sq km. Moderately dense forest shows a negative change from 402.17 sq km to 400.72 sq km during 2000 to 2010 .Open forest cover have been increased from 116.93 sq km to 119.69 sq km during that period of time. The net change shows that very dense forest has a positive change of 8.68 sq km, moderately dense forest has a negative change of 1.45 sq km and open forest has a positive change of 2.76 sq km.

As there is a qualitative improvement in forest whereby VDF has increased by 8.68 sq km and there is a overall increase in the forest cover which is substantiated by the carbon stock of the above said period and area. Flood, changes in river course (mostly Sharda and Ghaghra) flowing in the area also play a significant role for the negative changes in different forest classes.

Table 3.3.2a : Forest Cover changes in Core Area of Dudhwa Tiger Reserve (2000-2010)

(Area in sq km)

Category	2000 Assessment	2010 Assessment	Change
Very Dense Forest	399.62	408.30	8.68
Moderately Dense Forest	402.17	400.72	-1.45
Open Forest	116.93	119.69	2.76
Total Forest	918.72	928.71	9.99
Scrub	0.44	5.48	5.04
Non Forest	174.63	159.60	-15.03

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

During the period of 2000 to 2010 total forest cover decreased by 0.90 sq km in the AUTKBTR of Dudhwa Tiger Reserve. It shows that very dense forest in 2000 was 170.72 sq km and in 2010 it has been increased up to 171.27 sq km. Moderately dense forest shows a negative change from 165.60 sq km to 156.68 sq km during 2000 to 2010 but in case of Open forest cover area figure have been increased from 56.72 sq km to 64.19 sq km during that period of time. The net change shows that very dense forest has a positive change of 0.55 sq km, moderately dense forest has a negative change of 8.92 sq km and open forest has a positive change of 7.47 sqkm .

Increase in the flood plain area of the river (Sharda, Ghaghra, Suheli) causes negative changes in forest cover. Over a period of time there has been a constant of pressure over forest resources due to increase of population as such the open forest area have increased. As a result a negative change of 0.88 sq km forest has been observed during that period of time.

Table 3.3.2b: Forest Cover changes in AUTKBTR of Dudhwa Tiger Reserve (2000-2010)

(Area in sq km)

Category	2000 Assessment	2010 Assessment	Change
Very Dense Forest	170.72	171.27	0.55
Moderately Dense Forest	165.60	156.68	-8.92
Open Forest	56.72	64.19	7.47
Total Forest	393.04	392.14	-0.90
Scrub	0.20	5.51	5.31
Non Forest	2341.32	2336.91	-4.41

CHANGES OF FOREST COVER DURING 10YEARS(2000-2010)

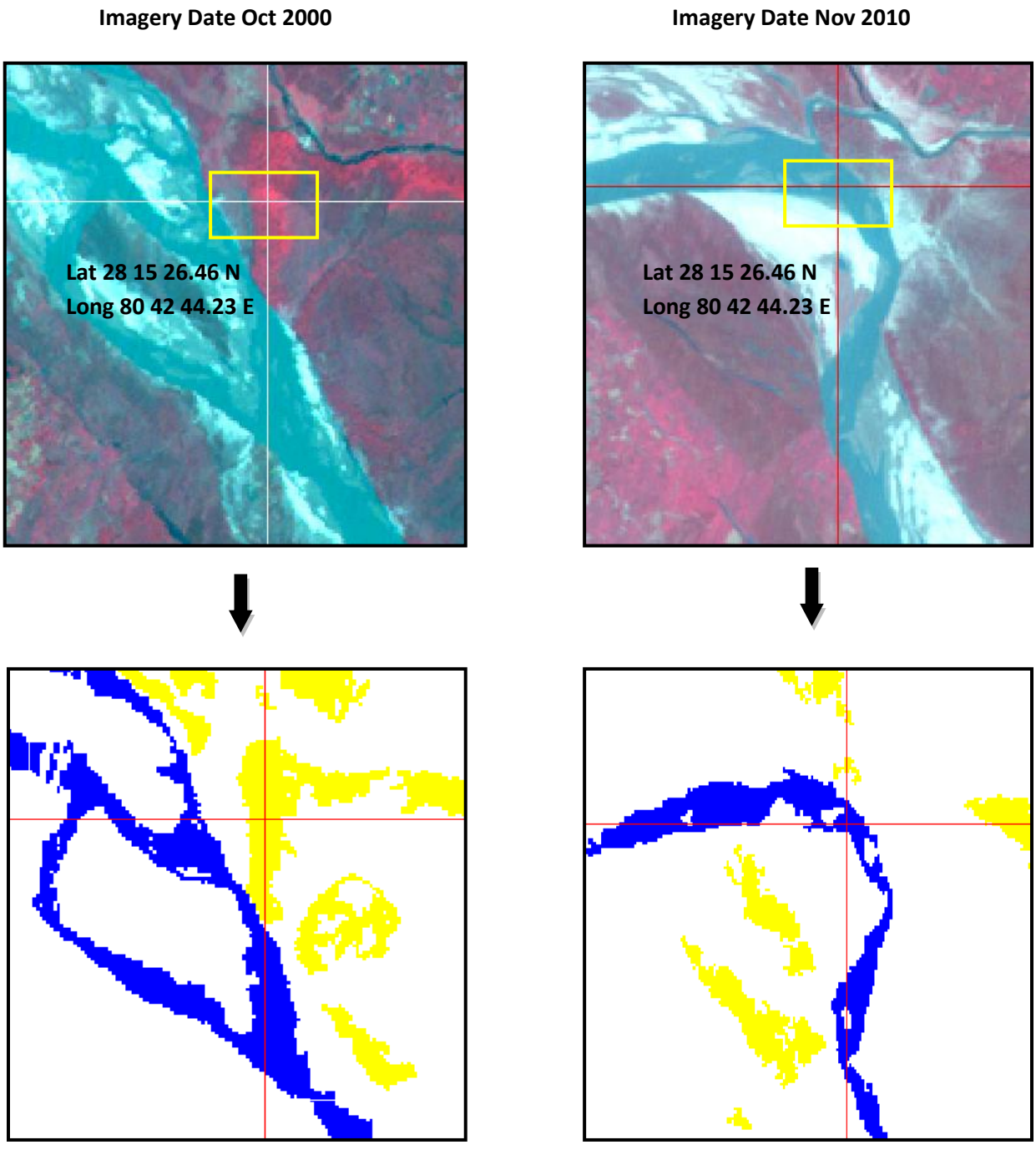


Fig. 1 :**Area showing in maps falling in AUTKBTR of the reserve**

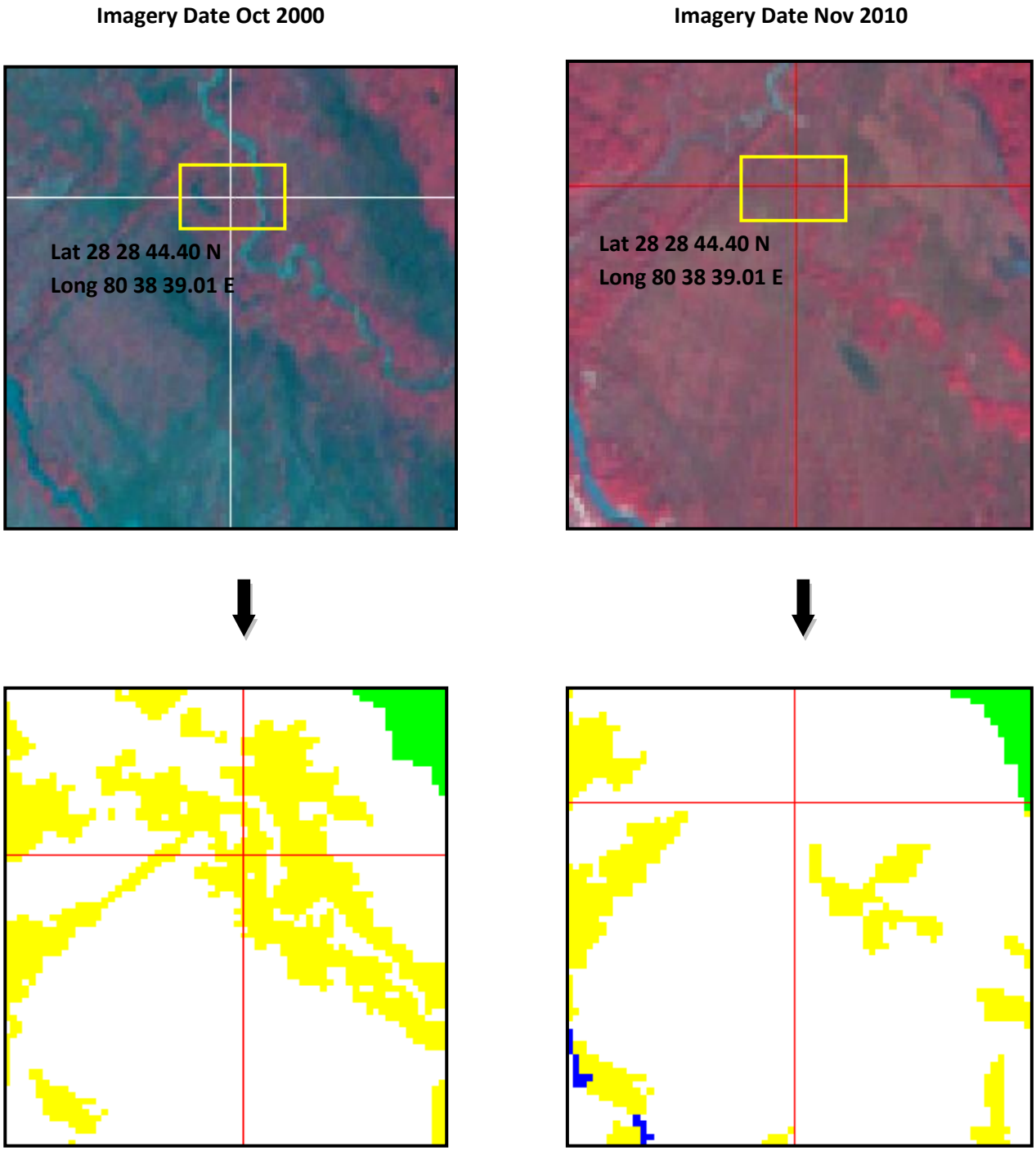


Fig.2: **Area showing in maps falling in core area (Dudhwa Park Range) of the reserve**

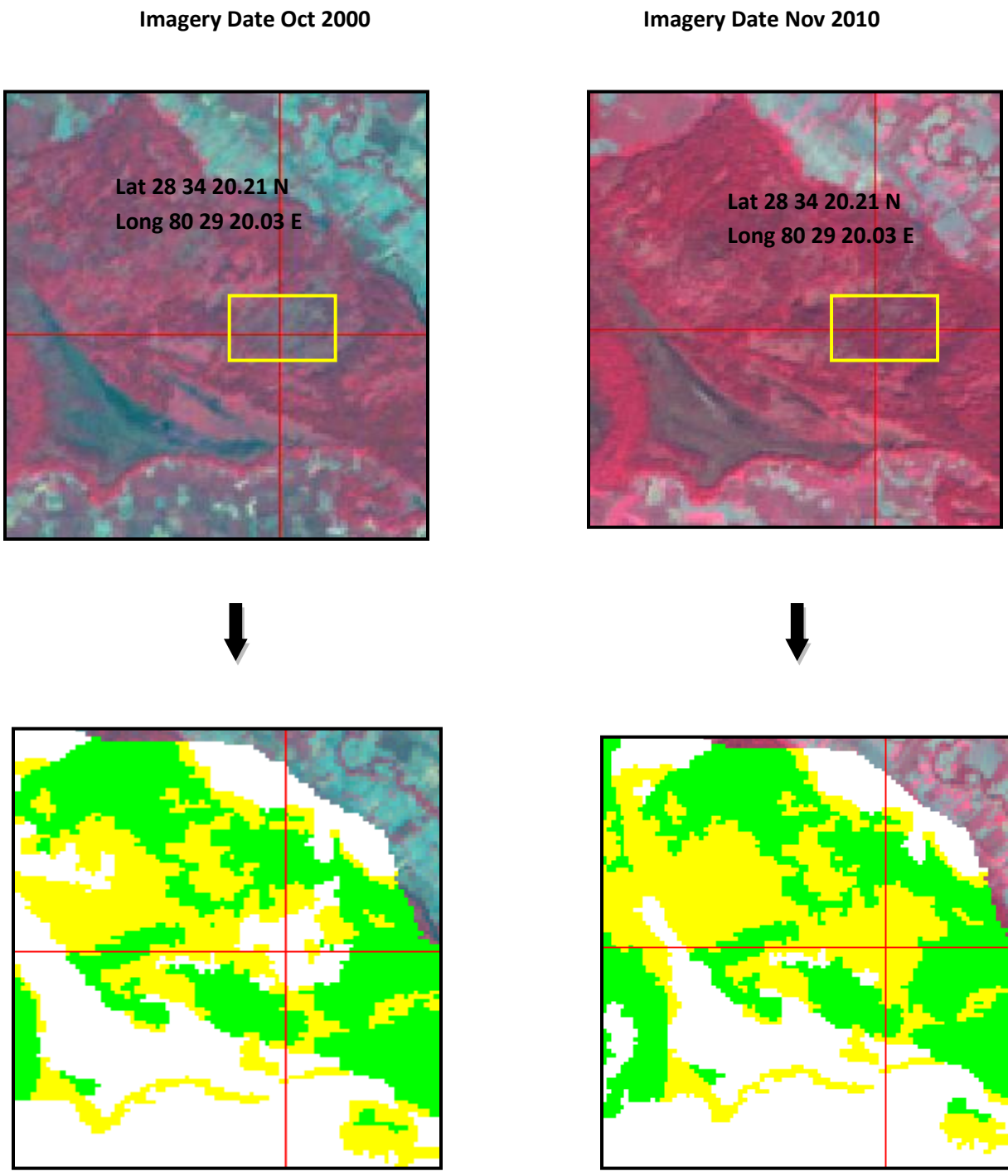


Fig.3: **Area showing in maps falling in core area (Dudhwa Park Range) of the reserve**

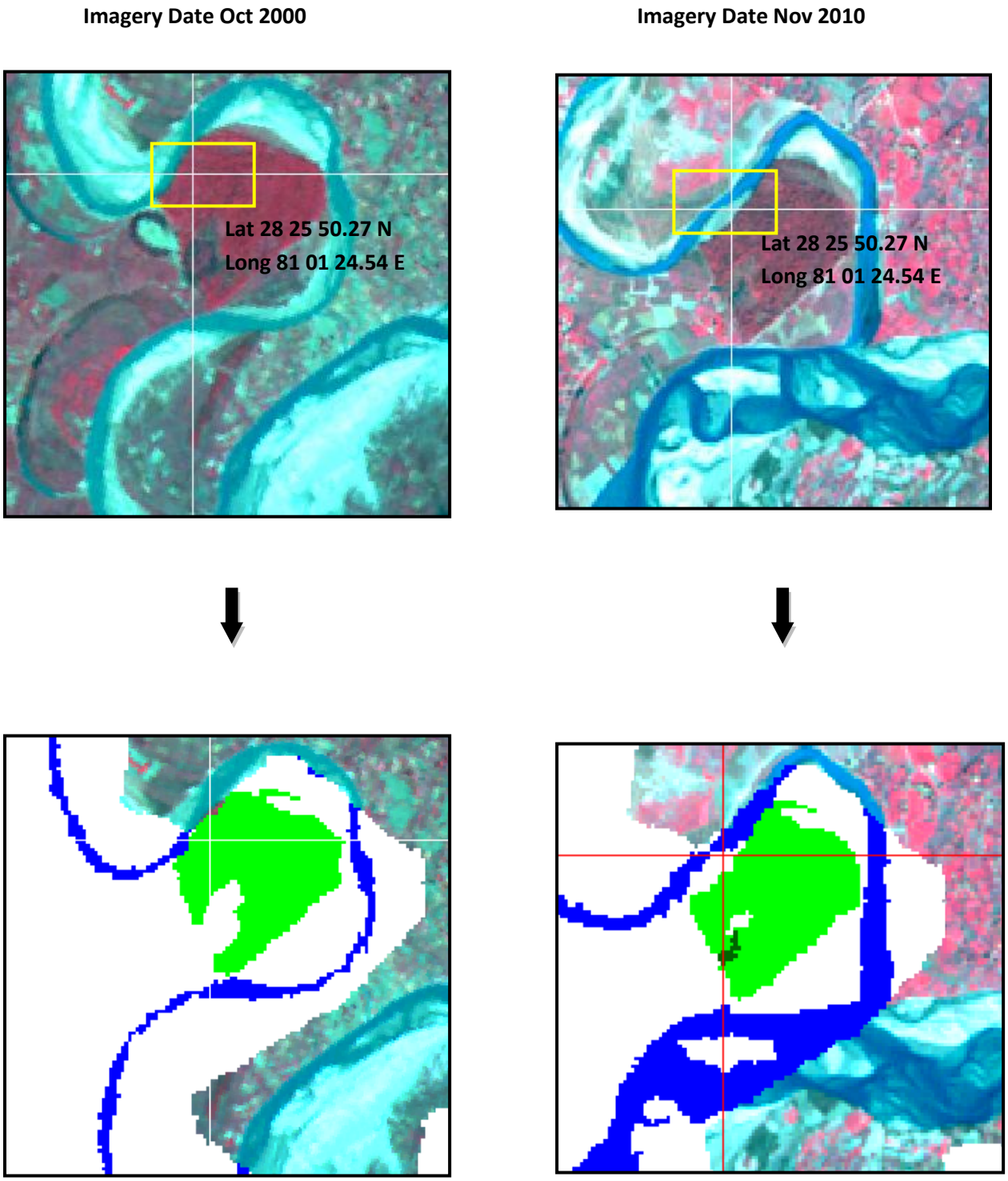


Fig.4: **Area showing in maps falling in AUTKBTR of the reserve**

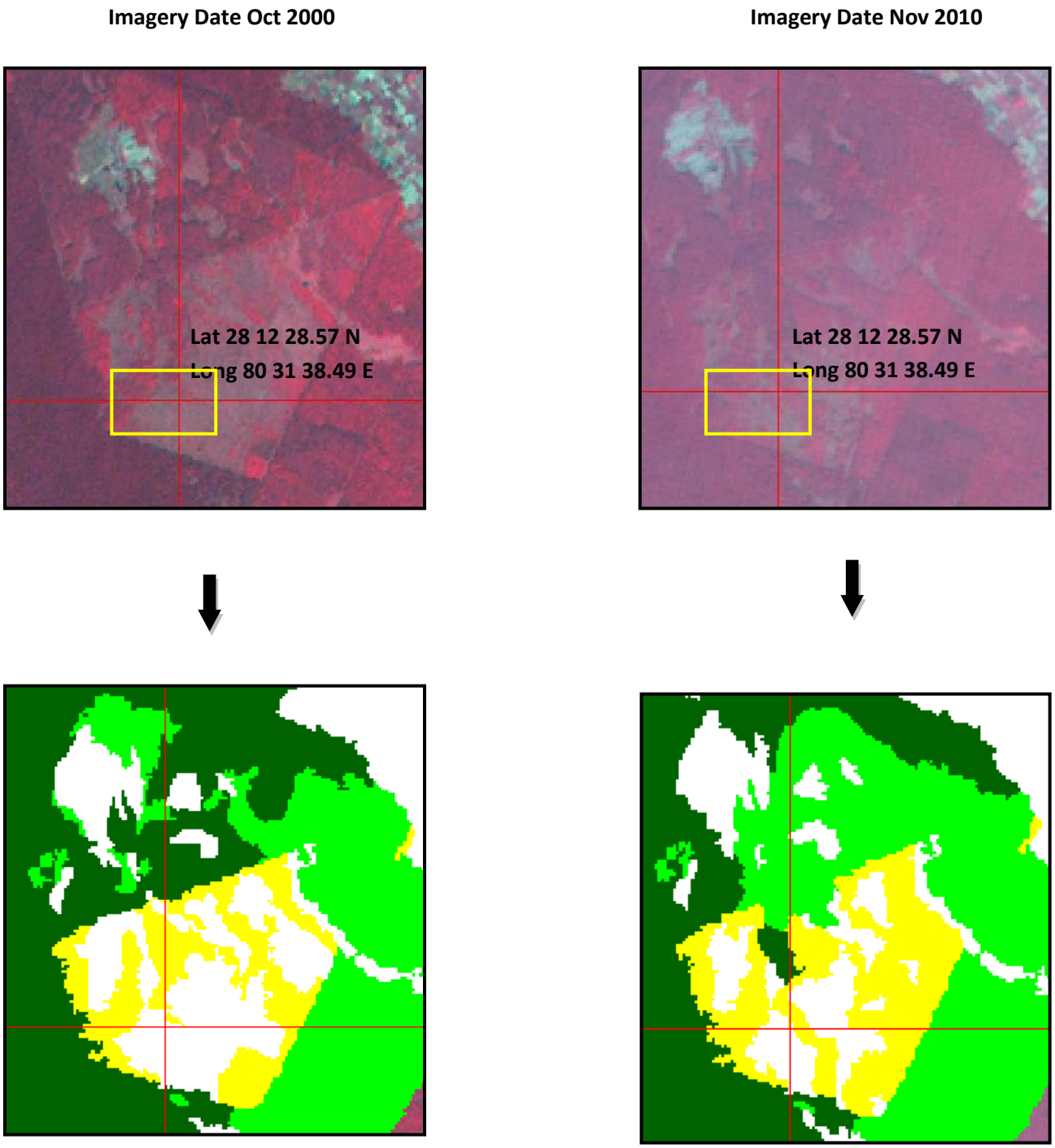


Fig.5 **:Area showing in maps falling in core area (Bhira Range) of the reserve**

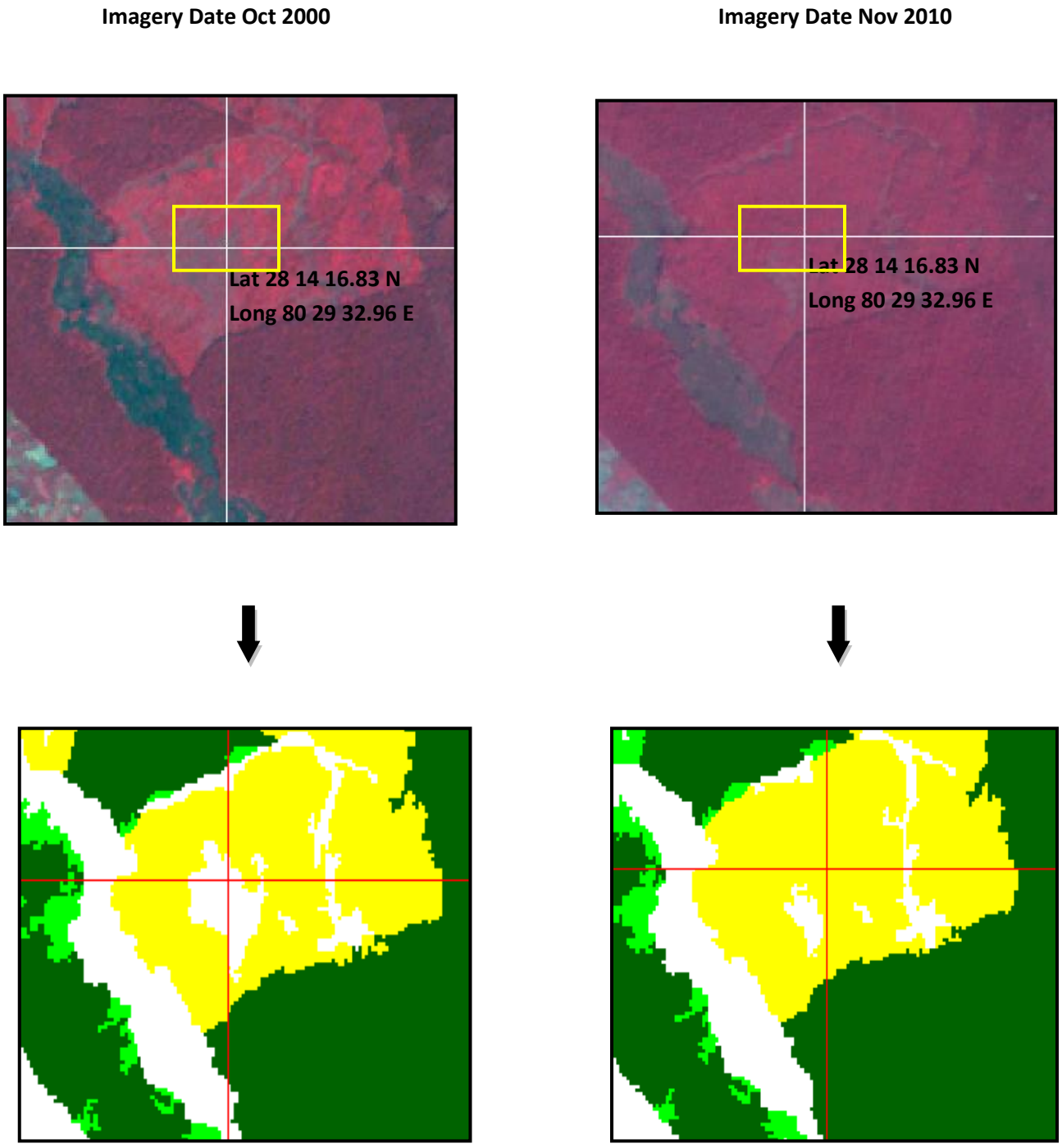


Fig.6: **Area showing in maps falling in AUTKBTR (Bhira Range) of the reserve**

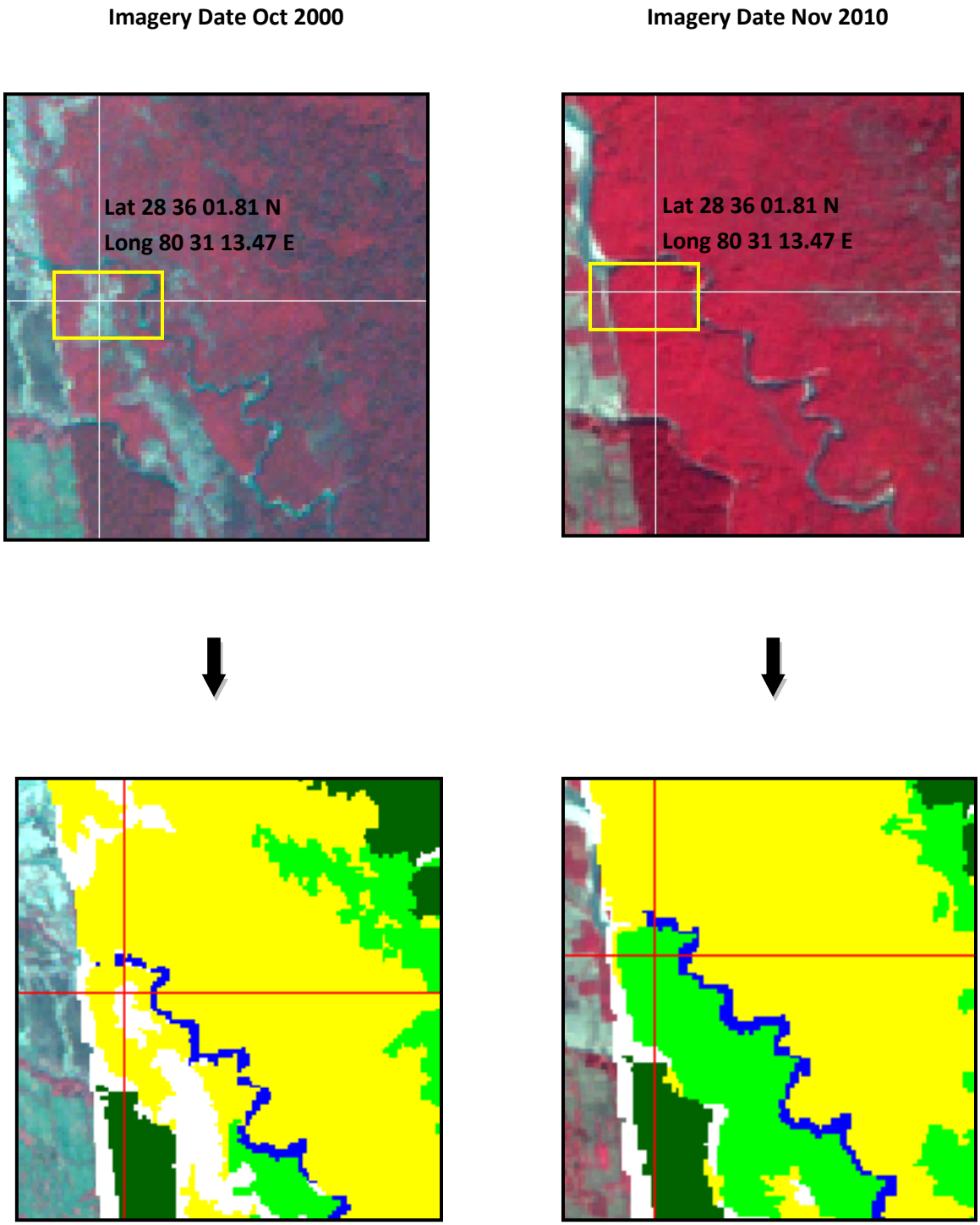


Fig.7: **Area showing in maps falling in core area (Dudhwa Park Range) of the reserve**

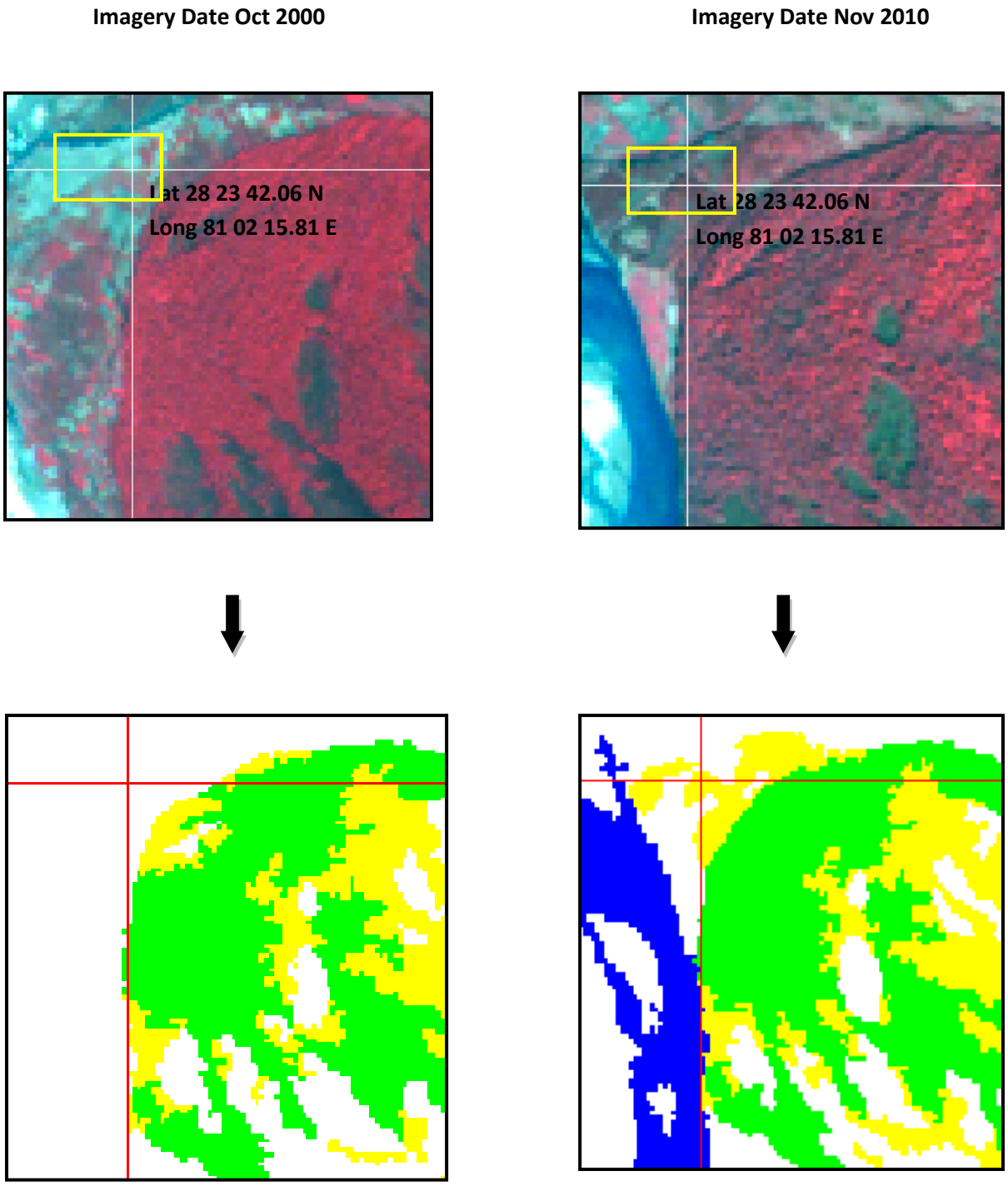


Fig.8: **Area showing in maps falling in AUTKBTR of the reserve**

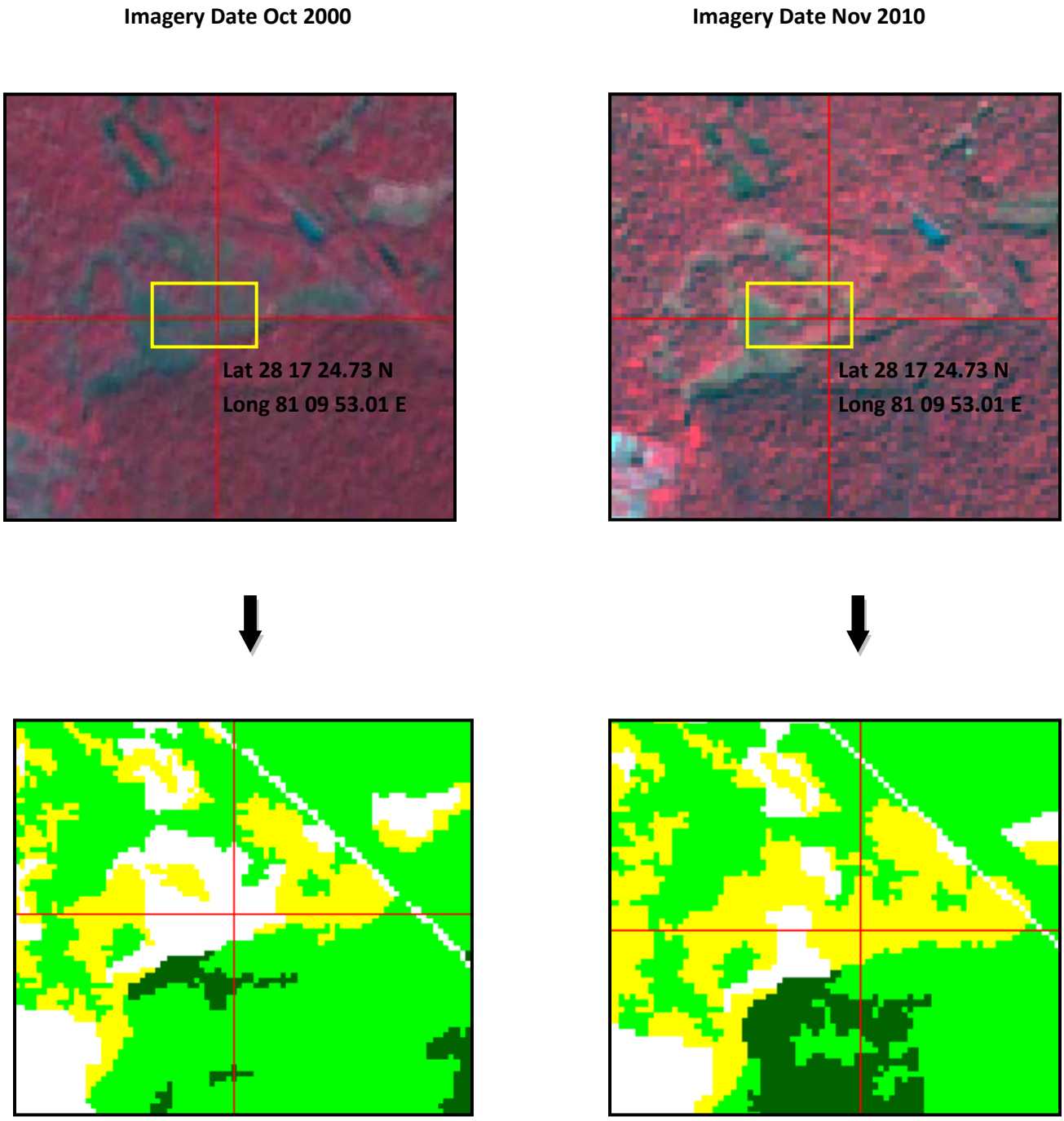


Fig.9: **Area showing in maps falling in core area of the reserve**

3.3.3 Changes in Forest Cover during 1990-2010

- **Core Area:**

During the period of 1990 to 2010 total forest cover increased by 36.55 sq km in the core area of Dudhwa Tiger Reserve. It reveals that very dense forest in 1990 was 402.66 sq km and in 2010 it has been increased up to 408.30 sq km. Moderately dense forest shows a positive change from 367.58 sq km to 400.72 sq km during 1990 to 2010 .Open forest cover have been decreased from 121.92 sq km to 119.69 sq km during that period of time. The net change shows that very dense forest has a positive change of 5.64 sq km,moderately dense forest has a positive change of 33.14 sq km and open forest has a negative change of 2.23 sq km .

Anthropogenic pressure was contained with the help of locals & effective protection and conservation strategies by the park management and it has yielded a positive result in increasing total forest cover by 36.55 sq km. The overall increase in forest cover is also substantiated by the Carbon stock assessment of the above mentioned period.

Table 3.3.3a: Forest Cover changes in Core Area of Dudhwa Tiger Reserve (1990-2010)

(Area in sq km)

Category	1990 Assessment	2010 Assessment	Change
Very Dense Forest	402.66	408.30	5.64
Moderately Dense Forest	367.58	400.72	33.14
Open Forest	121.92	119.69	-2.23
Total Forest	892.16	928.71	36.55
Scrub	13.00	5.48	-7.52
Non Forest	188.63	159.60	-29.03

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

During the period of 1990 to 2010 total forest cover increased by 16.6 sq km in the AUTKBTR of Dudhwa Tiger Reserve. It shows that very dense forest in 1990 was 168.49sq km and in 2010 it has been increased up to 171.27 sq km. Moderately dense forest shows a positive change from 149.24 sq km to 156.68 sq km during 1990 to 2010 and in case of Open forest cover also area figure have been increased from 57.81 sq km to 64.19 sq km during that period of time. The net change shows that very dense forest, moderately dense forest and open forest have a positive change of 2.78 sq km, 7.44 sq km and 6.38 sq km respectively.

Better management practices and better habitat management strategies by the Park authority yielded positive change or improvement in forest cover both qualitatively and quantitatively from 1990-2010.

Table 3.3.3b: Forest Cover changes in AUTKBTRof Dudhwa Tiger Reserve (1990- 2010)

(Area in sq km)

Category	1990 Assessment	2010 Assessment	Change
Very Dense Forest	168.49	171.27	2.78
Moderately Dense Forest	149.24	156.68	7.44
Open Forest	57.81	64.19	6.38
Total Forest	375.54	392.14	16.6
Scrub	4.76	5.51	0.75
Non Forest	2354.26	2336.91	-17.35

CHANGES OF FOREST COVER DURING 20 YEARS(1990-2010)

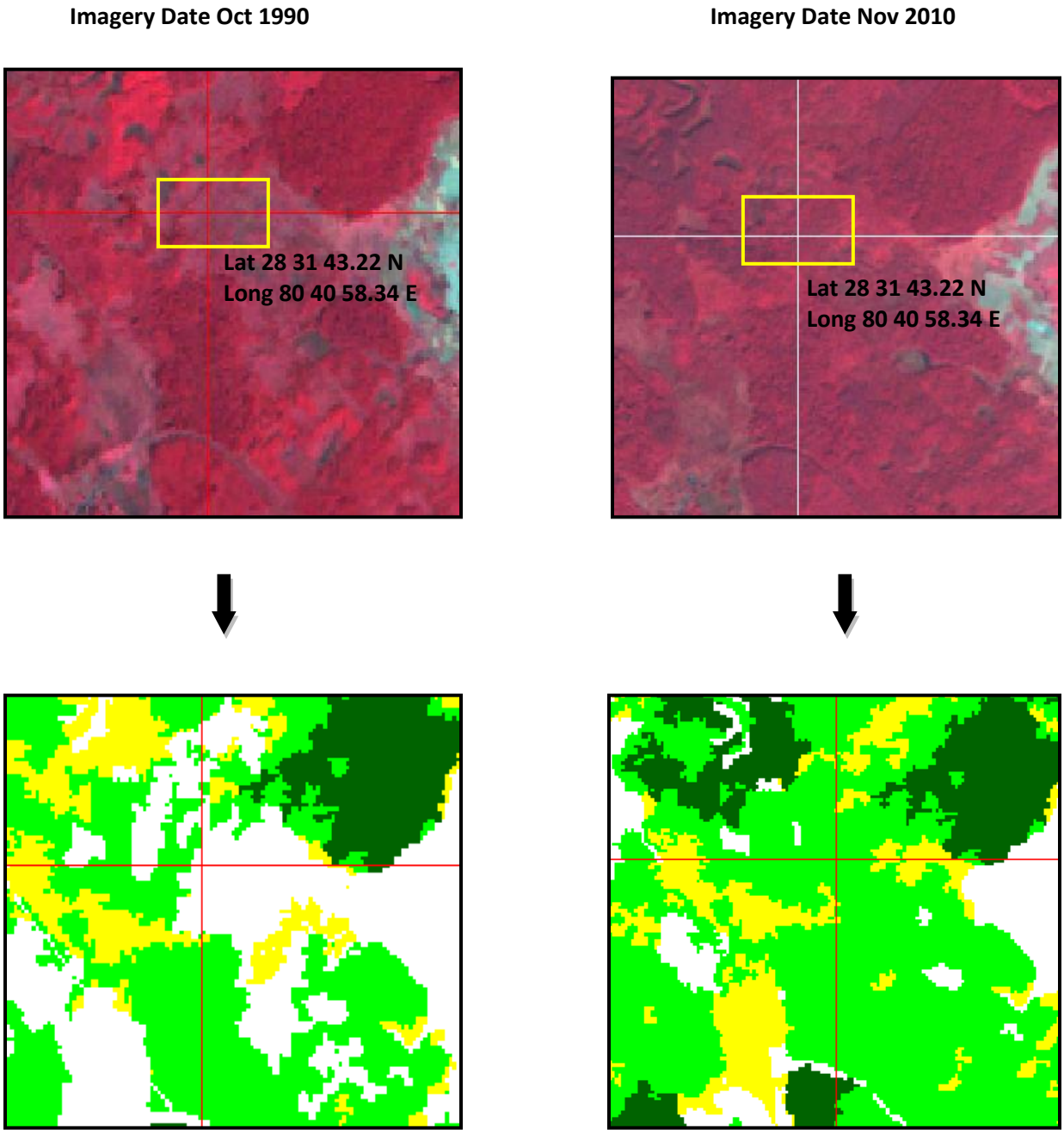


Fig.1: **Area showing in maps falling in core area (Dudhwa Park Range)of the reserve**

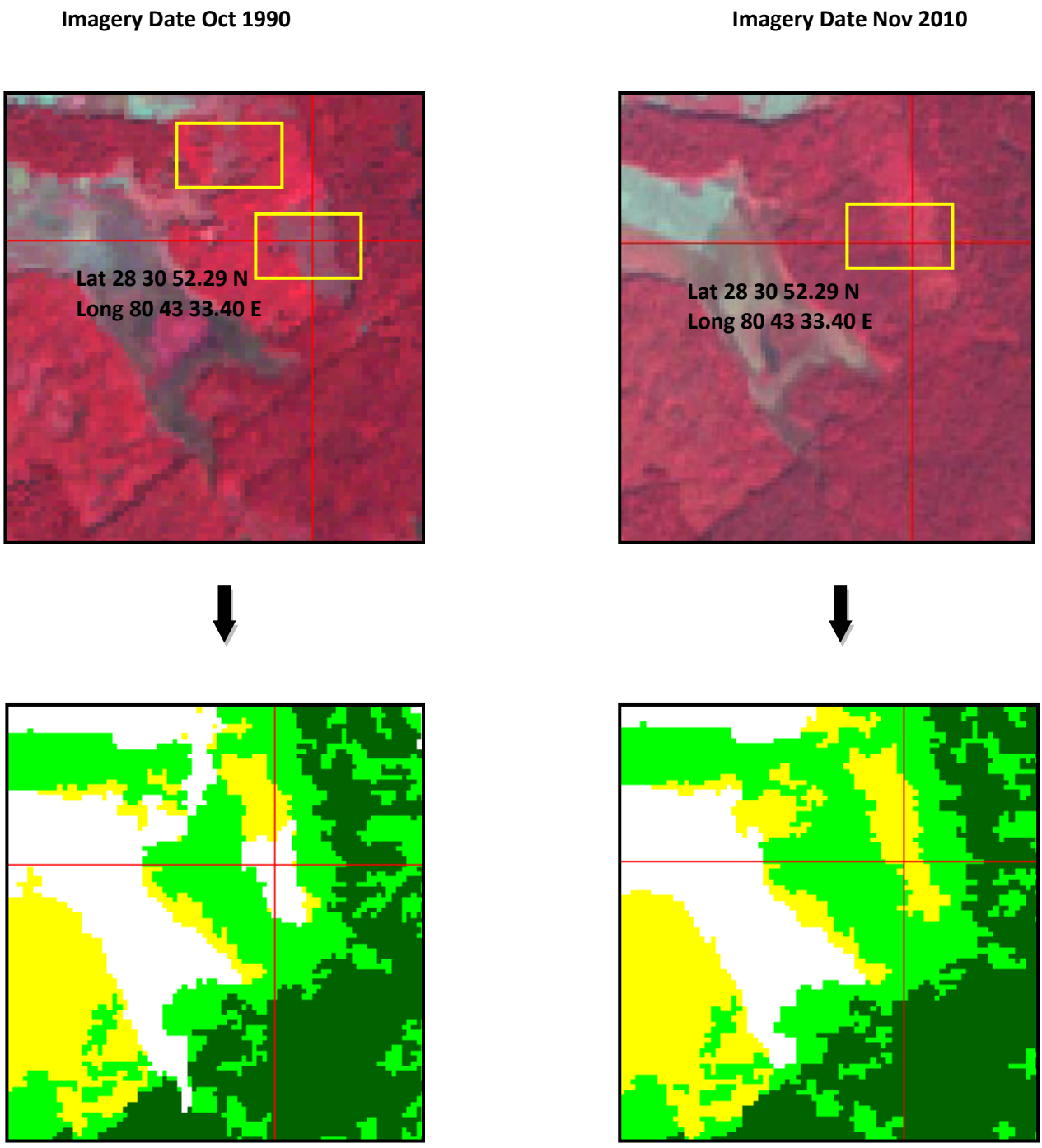


Fig.2: **Area showing in maps falling in core area (Dudhwa Park Range) of the reserve**

Imagery Date Oct 1990

Imagery Date Nov 2010

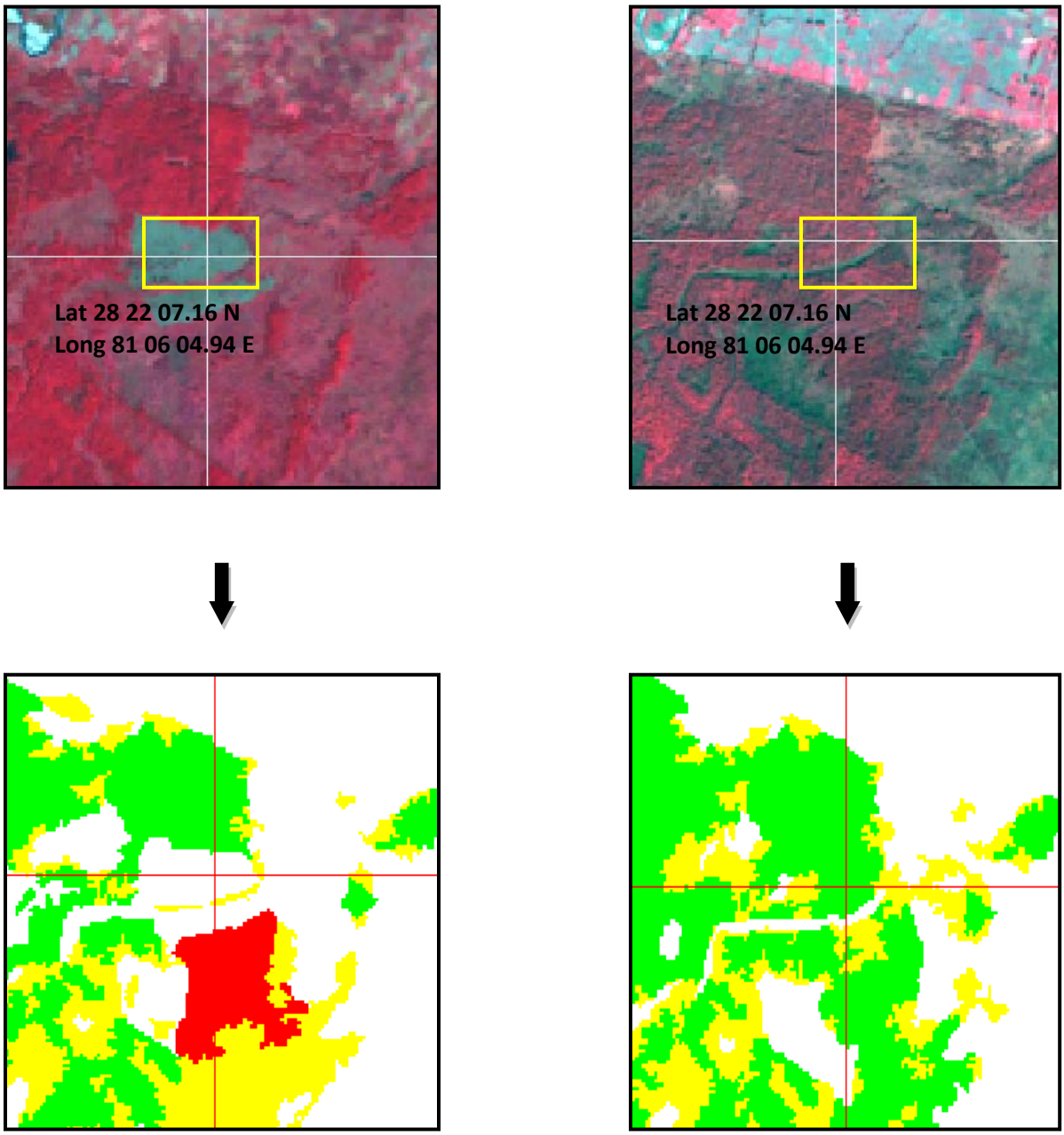


Fig.3 **:Area showing in maps falling in core area of the reserve**

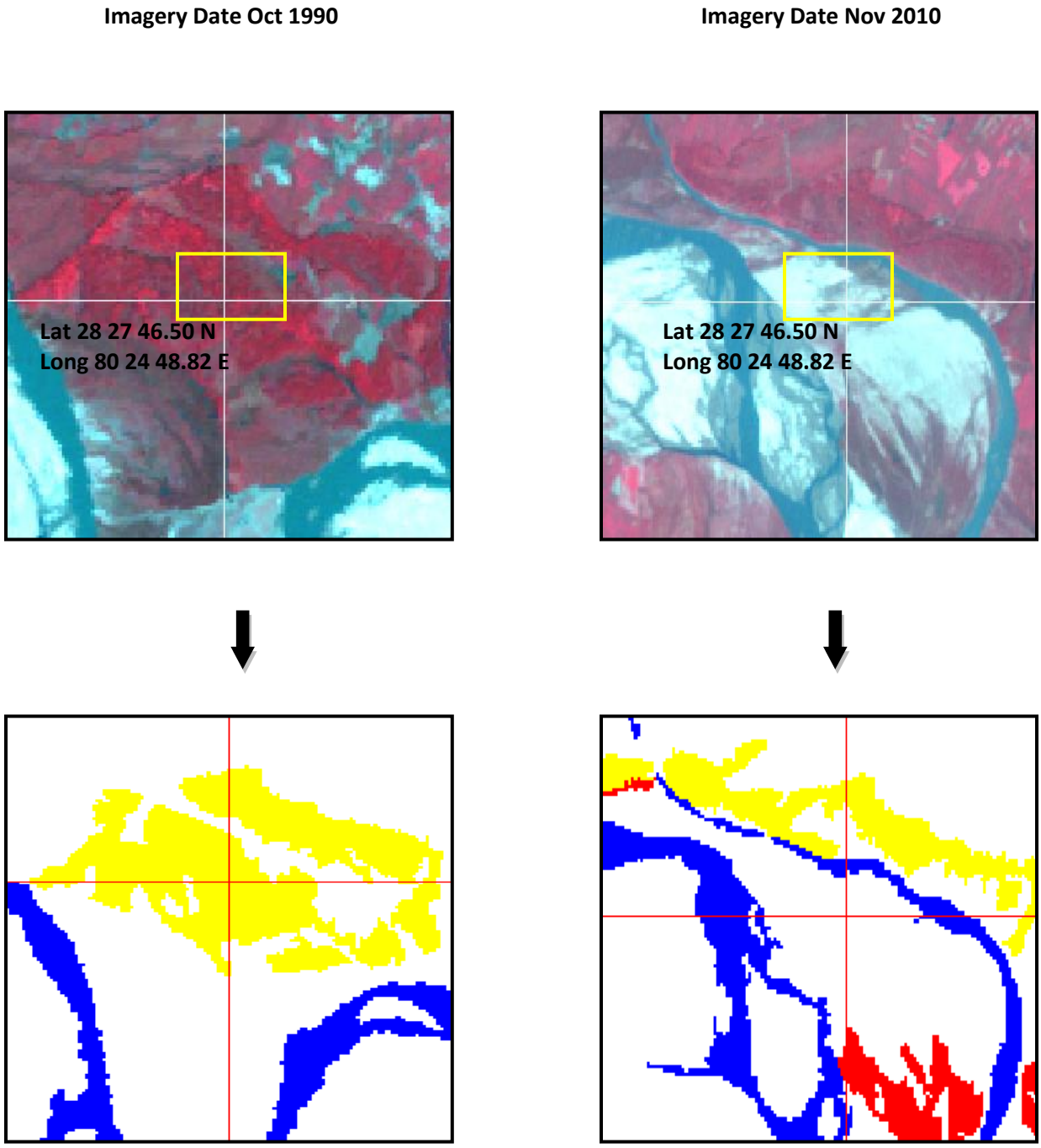


Fig.4: **Area showing in maps falling in AUTKBTR of the reserve**

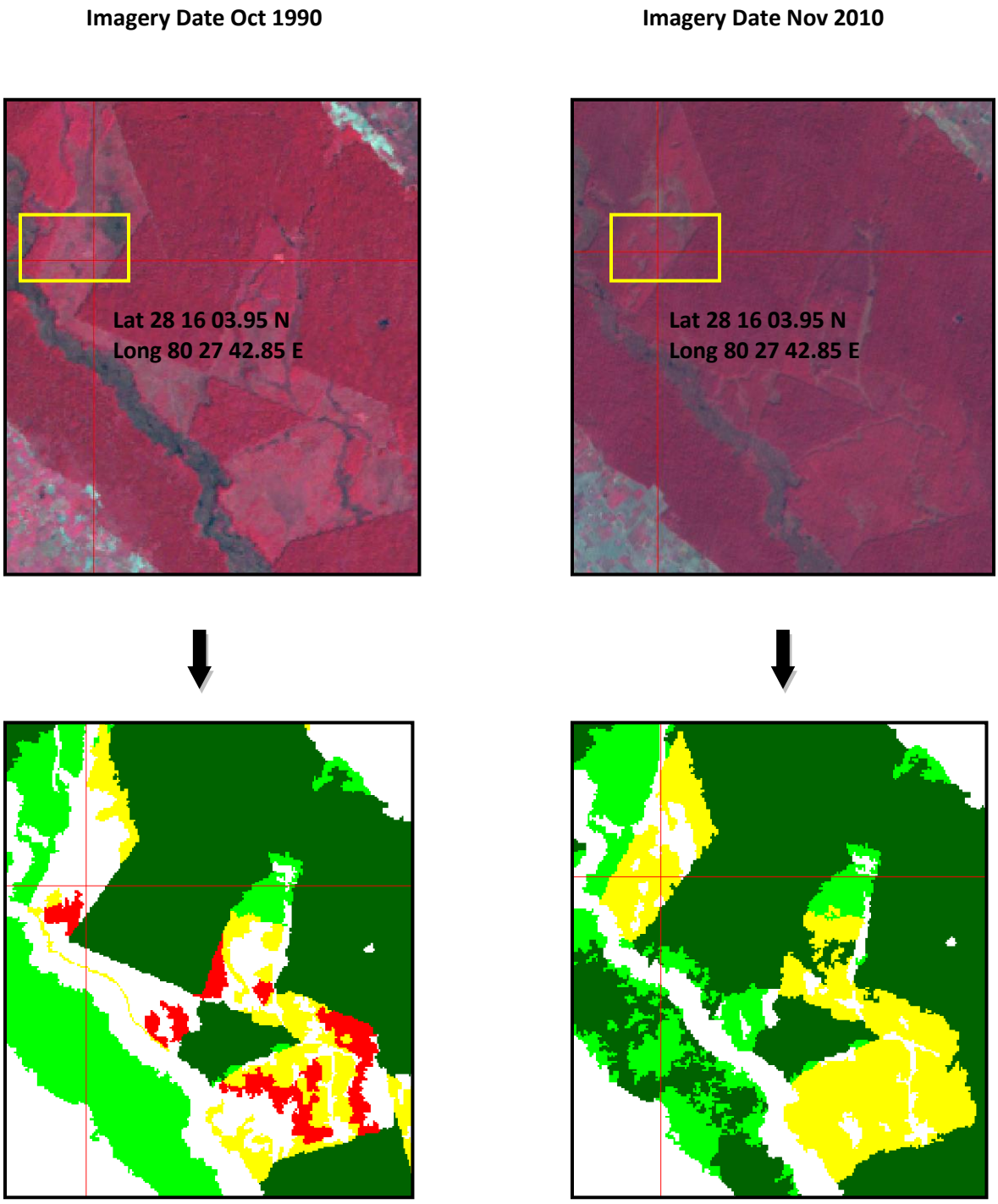


Fig.5: **Area showing in maps falling in AUTKBTR (Bhira Range)of the reserve**

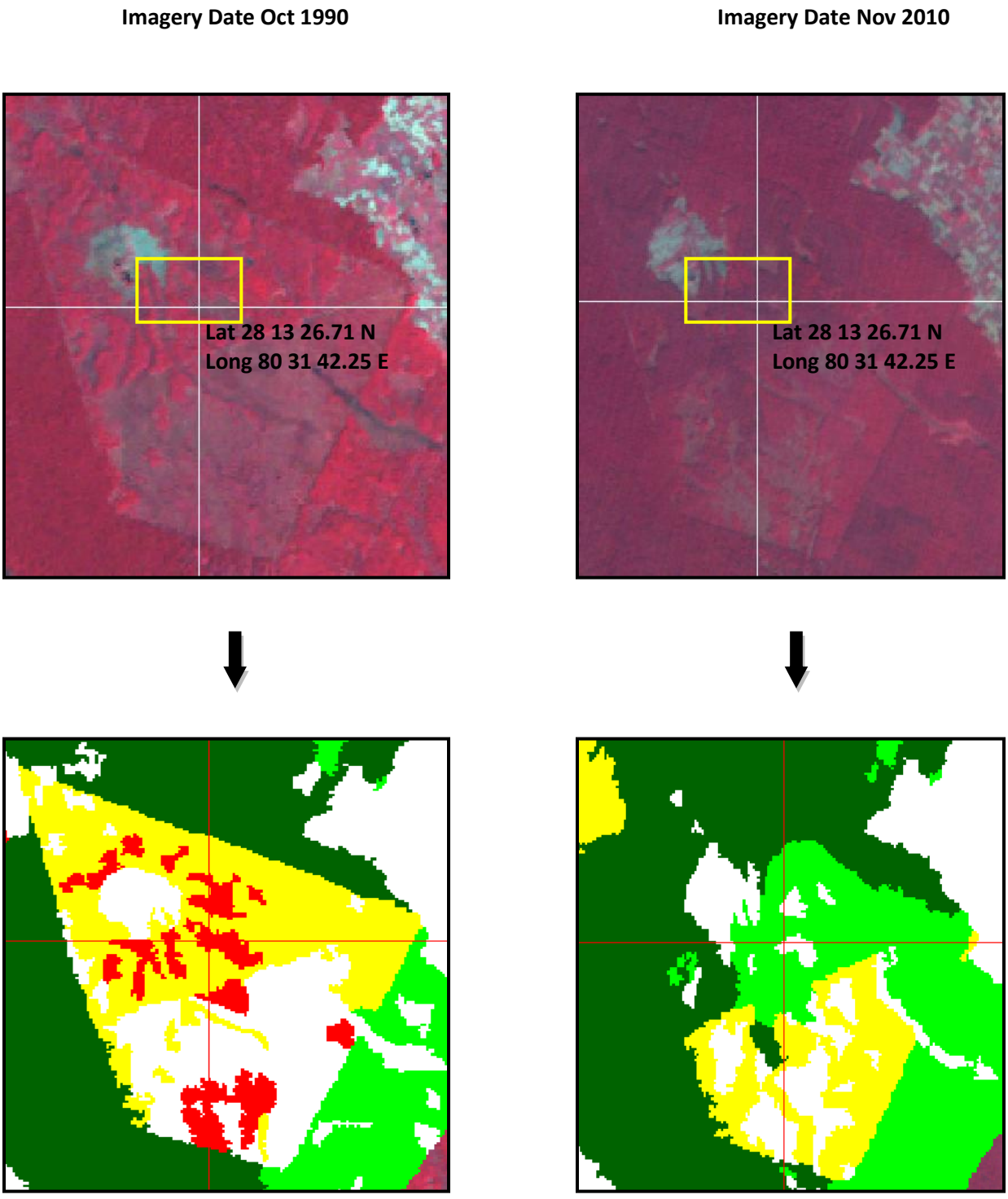


Fig.6 **:Area showing in maps falling in AUTKBTR Bhira Range)of the reserve**

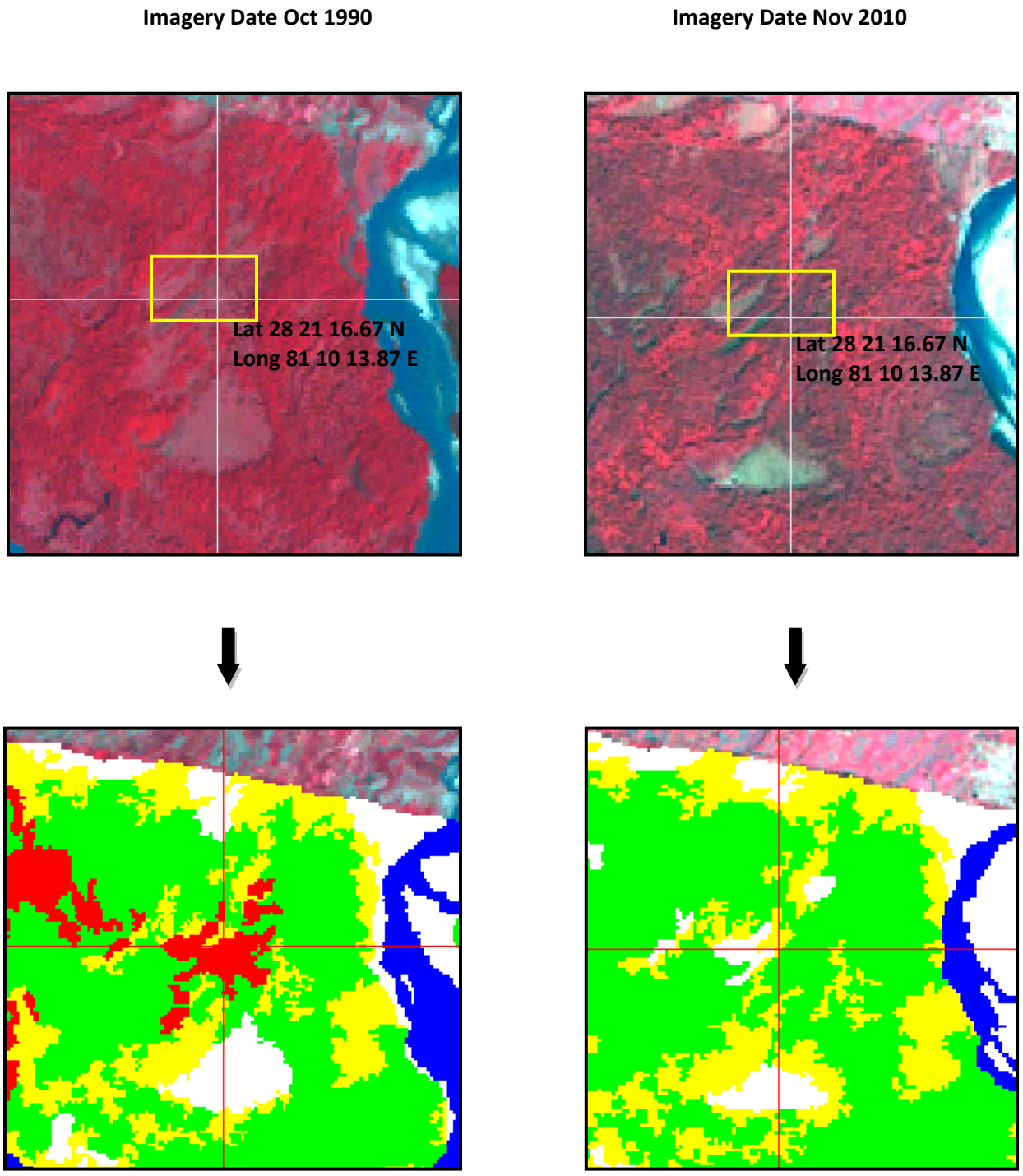


Fig.7: **Area showing in maps falling in core area of the reserve**

Imagery Date Oct 1990

Imagery Date Nov 2010

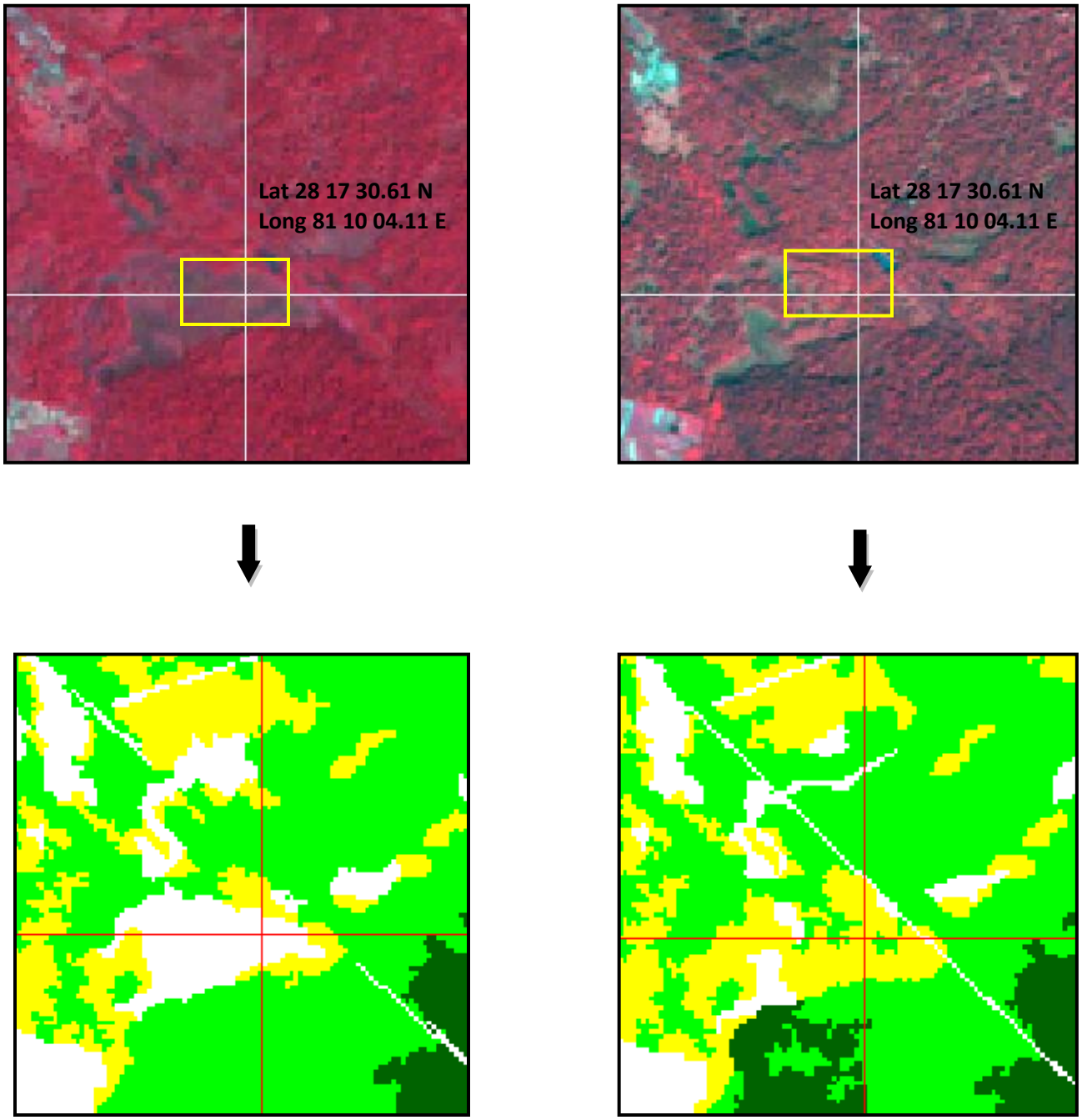


Fig.8: **Area showing in maps falling in core area of the reserve**

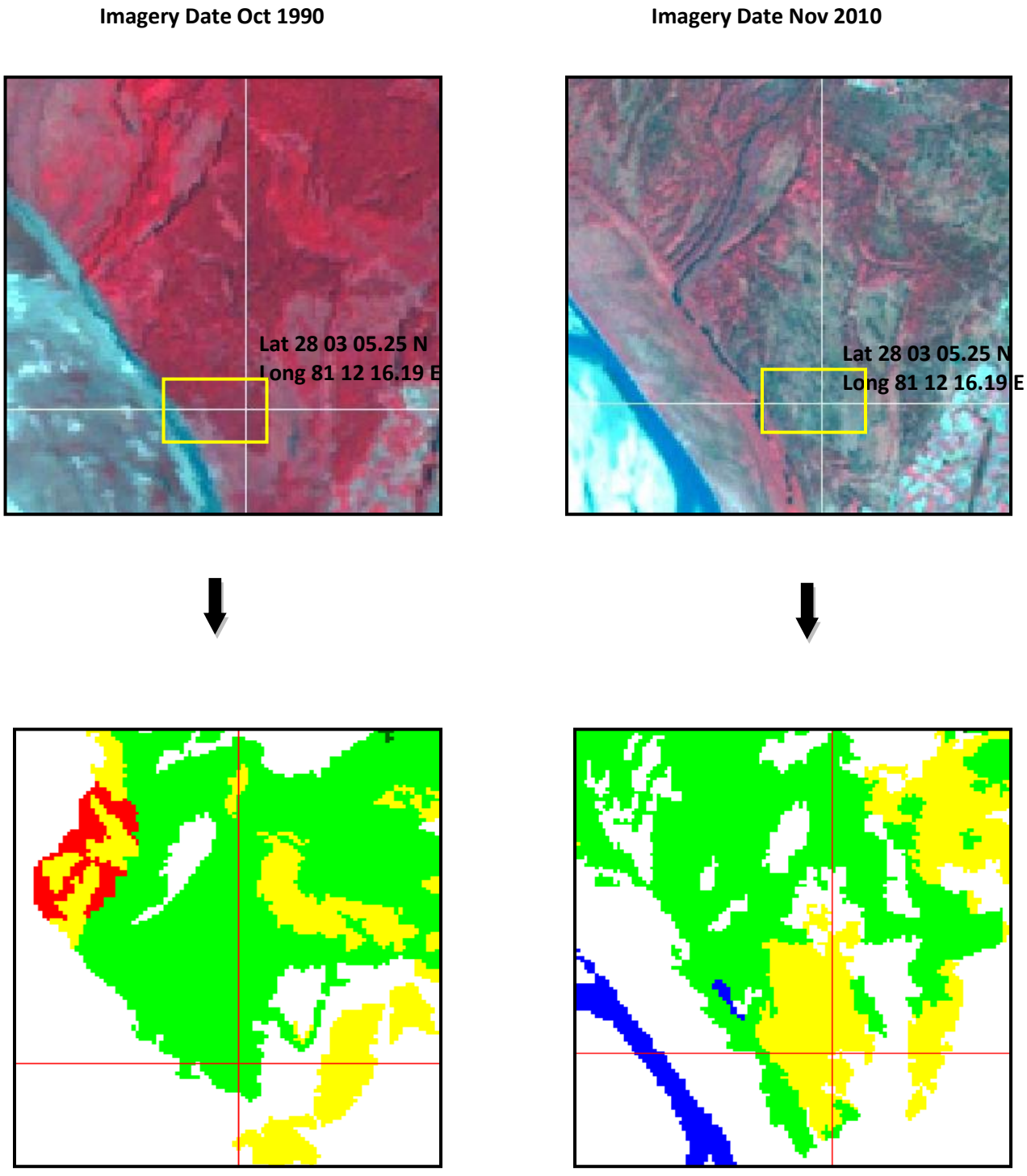


Fig.9: **Area showing in maps falling in AUTKBTR of the reserve**

Imagery Date Oct 1990

Imagery Date Nov 2010

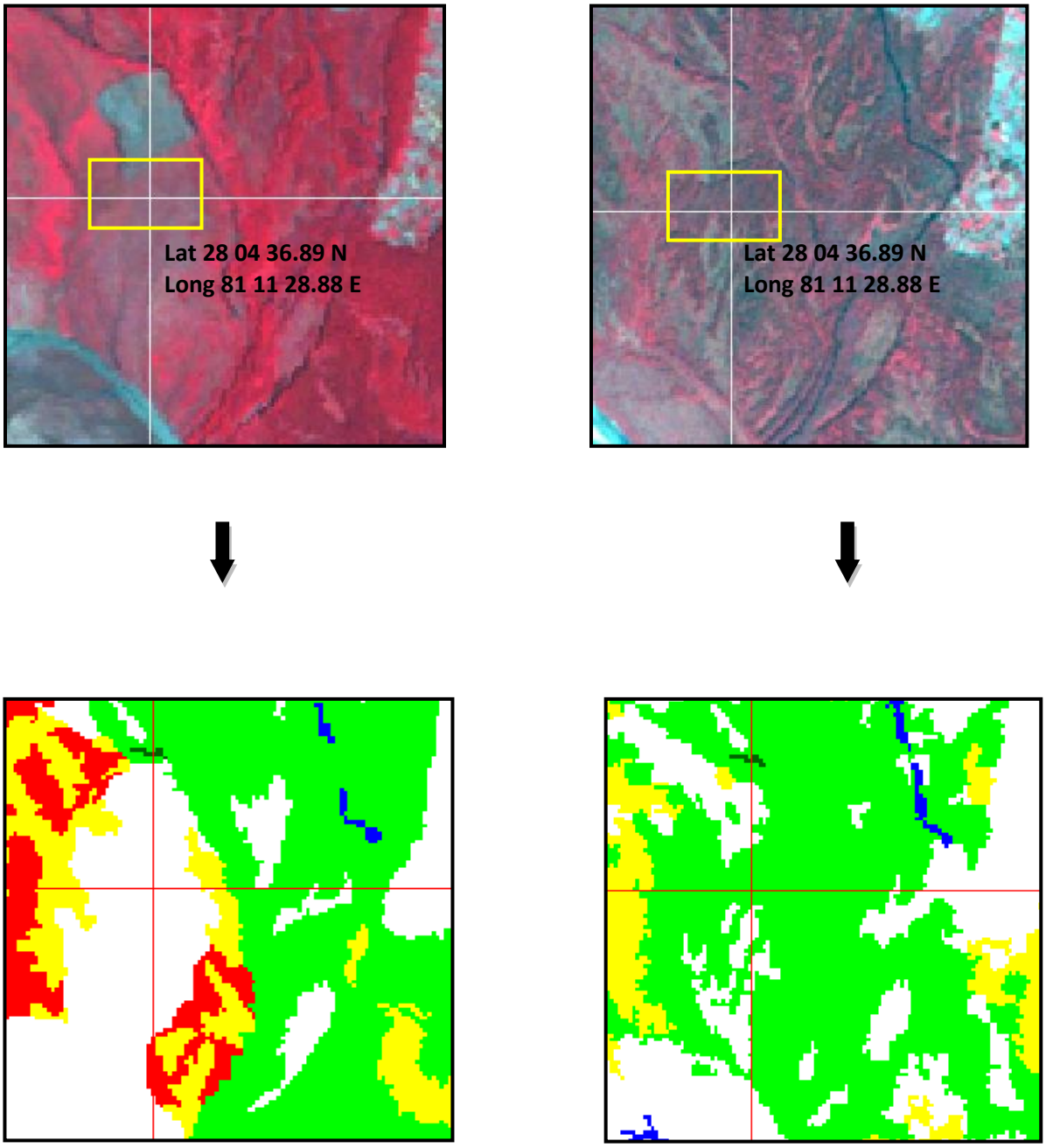


Fig.10 **:Area showing in maps falling in core area of the reserve**

Comparative Bar diagram showing Forest Cover Area in Dudhwa Tiger Reserve(Core & AUTKBTR) during different assessment year

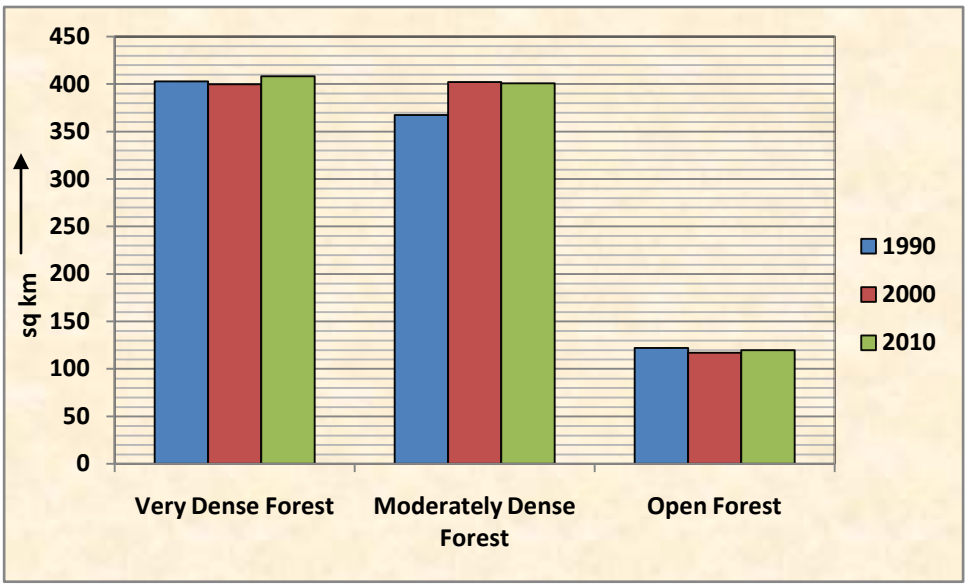


Fig 3.3a: Forest Cover Area in Dudhwa Tiger Reserve(Core Area)

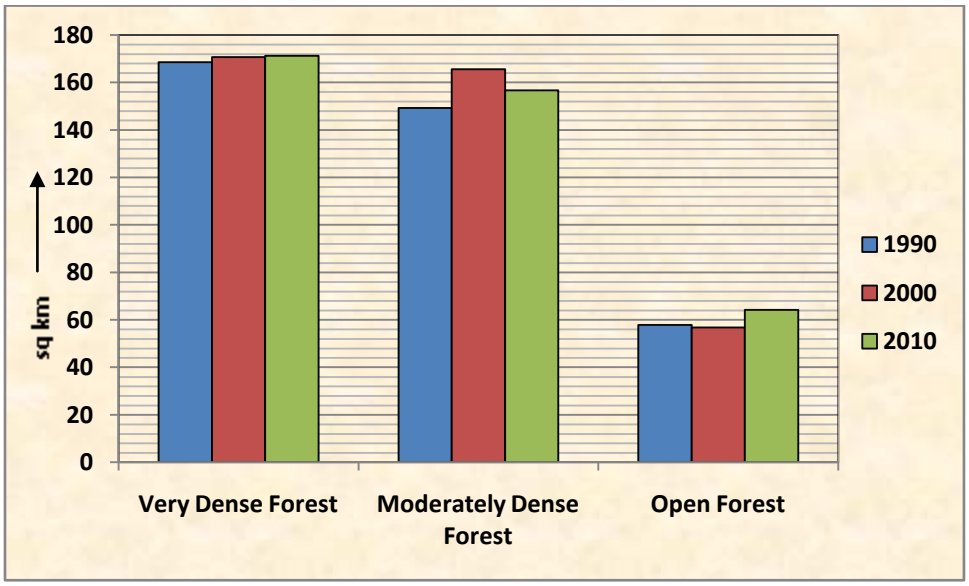
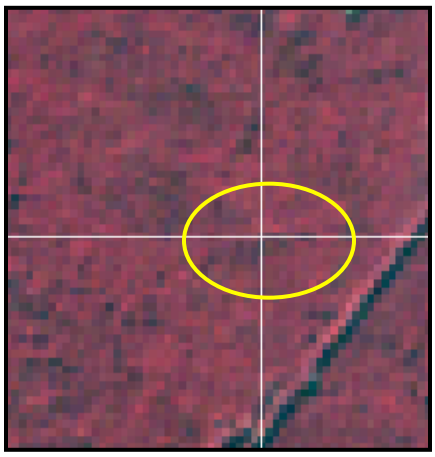


Fig 3.3b: Forest Cover Area in Dudhwa Tiger Reserve (AUTKBTR)

Plates showing satellite images and corresponding ground photos captured during ground truth verification of Dudhwa Tiger Reserve

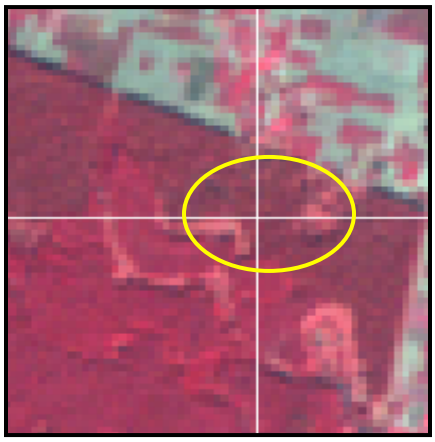


IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 28 17 09.86 N; Long 81 13 37.04 E)

Rampura (Katerniaghat WLS)

(Mix patch of Sal and Teak)



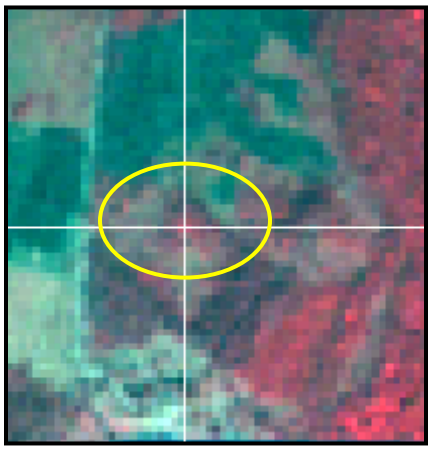
IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 28 35 55.75 N; Long 80 37 33.82 E)

Diginia (Dudhwa National Park)

(Eucalyptus Plantation)

Plate 1

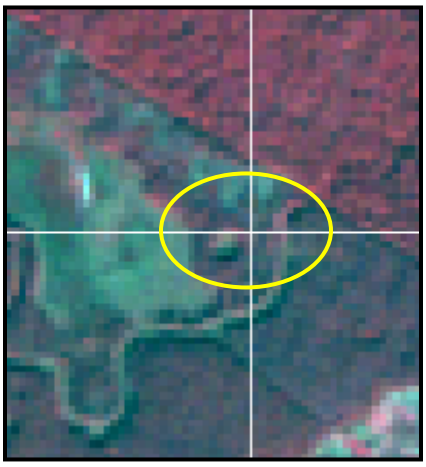


IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 28 21 00.83 N; Long 81 07 46.15 E)

Katerniaghat(Katerniaghat WLS)

(Mix patch of Sal, Shisam and Teak)



IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 28 23 28.80 N; Long 80 54 03.33 E)

Ludaria (Dudhwa National Park)

(Mix patch of Sal, Khair)

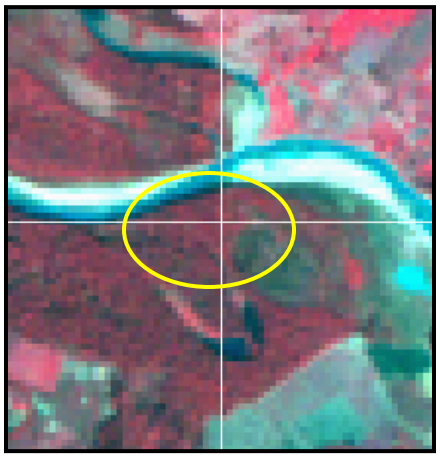
Plate 2

IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 28 19 03.43 N; Long 80 27 54.92 E)

Tangia,near Bhira (Kishanpur WLS)

(Mix patch of Sal, Shagwan)



IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 28 27 30.35 N; Long 80 55 07.87 E)

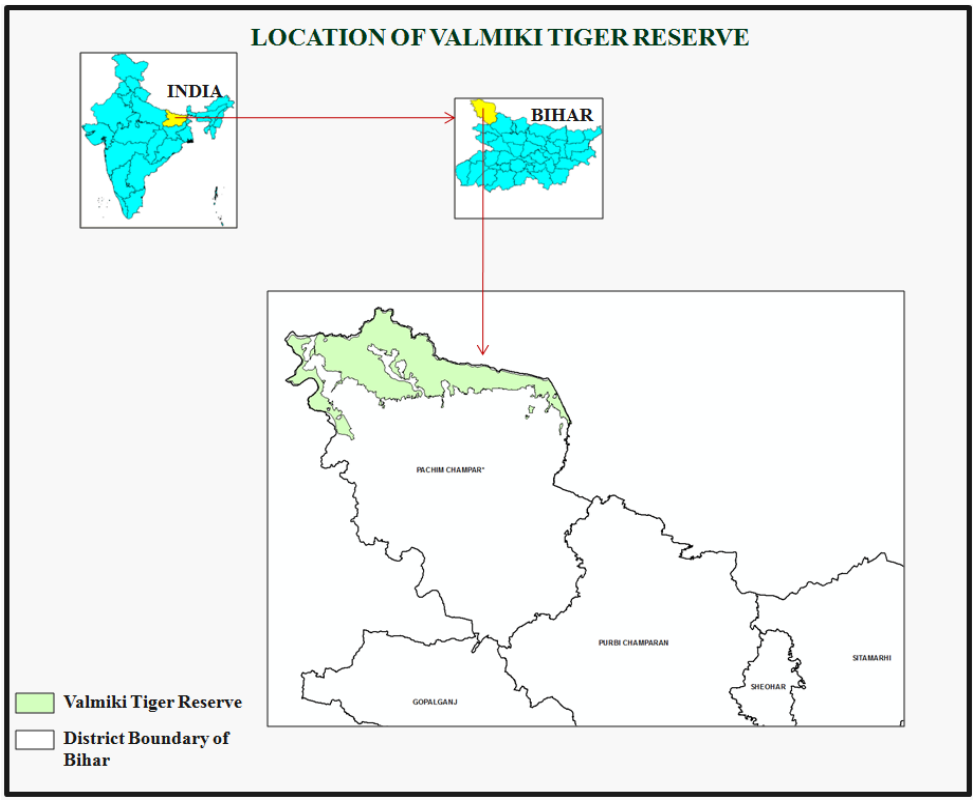
Raghunagar,(near Dudhwa National Park)

(Shisam Plantation)

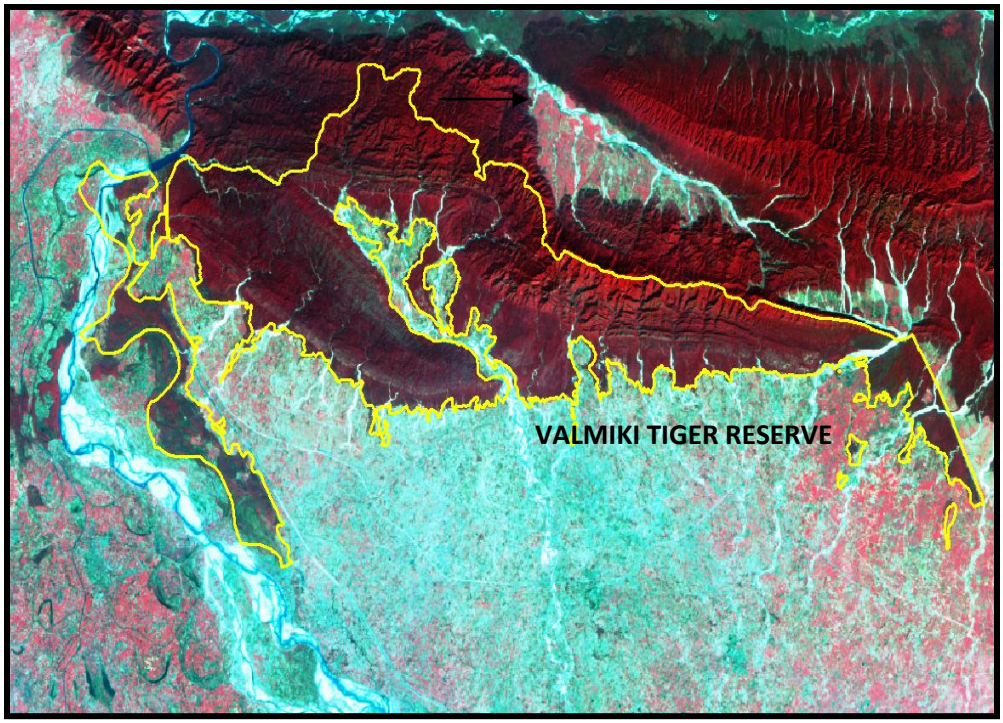
Plate 3

VALMIKI TIGER RESERVE

VALMIKI TIGER RESERVE



VALMIKI TIGER RESERVE BOUNDARY OVERLAID ON IRS – P6 LISS III (2010)



INTRODUCTION

4.1 Name and Location

4.1.1 Name:

Along the Indo-Nepal Border at the foothills of Himalaya Terai in West Champaran district of Bihar is located one of India's important wildlife reserves - **Valmiki Tiger Reserve**. It is one of the Tiger Reserves (TR), declared as such in 1994 under **Project Tiger**, which has been an enduring nation-wide effort launched in 1972 to halt the decline of the magnificent species - tiger.

The reserve occupies the lion share of 901.13 sq. km. of forest tracts all along the northern boundary of the Champaran district in Betiah taluka. The "Valmiki Tiger Reserve" covers an area of 899.38 sq km with 880.78 sq. km notified as Valmiki Wildlife Sanctuary which includes 335.64 sq km declared as "Valmiki National Park".

It is connected to the Chitwan National Park in Nepal to the north through the Churia forests and has a highly undulating terrain, which to some extent restricts movement of animals between the two countries. However, animals are known to move across the international boundaries.

Nestling at the foothills of the Himalayas, the terrain of the area is characterized by rocky hills and doon valleys drained by numerous rivers and streams which merge gradually with flat alluvial plains in the south. The main geo-morphological formation is Siwalik, Bhabar and Terai. Soil of the area is alluvial soil and newer alluvium.

4.1.2 Location:

The forest areas which cover 901.13 sq.km or 17.4% of the total area of the district (5228 sq. km) are situated in Bagaha and Narkatiaganj Subdivisions of West Champaran district which is located in the northwest corner of the State of Bihar. The area lies between latitude 27^0 10' N and 27^0 30 N and longitude 83^0 50' and 84^0 10' E.

Break-up of the areas under the Valmiki Tiger Reserve administration is as follow:

A tiny disjoint pocket of protected forest with area of 1.75 sq km is situated outside TR near the eastern end of the reserve is not included in this table.

4.2 Geology Rock and Soils:

4.2.1 Geology and Rock:

Nestling at the foothills of the Himalayas, the terrain of the area is characterized by rocky hills and *dun* valleys drained by numerous rivers and streams which merge gradually with flat alluvial plains in the south. The main geo-morphological formation is Siwalik, Bhabar and Terai. Soil of the area is alluvial soil and newer alluvium. Rivers flowing from north to south direction traverses the entire tract bringing down huge quantities of sand to the cultivated lands in the lower reaches. Below this hilly tract comes the Terai area consisting mostly of grassland and open forests. The Terai region generally consists of sandy soil, loose boulders. Beyond this lie the alluvial plains mostly under cultivation. Locally the drainage is not perfect and many swamps exist.

4.2.2 Soils:

It is most important abiotic component of natural ecosystem, which is intermediary in the bio-geo-chemical cycle. The entire floral and faunal diversity of the area depends upon the soil.

Soils of Valmiki TR can be divided on following basis

4.2.2.1 Parent Material:

A. Bangar hard clay Soil
B. Babhani reddish loam Soil
C. Lateritic Soil
D. Baldhus loose Sandy Soil
E. Kankar and Saline Soil
F. Alluvial Soil

A. Bangar hard Clay Soil :

The traps give rise to either a brown to deep brown soil or to Bangar (hard clay soil). Bangar is rich in plant nutrients such as lime, magnesia, iron and alkalies on which paddy and wheat crops flourish.

B. Lateritic Soil :

Another product of weathering of trap is laterite, a material from which silica, alkalies and alkaline earths have been leached away, leaving behind alumina, iron, manganese and titanium. It has vermicular or pisolitic structures and contains much water. Some laterites which are highly aluminous form deposits of bauxite.

C. Sandy Soil :

Most of the area of Core Zone is covered with sandy loame soil. The soil is the result of weathering of granitic gneisses. This soil type mostly occurs on gentle slope and valleys.

D. Kankar and Saline Soil :

This soil type is found in the foothills in areas with less tree cover and forest gaps. They contain large proportion of silica and orthoclase quartz and have low water holding capacity. They are generally mineral deficient and have low productivity. They are easily eroded under insufficient vegetation cover.

E. Alluvial Soil :

Alluvial soils do not really form a definite group. They represent both transported and residual soils, which may have been re-worked to some extent by water. Most of the alluvial soils are found in valleys and nala beds. Recent alluvial deposits are found along the Masan, Pachanad, Gandak River and small streams of the tract.

4.2.3 Slopes

The slope categories in Valmiki Tiger Reserve have been identified into three class viz. (0-11 degrees, 12-22 degrees, and 23-34 degrees). Most of the area falls into flat to gentle slope (0-22 degrees) class. The north-western part of the reserved forests has a highly rugged terrain with steeper slopes (23-34 degrees).

4.3 Climate

4.3.1 Rainfall and Temperature:

Rain is the source of maximum annual precipitation in the area other than mist, fog and dew. Monsoon is the main source of rainfall, though pre- monsoon showers and sometimes winter rains are also experienced in this area. As per the available current data the average month wise rainfall is presented below.

May is the hottest and January is coolest month of the year. Both of these months shrink the biological activities of lower vertebrate and invertebrate fauna and cold-blooded animals. Desiccating cold and dry summer both induce the hibernation among these animals. Higher vertebrates like mammalian and avian fauna also intend to pass hot hours of the day near the moisture or under the shade. The den, cave, cliff, overhangs, nests are occupied during the severe cold.

4.3.2 Relative Humidity:

Pre-monsoon thundershowers in April are followed by monsoon, which usually sets in from mid June and lasts till October. Maximum rainfall, which reaches about 407.36mm, occurs in the month of July. Average annual rainfall is 1106.mm and varies from year to year. A high of about has been recorded in the forest foothills area of Valmiki Nagar. The climate is very humid in this season.

4.4 Land Use Land Cover:

Based on satellite imagery of 2009, the following land use – land cover classes have beenidentified.

Table - 4.4: Area under different land use land cover (LULC) category in VTR (Area in km^2)

LULC Category	Area (Km^2)	%
Dense Forest	711.1	81.0
Open Forest	56.64	6.4
Scrub	17.6	2.0
Agriculture	12.84	1.5
Riverbed	25.81	2.9
Water	9.74	1.1
Grassland	44.45	5.1
Swamp	0.96	0.1

(WTI Report, 2012)

VEGETATION:

4.5 Forest Types:

The forests of the Tiger Reserve are varied and rich. The forests of this area can be broadly classified into seven types according to the Revised Survey of Forest types by Champion and Seth 1968.

4.5.1. Bhabar Dun Sal forest (3C/c2/b (i)):

This type occurs in the gentle lower slopes of the hills and adjoining flat ground with very porous and aerated soil underlain by gravel and boulders. It is noticed in mainly Triveni Block where valleys are very rich in Sal which is the predominant species; Manor, Sonha and Kaila valleys .A very striking shrub Piper pepuloides which belongs to the community of the lower Himalayan flora is found here in damp localities in the hilly region. *Piper longom* (Peepar) is found in abundance as a creeper especially in the damp areas of Raghia Block

4.5.2. Dry Siwalik Sal Forest (5B/c1/a):

This type includes the elevated valley Sal and hill Sal. It occupies the rising ground on the hills and spurs and the ridges where on account of rapid sub-soil drainage dry conditions prevail resulting in abrupt deterioration of the site quality from gentle slopes to down below. The tracts have two storey tree cover with Sal with magnitude of preponderance is relatively low and its associates. Among shrubs, *Phoenix humilis* and *Pacualis* are most prevalent. Among grasses, *Eulaliopsis binata* (Sabai), *Heteropogon contortus* (suara) and Khus are prevalent. A few patches of *Pinus roxburghii* (Chirpine) also occur in this type of forests as an associate of Sal on elevation between 300 to 500m, a unique feature since the normal occurrence of Chirpine is considerably higher. The locations were on the sand rock and conglomerate formations. The Chirpine is usually found on ridge tops and sometimes on landslips down below. The area occupied as recorded in Working Plan was 3755 ha limited by Kapan nala in the west and Pakhnahwa in the east in several Compartments of Raghia Block.

4.5.3. West Gangetic Moist Mixed Deciduous Forest (3C/c3/a):

It is an edaphic formation on fresh alluvium found in Madanpur Block where the tract is liable to annual inundation with the result that the soil remains immature perpetually. The tract supports two storey tree cover with miscellaneous/mixed species. The species composition canopy-wise is given in the annexure.

4.5.4. Khair- Sissoo Forest (1S/2):

This type of vegetation is confined along the Gandak river and its tributaries in Madanpur Block. The tract is liable to inundation and starting from pure sand deposits in the form of islands, there are tracts at various stages of soil formation which are not mature enough to sustain Sal. It is seen that grasses *Saccharum munja* and *Tamarix dioca* appear first on fresh alluviual deposits followed successfully by *Acacia catechu*, *Dalbergia sissoo*, *Salmalia malbarica*, *Adina cordifolia* and lastly by mixed miscellaneous forest. Khair occurs along the nalas in few other miscellaneous forests, but the incidence has been negligible.

4.5.5. Cane Brakes (1B/E1):

This type of forest is found in wet hollows and depressions along the various tributaries of Gandak in Madanpur block and in three compartments of Tribeni Block. The soil consists of fine clay very rich in humus and remains wet more or less throughout the year. *Calamus tenuis* (cane) occurs under large sized miscellaneous trees and rise up to 60 ft or more depending upon support of the trees.

4.5.6. Eastern Wet Alluvial Grass land (4D/2S2):

These are natural low level savannah lands subject to inundation and carry tall and luxuriant grasses with few scattered trees of Khair and semal. The commonly seen grasses are P*hragmites karka* (Narkat), *Erianthus munja*, *Vetiveria ziznoides*, *Cymbopogon nardus*, *Saccharum spontaneum* and *Typha elephantina*. Such grasslands are found in sizable in all the compartments of Madanpur

Block and in a few compartments of Triveni Block and also in Someswar block but with smaller extents. Quite a number of these grasslands have been converted into plantations – the main species being Sisso, Khair, Teak and bamboo.

4.5.7. Barringtonia Swamp Forest (4 D/SS2):

This type is confined to compartment no.18 and 19 of Madanpur Block, where in horse-shoe shaped low level marshy land located at the confluence of Rohua stream and Gandak supported the species of *Salix tetrasperma, Barringtonea acutangula, Bischofia javanica, Syzium cumini* with Semal, Sissoo and Khair on slightly raised ground and grasses alongwith cane in depressions.

Table 4.5.a.: Area according to Forest Types of the Core Area of Valmiki Tiger Reserve

Sr.No.	Forest Types	Area In (% of Total area) Assessment Year 2004
1	1/E1 Cane Brakes	0.84
2	3C/C2 b(i) Bhabar-Dun Sal Forest	14.66
3	3C/C3 a West Gangetic Moist Mixed Deciduous Forest	2.53
4	4D/2S1 Eastern Wet Alluvial Grassland	0.13
5	5B/C1 a Dry Siwalik Sal Forest	14.42
6	Plantation/TOF	0.18

Table 4.5.b: Area according to Forest Types of the Buffer Area of Valmiki Tiger Reserve

Sr.No.	Forest Types	Area In (% of Total area) Assessment Year 2004
1.	1/E1 Cane Brakes	2.50
2.	3C/C2 b(i) Bhabar-Dun Sal Forest	0.68
3.	3C/C3 a West Gangatic Moist Mixed Deciduous Forest	3.91
4.	4D/2S1 Eastern Wet Alluvial Grassland	0.34
5.	5B/C1 a Dry Siwalik Sal Forest	7.17
6.	Plantation/TOF	0.10

Table 4.5.c: Area according to Forest Types of the Area upto 10km from the boundary of Tiger Reserve of Valmiki Tiger Reserve

Sr.No.	Forest Type	Area In (%) Assessment Year 2004
1.	1/E1 Cane Brakes	2.01
2.	3C/C2d (iii) Eastern Heavy Alluvium Plain Sal	0.09
3.	3C/C3 a West Gangatic Moist Mixed Deciduous Forest	1.58
4.	4D/SS3 Syzygium cumini Swamp Low Forest	1.04
5.	5/DS1 Dry Deciduous Scrub	0.01
6.	5B/C1 a Dry Siwalik Sal Forest	0.59
7.	5B/C2 Northern Dry Mixed Deciduous Forest	0.07
8.	Plantation/TOF	0.83

4.6 Floristic composition:

4.6.1. Over wood:

The predominant species is Sal and associates are Asan (*Terminelia tomentosa*), Siras (*Albizzia procera*), Mallotus philippensis (Rohina), Holarrhena antidysenterica, Buchanania latifolia, Terminalia ballerica (Bahera), Dhawda (*Anogeissus latifolia*), Lendia (*Lagerstroemia parviflora*), *Lannea grandis*, Mahua (*Madhuca indica*), Tendu (*Diospyros melanoxylon*), Panan (*Ougeinia oojeinensis*) and scattered trees of Shisham, Satsal (*Dalbergia latifolia*), Semal (*Bombax cieba*), Haldu (*Adina cordifolia*) also occur. The trees of Kahua (*Terminalia arjuna*) and Jamun (*Syzygium cumini*) are found along the banks of rivers. Teak is mainly from plantation.

4.6.2. Underwood:

There is generally an under wood of middle density comprising of Alma (*Emblica officinalis*), Dhaman (*Grewia tiliaefolia*), Kumbhi (*Careya arborea*), Ghont (*Zizyphus xylopyra*), Trewia nudiflora, Baranga (*Kydia calycina*), Amaltas (*Cassia fistula*), Ashta (*Bauhinia racemosa*), etc.

Dwarf Phoenix (*Phoenix humilis*) is widely distributed in all the Blocks except Madanpur and more intensely colonised in the open forests in hilly terrain.Bamboo (*Dandrocalamus strictus*) occurs sparsely, restricted to valley areas and patches of earlier plantaions in fringe areas.

4.7 Phytosociology:

1.7.1. Tree communities:

i. Sal Dominant Community – major coverage
    1. Asan Dominant Community
    2. Terminalia Dominant Community
ii. Jamun / Semul Dominant Community – in moist pockets of Madanpur Block
iii. Khair / Sisoo Dominant Community – in riverine fringes
iv. Old plantation areas - Teak / Bamboo

4.8 Grasslands:

i) Grasslands in VTR show presence of following grass species under 3 types of grasslands. **Table 4.8: Grasslands in VTR**

Grassland Type	Common grass and sedge species
Streambeds	*Cyperus sp., Heteropogon contortus, Imperata cylindrica, Oplismenus compositus, Pasplaum sp., Saccharum munja, Saccharum spontaneum, Sclerostachya fusca, Themeda quadrivalvis.*
Openings on hilly and undulating terrain areas	*Apluda mutica, Chrysopogon sp., Cyperus sp., Eulaliopsis binate, Heteropogon contortus, Imperata cylindrica, Oplismenus composites, Themeda quadrivalvis.*
Alluvial plains in Madanpur	*Chrysopogon sp., Heteropogon contortus, Imerata cylindrica, Saccharum munja, Vetiveria zizanioides, Typha angustata, Sclerostachya fusca, Themeda quadrivalvis, Paspalum sp., Oplismenus composites, Saccharum spontaneum.*

ii) **Grasses and herbs associations and abundance:**

Veteveria zizanioides, Cyandon dactylon, cyperus iria, Doiscores bulbifera, Diplazium esculentum, Eranthemum nervosum, Eupatorium adinophorum, Flemingia macrophylla, *Ichnocarpus* were widely distributed in all 6 Blocks.

Among the herbs and grasses in Triveni Block, *Cleredendron viscosum* and *Ichnocarpous frutescens, Piper spp.* are the most frequent herbs in association with grass species *Imperata cylindrica, Veteveria zizanioides, Eulaliopsis binata, Ischaemim indicum, Oplismenus compositus, Phragmites karka,* (highest density wise)

In Kosil and Naurangia Blocks, *Phragmites karka, Imperata cylindrica, ichnocarpous frutescens, Cymbopogon citrates and Oplismenus compositus* are most frequent spp. Other spp. are *Diplazium esculentum, eulaliopsis binata and heteropogon contortus.*

Duschnea indica is most abundant herb species in Madanpur range along with *Rungia pectinata, Centella asiatica, Phragmites karka and Cyperus iria. Imperata cylindrica, Cleredendron viscosum*. In Chiutaha Range, *Phragmites karka, Cynodon dactylon, Heteropogon contortus and Cyperus iria are abundant.*

In Raghia Block most abundant species are *Capillipedium assimili, Phragmites karka and Imerata cylindrica*.

Someswar Block has abundant growth of *Equisteum sp. Centella asiatica, Heteropogon controtus, Phragmites karka, Piper spp. and Ichnocarpus frutescens*. In eastern part of Someswar block

Phragmites karka, Cynodon dactylon, Diplazium esculentum, Cymbopogon citrates and Heteropogon contortus are more frequently distributed.

4.9 Wild Fauna, Habitats and Tropic Niches

4.9.1 Fauna:

The diversity of physiography, geology and climate creates mosaic of vegetation and faunal habitats forming varied niches for various species of plants and animals.

Faunal Survey: The animals generally seen in the Tiger Reserve are the Chital (*Axis axis*), Sambar (*Cervus unicolor*), Hog deer (*Axis porcinus*) Barking Deer (*Muntiacus muntjak*), Gaur (*Bos gaurus*), Langur (*Presbytis entellus*), Wild Pig (*Sus scrofa*), Jackal (*Canis aureus*), Sloth beer (*Melursus ursinus*), Wild dog (*Cuon alpinus*), Leopard (*Panthera pardus*) and Tiger (*Panthera tigris*). Apart from mammals (58 spp), Valmiki Tiger Reserve is inhabited by a variety of avifauna (261 spp), reptiles (26 spp), amphibians (13 spp).

The above typical fauna of the Himalayan Shiwalik foothills, part of the Oriental-Zoological Realm, is an amalgam of Indo-Chinese, Ethiopean and Palaearctic elements (Prater, 1948; Roberts, 1977)

The heterogeneity of habitats influences the local distribution of mammals. The presence of the mosaics of grasslands within the woodland, expanses of herbage availability has a bearing on the concentration of herbivores.

Recently in June 2012, an estimation exercise was undertaken over 130 transect lines (2 to 4 kms) spread over the entire reserve and as per prescribed method the estimated numbers of the observed fauna are as follows :

4.9.2 Status of Rare and Endangered Species:

The main threatened species occurring in VTR are enlisted hereunder:

1988 IUCN Red List of Threatened Animals Found in Valmiki Tiger Reserve -

Mammals:

1.	Dhole	–	*Cuon alpinus*
2.	Bengal Fox	–	*Vulpes bengalensis*

3.	Sloth Bear	–	*Melursus ursinus*
4.	Smooth Coated Otter	–	*Lutra perspicillata*
5.	Leopard	–	*Panthera pardus*
6.	Tiger	–	*Panthera tigris*
7.	Gaur	–	*Bos gaurus*
8.	Rhino	–	*Rhinoceros unicornis*
9.	Gangetic Dolphin	–	*Platanista gangetica*

Birds

1. Gyps species (Vultures)

Reptiles

1. Indian Python	–	*Python molurus*
2. Muggar	–	*Crocodylus paulstris*
3. Gharial	–	*Gavialis gangeticus*

Gandak River which forms the western boundary of the reserve is home to Gharial, Crocodiles and Dolphins.

A separate management plan for these species is being prepared.

4.9.3 Locally Extinct species -

(i) Elephant - (Elaphus maximus)

Ain- i-Akabari contains some reference regarding presence of elephant in the lower foothills during sixteenth century, but there is no such indication in records pertaining to eighteenth century. It is therefore apparent that elephants became extinct by the time of seventeenth century. Some episodes of elephants visiting from Parsa WLS of Nepal have occurred from 1997.

(ii) Chausinga, Black Buck and Barasingha - These were recorded last before 1970s.

4.10 FOREST COVER IN VALMIKI TIGER RESERVE

4.10.1 Forest Cover in the year of 1990

- **Core Area:**

The assessment of 1990 data reveals that area under forest cover in the core area of Valmiki Tiger Reserve is **564.34 sq km** which is about **94.30 %** of the total area of the reserve. The study of 1990 image interpretation is based on the satellite data of Landsat-5 TM (1990). **194.48** sq **km** of forest falls in Very Dense Forest category**, 311.81 sq km** of forest lie in Moderately Dense Forest category and **58.05 sq km** forest is in Open Forest category.

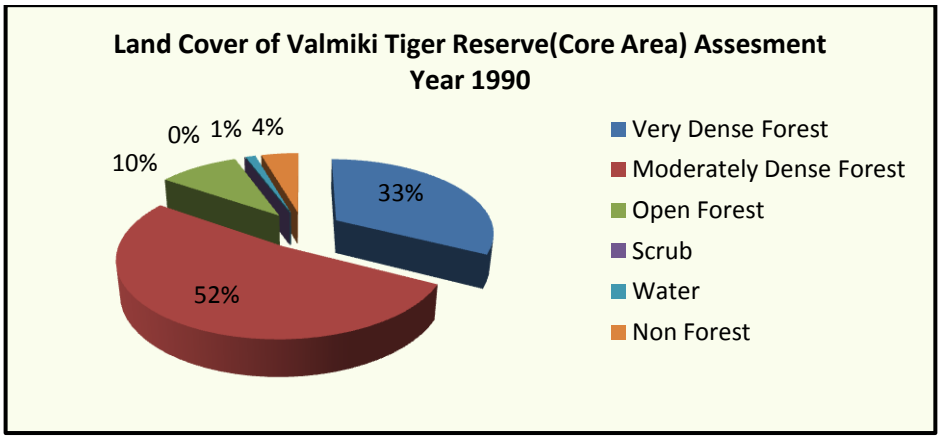


Fig 4.10.1a: Pie chart showing percentage of Land Cover in core of Valmiki Tiger Reserve (1990)

- **Buffer Area :**

The assessment of forest cover in the buffer area of Valmiki Tiger Reserve is **228.25 sq km** which is about **75.41 %** of the total area of the reserve. The study of 1990 image interpretation is based on the satellite data of Landsat-5 TM (1990), **33.53 sq km** of forest falls in Very Dense Forest category,**150.12 sq km** of forest lie in Moderately Dense Forest category and **44.60 sq km** forest is in Open Forest category.

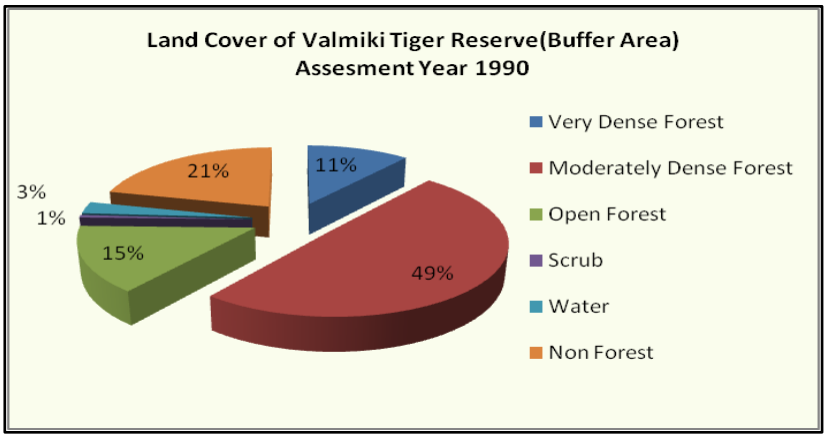


Fig 4.10.1b: Pie chart showing percentage of Land Cover in buffer of Valmiki Tiger Reserve (1990)

- **Area upto 10km from the boundary of Tiger Reserve:**

The Extended cover of 10 km radius from the periphery of the Tiger Reserve falls partly in India and partly in Nepal. In India it has a total area of **1686.27 sq km** out of which **1289.34 sq km** falls in Bihar and **396.92 sq km** in Uttar Pradesh state. The forest cover in the AUTKBTR(area 1686.27 sq km) of Tiger Reserve is **99.02 sq km** which is about 5.87 % of the total area. The study of 1990 image interpretation is based on the satellite data of Landsat-5 TM (1990), **1.79 sq km** of forest falls in Very Dense Forest category, **52.72 sq km** of forest lie in Moderately Dense Forest category and **44.51 sq km** forest is in Open Forest category.

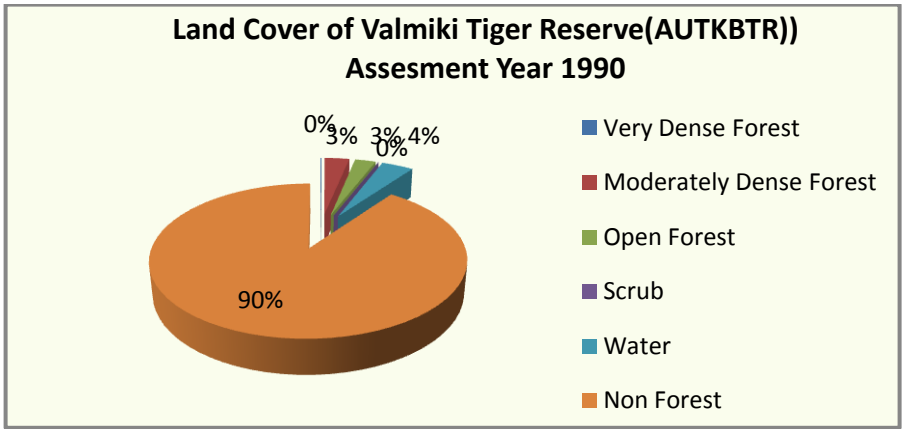


Fig 4.10.1c: Pie chart showing percentage of Land Cover in AUTKBTR of Valmiki Tiger Reserve (1990)

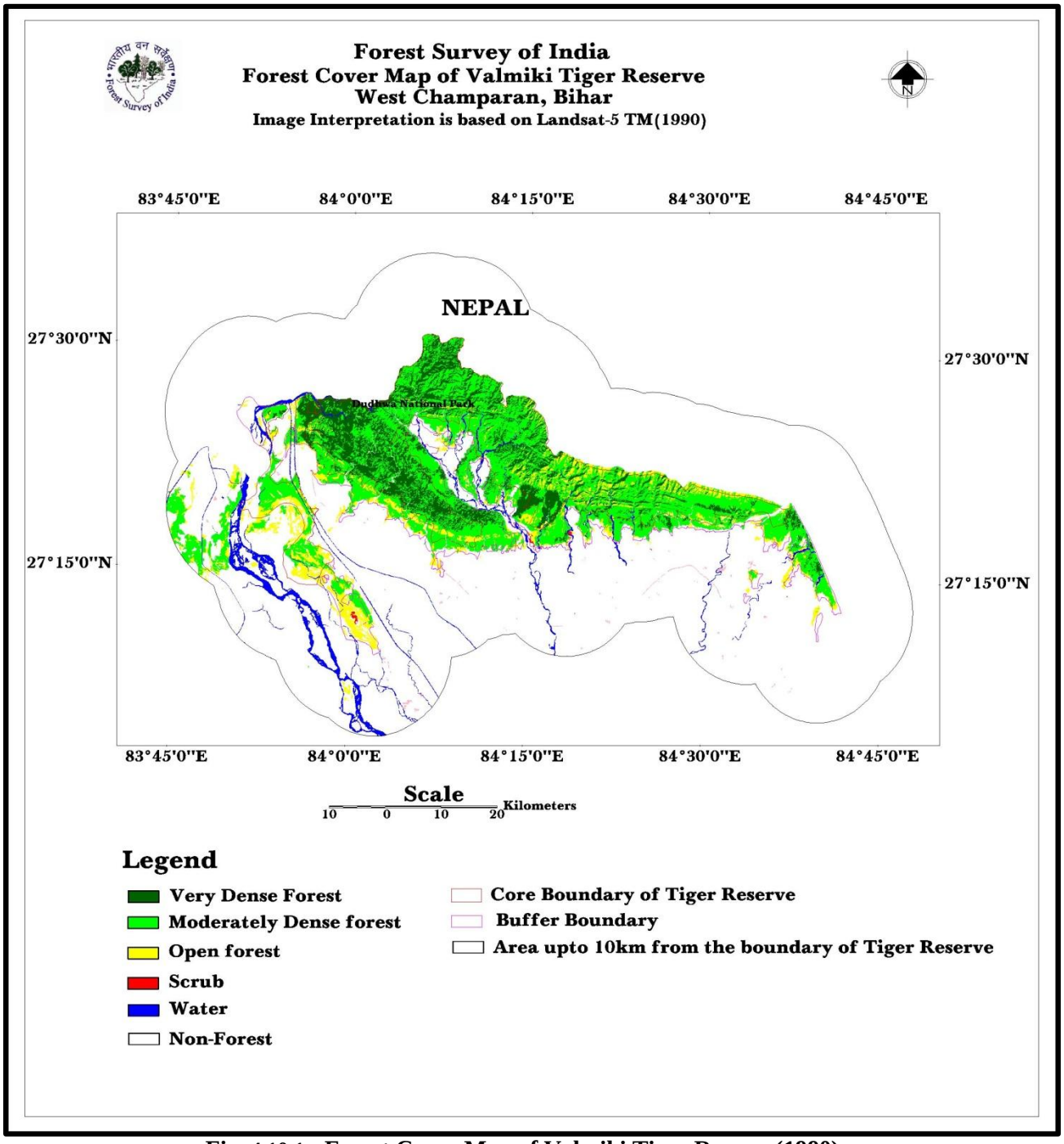


Fig. 4.10.1 : Forest Cover Map of Valmiki Tiger Reserve(1990)

4.10.2 Forest Cover in the year of 2000

- **Core Area:**

The assessment of 2000 data reveals that area under forest cover in the core area of Valmiki Tiger Reserve is **559.76 sq km** which is about **93.59 %** of the total area of the reserve. The study of 2000 image interpretation is based on the satellite data of IRS–1C/1D LISS III (2000).In this study **193.61 sq km** of forest falls in Very Dense Forest category, **314.68 sq km** of forest lie in Moderately Dense Forest category and **51.47 sq km** forest is in Open Forest category.

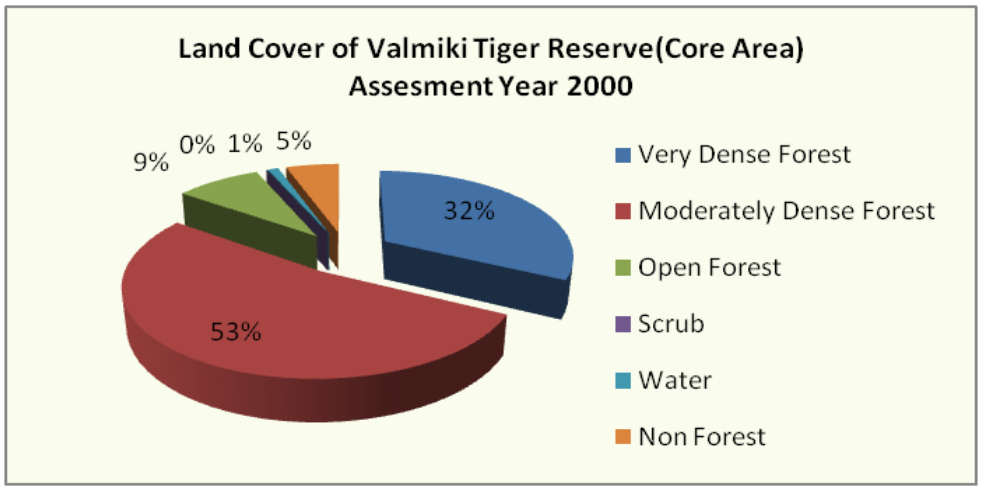


Fig4.10.2a: Pie chart showing percentage of Land Cover of Valmiki Tiger Reserve (Core in 2000)

- **Buffer Area :**

The assessment of forest cover in the buffer area of Valmiki Tiger Reserve is **222.89 sq km** which is about **73.64 %** of the total area of the reserve. The study of 2000 image interpretation is based on the satellite data of IRS–1C/1D LISS III (2000).The study reveals that **33.68 sq km** of forest falls in Very Dense Forest category,**148.12 sq km** of forest lie in Moderately Dense Forest category and **41.09 sq km** forest is in Open Forest category.

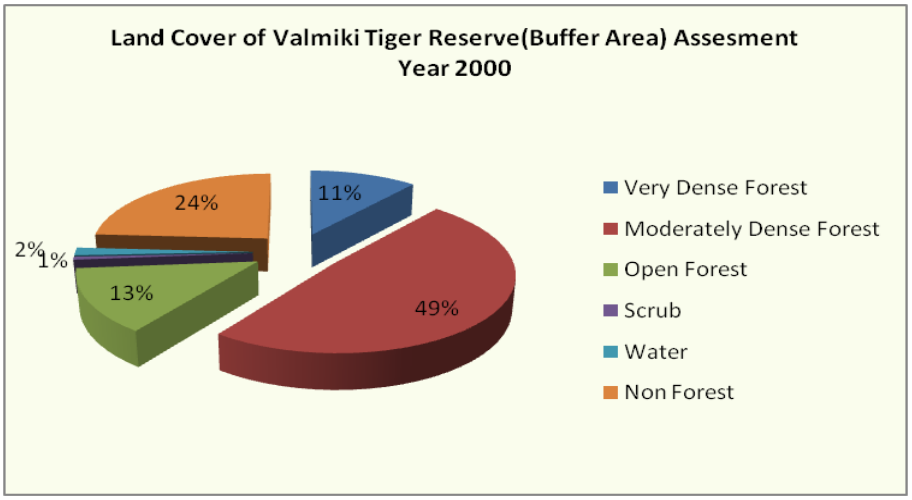


Fig 4.10.2b: Pie chart showing percentage of Land Cover of Valmiki Tiger Reserve(Buffer in 2000)

- **Extended Buffer**

The assessment of forest cover in the AUTKBTRof Tiger Reserve is **93.82 sq km** which is about **5.56 %** of the total area. For the study of 2000 image interpretation based on the satellite data of IRS–1C/1D LISS III (2000-01), **1.84 sq km** of forest falls in Very Dense Forest category, **50.37 sq km** of forest lie in Moderately Dense Forest category and **41.61 sq km** forest is in Open Forest category.

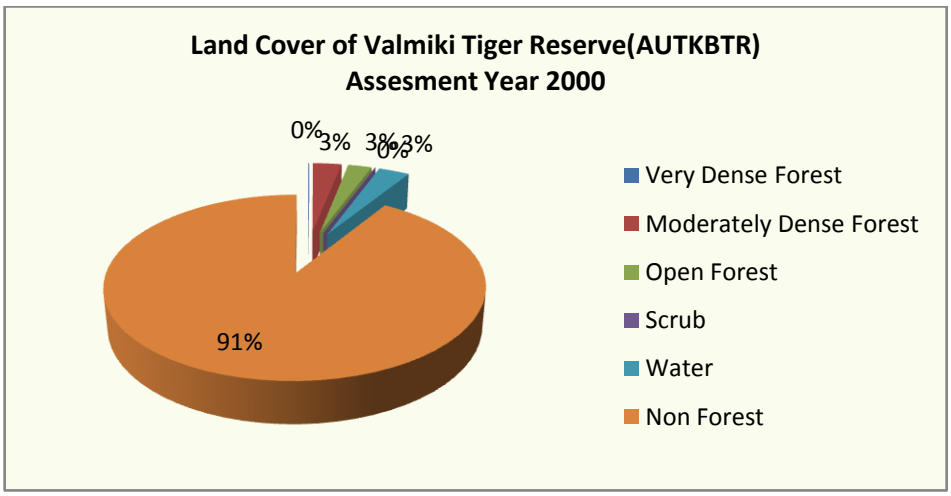


Fig 4.10.2c: Pie chart showing percentage of Land Cover of Valmiki Tiger Reserve(AUTKBTR in 2000)

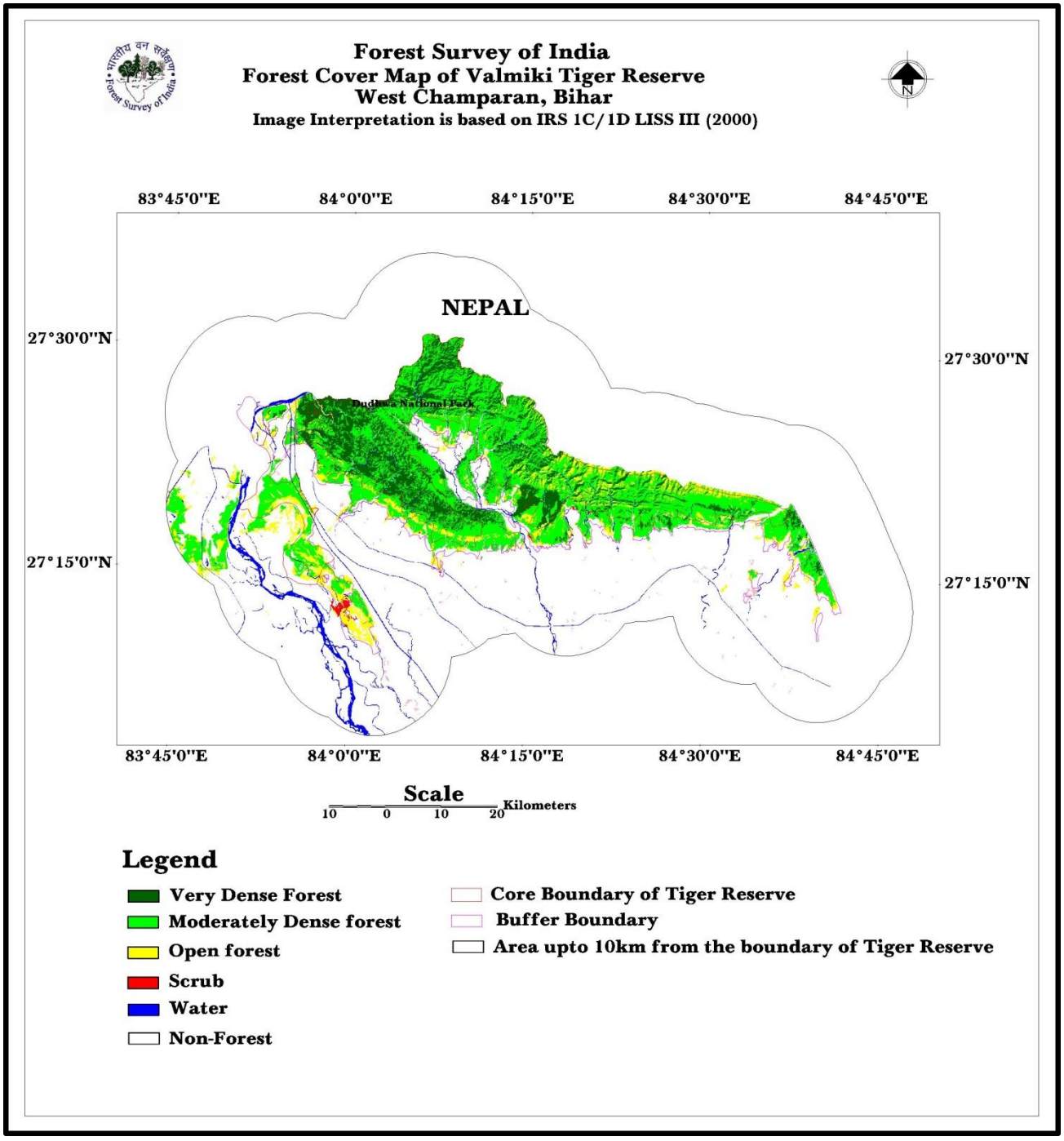


Fig. 4.10.2 : Forest Cover Map of Valmiki Tiger Reserve(2000)

4.10.3 Forest Cover in the year of 2010

- **Core Area:**

The assessment of forest cover in the core area of Valmiki Tiger Reserve is **551.98 sq km** which is about **92.04 %** of the total area of the reserve. For the study of 2010 image interpretation is based on the satellite data of IRS – P6 LISS III (2010-11), **194.54 sq km** of forest falls in Very Dense Forest category,**311.68 sq km** of forest lie in Moderately Dense Forest category and **45.76 sq km** forest is in Open Forest category.

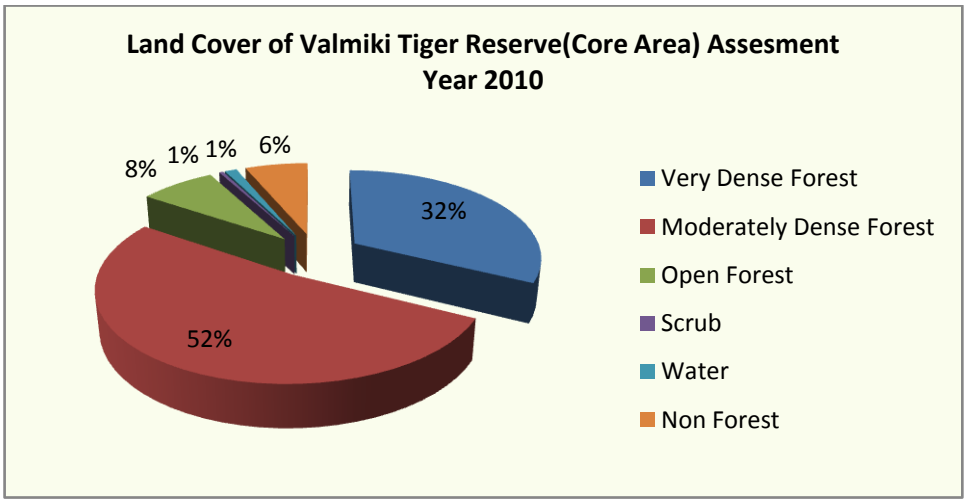


Fig4.10.3a: Pie chart showing percentage of Land Cover of Valmiki Tiger Reserve(Core in 2010)

- **Buffer Area :**

The assessment of forest cover in the buffer area of Valmiki Tiger Reserve is **207.00 sq km** which is about **68.39 %** of the total area of the reserve. For the study of 2010 image interpretation based on the satellite data of IRS – P6 LISS III (2010-11), **33.69 sq km** of forest falls in Very Dense Forest category, **144.26 sq km** of forest lie in Moderately Dense Forest category and **29.05 sq km** forest is in Open Forest category.

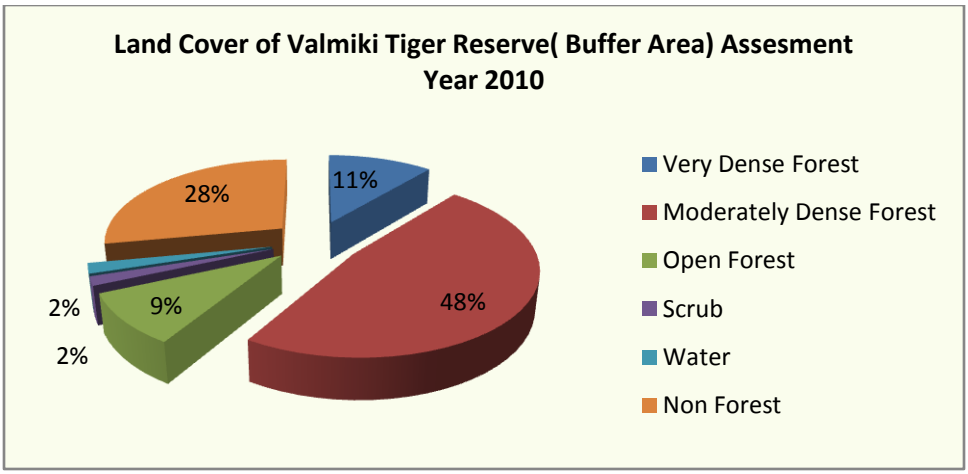


Fig 4.10.3b: Pie chart showing percentage of Land Cover of Valmiki Tiger Reserve (Buffer in 2010)

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

The assessment of forest cover in the AUTKBTRof Tiger Reserve is **73.66 sq km** which is about **4.36 %** of the total area. For the study of 2010 image interpretation based on the satellite data of IRS–P6 LISS III (2010-11), **1.80 sq km** of forest falls in Very Dense Forest category, **47.16 sq km** of forest lie in Moderately Dense Forest category and **24.70 sq km** forest is in Open Forest category.

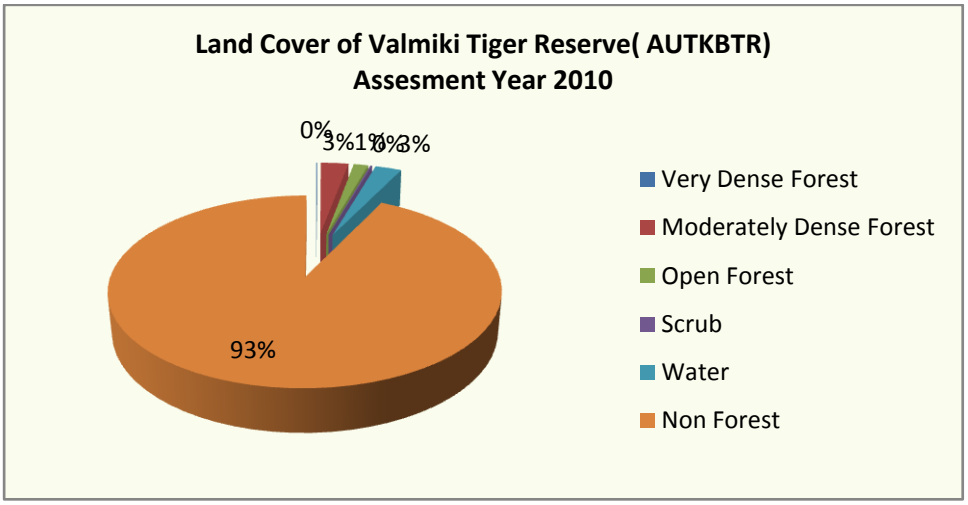


Fig 4.10.3c: Pie chart showing percentage of Land Cover of Valmiki Tiger Reserve (AUTKBTR in 2010)

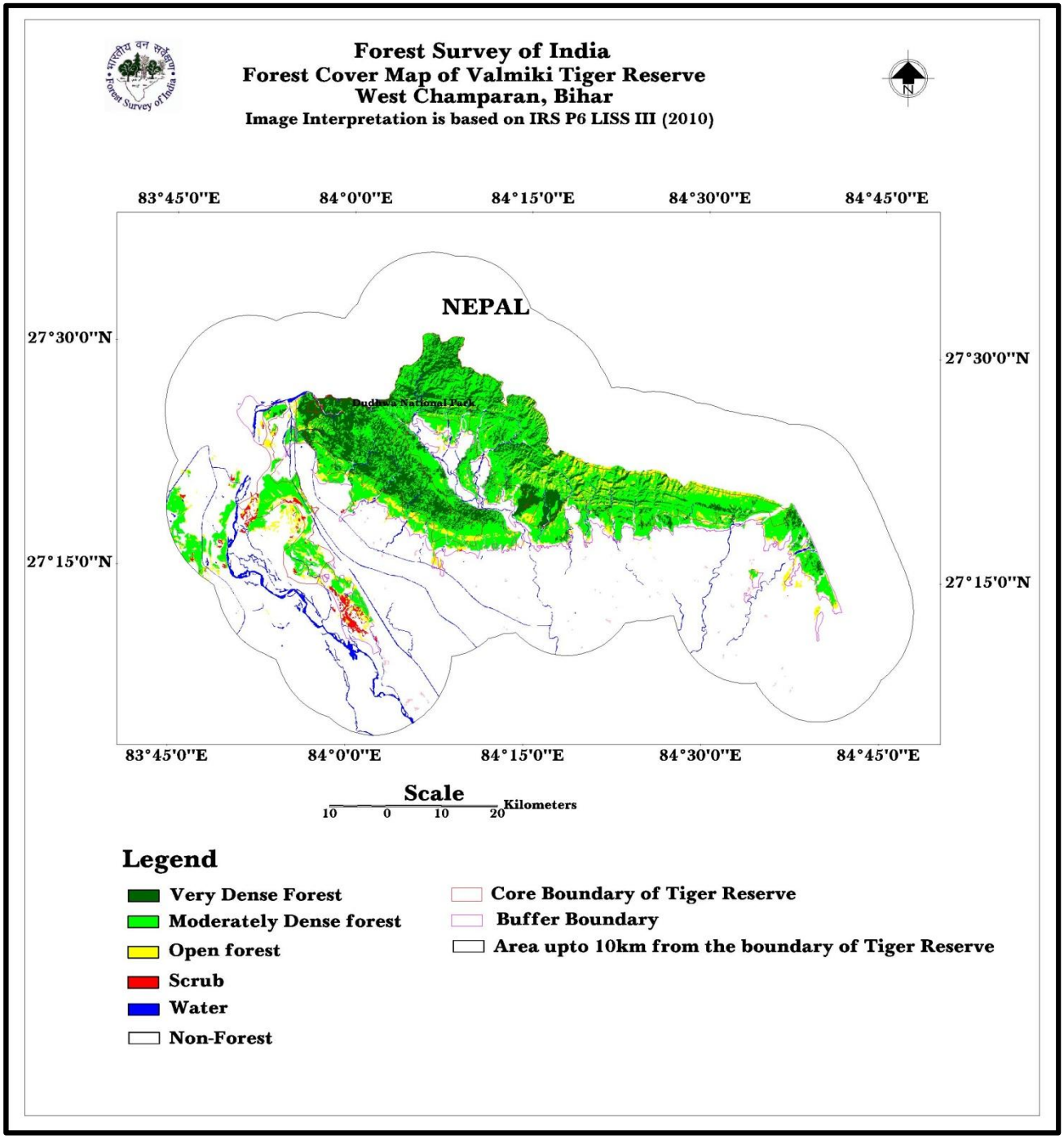


Fig 4.10.3: Forest Cover Map of Valmiki Tiger Reserve(2010)

Table 4.10: Forest Cover (in sq km)in Core, Buffer and AUTKBTR of Valmiki Tiger Reserve

ASSESSMENT YEAR	TIGER RERSERVE BOUNDARY	VDF	MDF	OF	TOTAL FOREST	SCRUB	WATER	NON FOREST
1990	CORE	194.48	311.81	58.05	564.34	0.00	7.22	26.89
	BUFFER	33.53	150.12	44.6	228.25	1.82	8.00	64.6
	AUTKBTR	1.79	52.72	44.51	99.02	0.55	68.03	1518.67
2000	CORE	193.61	314.68	51.47	559.76	0.09	6.49	32.11
	BUFFER	33.68	148.12	41.09	222.89	1.92	4.96	72.9
	AUTKBTR	1.84	50.37	41.61	93.82	1.54	54.3	1536.61
2010	CORE	194.54	311.68	45.76	551.98	2.39	7.27	36.81
	BUFFER	33.69	144.26	29.05	207.00	5.13	5.87	84.67
	AUTKBTR	1.80	47.16	24.70	73.66	3.30	44.98	1564.33

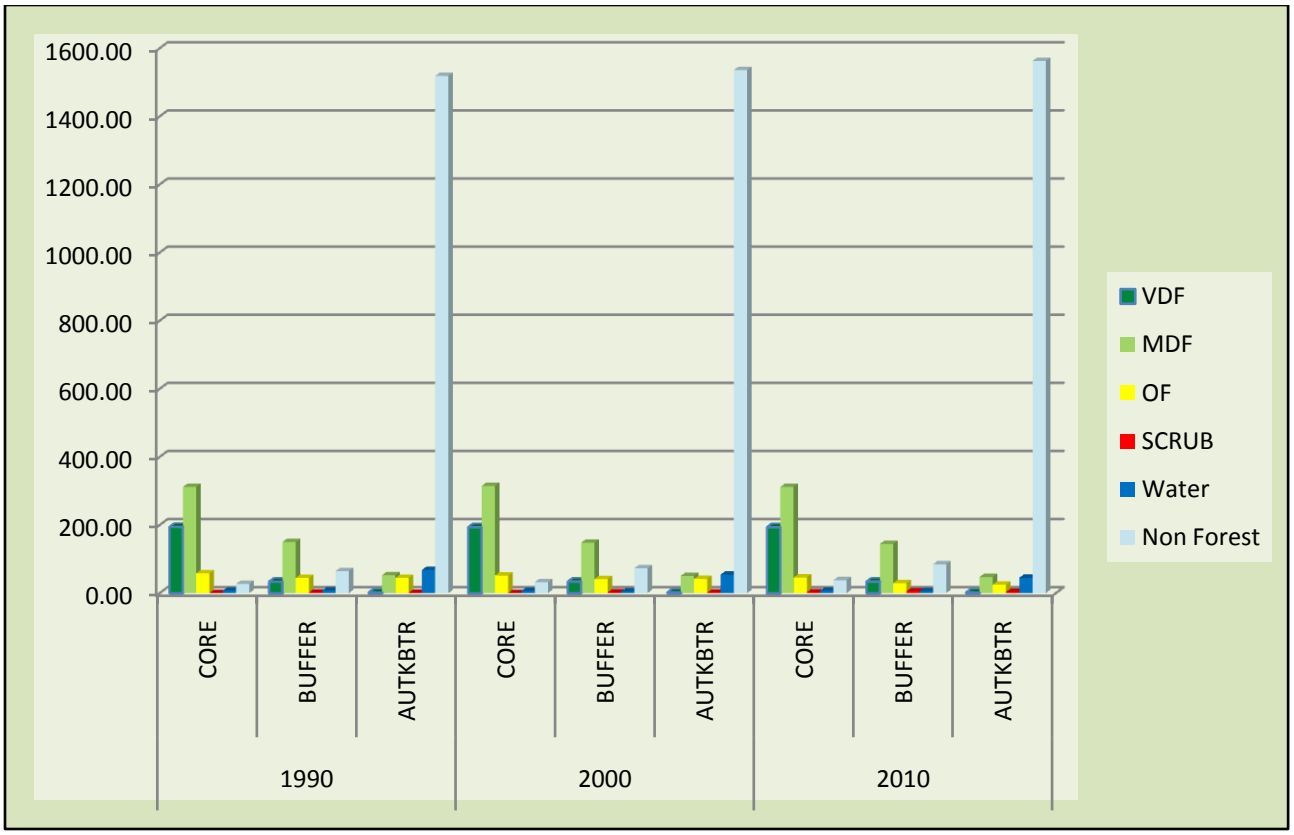


Fig 4.10: Bar diagram showing Land Cover of Corbett Tiger Reserve in Core, Buffer and AUTKBTR area of Valmiki Tiger Reserve (during 1990-2010)

4.11 CHANGE OF FOREST COVER IN VALMIKI TIGER RESERVE DURING 1990-2010

4.11.1 Changes in Forest Cover during 1990-2000

- **Core Area:**

During the period of 1990 to 2000 total forest cover decreased by **4.58 sq km** in the core area of Valmiki Tiger Reserve. It reveals that out of **194.48 sq km** of very dense forest in 1990, **193.61 sq km** of forest remain very dense in 2000 and rest has been converted in other category. Moderately dense forest shows a Positive change from **311.81 sq km** to **314.68 sq km** during 1990 to 2000 and Open forest cover decreased from **58.05 sq km** to **51.47 sq km** during that period of time. The net change in very dense forest has a negative change of **0.87 sq km**, moderately dense forest has a positive change of **2.87 sq km** and open forest has a negative change of **6.58 sq km.**

The changes have been observed mainly due to increase in anthropogenic activities, change in river course of Gandak flowing along the boundary of the Reserve. The decrease in very dense and open forest area is near the Doon valley. The increase in Moderately dense forest is mainly due to effective management practices.

Table4.11.1a: Forest Cover changes in Core Area of Valmiki Tiger Reserve (1990-2000)

(Area in sq km)

Category	Assessment Year		Change
	1990	2000	
Very Dense Forest	194.48	193.61	-0.87
Moderately Dense Forest	311.81	314.68	2.87
Open Forest	58.05	51.47	-6.58
Total Forest	564.34	559.76	-4.58
Scrub	0.00	0.09	0.09
Non Forest	34.11	38.60	4.49

- **Buffer Area :**

During the period of 1990 to 2000 total forest cover decreased by **5.36 sq km** in the buffer area of Valmiki Tiger Reserve. It reveals that very dense forest in 1990 was **33.53 sq km** and in 2000 it has been increased up to **33.68 sq km.**, Moderately dense forest shows a negative change from **150.12 sq km** to **148.12 sq km** during 1990 to 2000 and Open forest cover area figures have been decreased from **44.60 sq km** to **41.09 sq km** during this period of time. The net change in very dense forest has a Positive change of **0.15 sq km**, moderately dense forest has a negative change of **2.00 sq km** and open forest has a negative change of **3.51 sq km**.

The main decrease in forest cover has been seen in the Madanpur Range of Valmiki Tiger Reserve due to increase in anthropogenic activities from three sides of the range and change in river course flowing along the Reserve.

Table4.11.1b: Forest Cover changes in Buffer Area of Valmiki Tiger Reserve (1990-2000)

(Area in sq km)

Category	Assessment Year		Change
	1990	2000	
Very Dense Forest	33.53	33.68	0.15
Moderately Dense Forest	150.12	148.12	-2.00
Open Forest	44.60	41.09	-3.51
Total Forest	228.25	222.89	-5.36
Scrub	1.82	1.92	0.10
Non Forest	72.60	77.86	5.26

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

AUTKBTRof the Tiger Reserve has a total area of **1686.27 sq km** in India. During the period of 1990 to 2000 total forest cover decreased by **5.20 sq k**m in the AUTKBTRof 10 km beyond the Notified boundary of Valmiki Tiger Reserve. It reveals that very dense forest in 1990 was **1.79 sq km** and in 2000 it has been increased up to **1.84 sq km**, Moderately dense forest shows a negative change from **52.72 sq km** to **50.37 sq km** during 1990 to 2000 and Open forest cover area figure have been decreased from **44.51 sq km** to **41.61 sq km** during that period of time.The net change in very dense forest has a positive change of **0.05 sq km**, moderately dense forest has a negative change of **2.35 sq km** and open forest has a negative change of **2.90 sq km**.

Extensive human pressure for fuel wood and timber has resulted in decrease in the forest and tree cover.

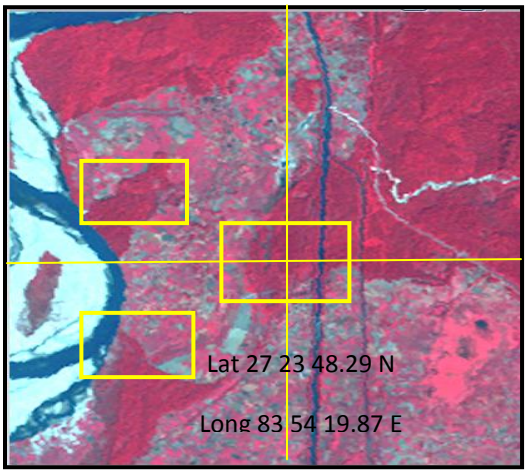
Table4.11.1c: Forest Cover changes in AUTKBTR Area of Valmiki Tiger Reserve (1990-2000)

(Area in sq km)

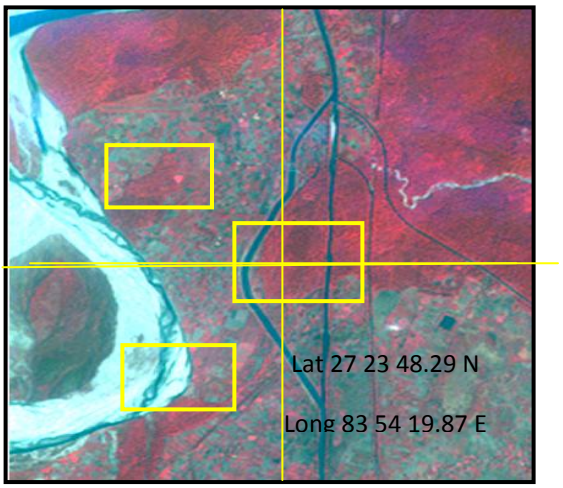
Category	Assessment Year		Change
	1990	2000	
Very Dense Forest	1.79	1.84	0.05
Moderately Dense Forest	52.72	50.37	-2.35
Open Forest	44.51	41.61	-2.90
Total Forest	99.02	93.82	-5.20
Scrub	0.55	1.54	0.99
Non Forest	1586.70	1590.91	4.21

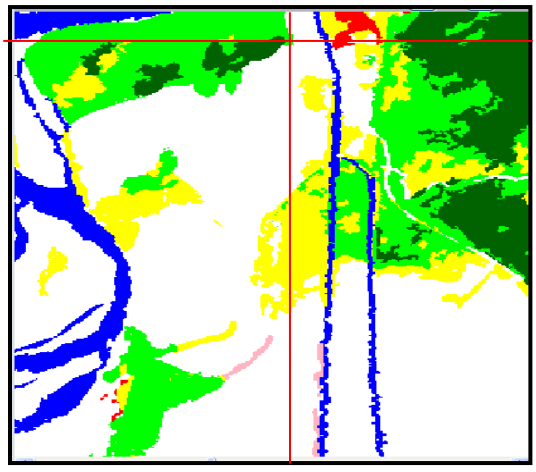
CHANGES OF FOREST COVER DURING 10 YEARS (1990-2000)

Imagery date October 1990



Imagery Date October 2000





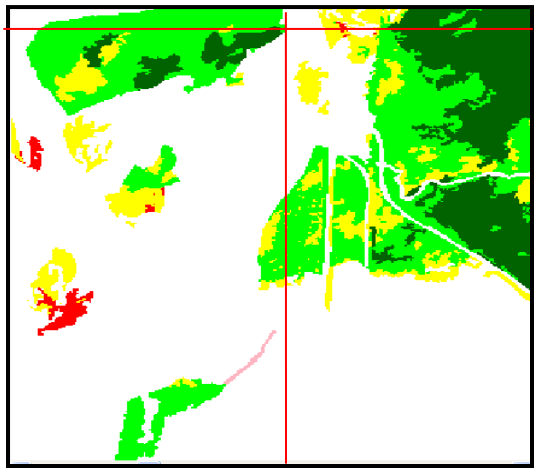


Fig.1: **Area showing in maps falling in Buffer area of the reserve**

Imagery date October 1990

Imagery Date October 2000

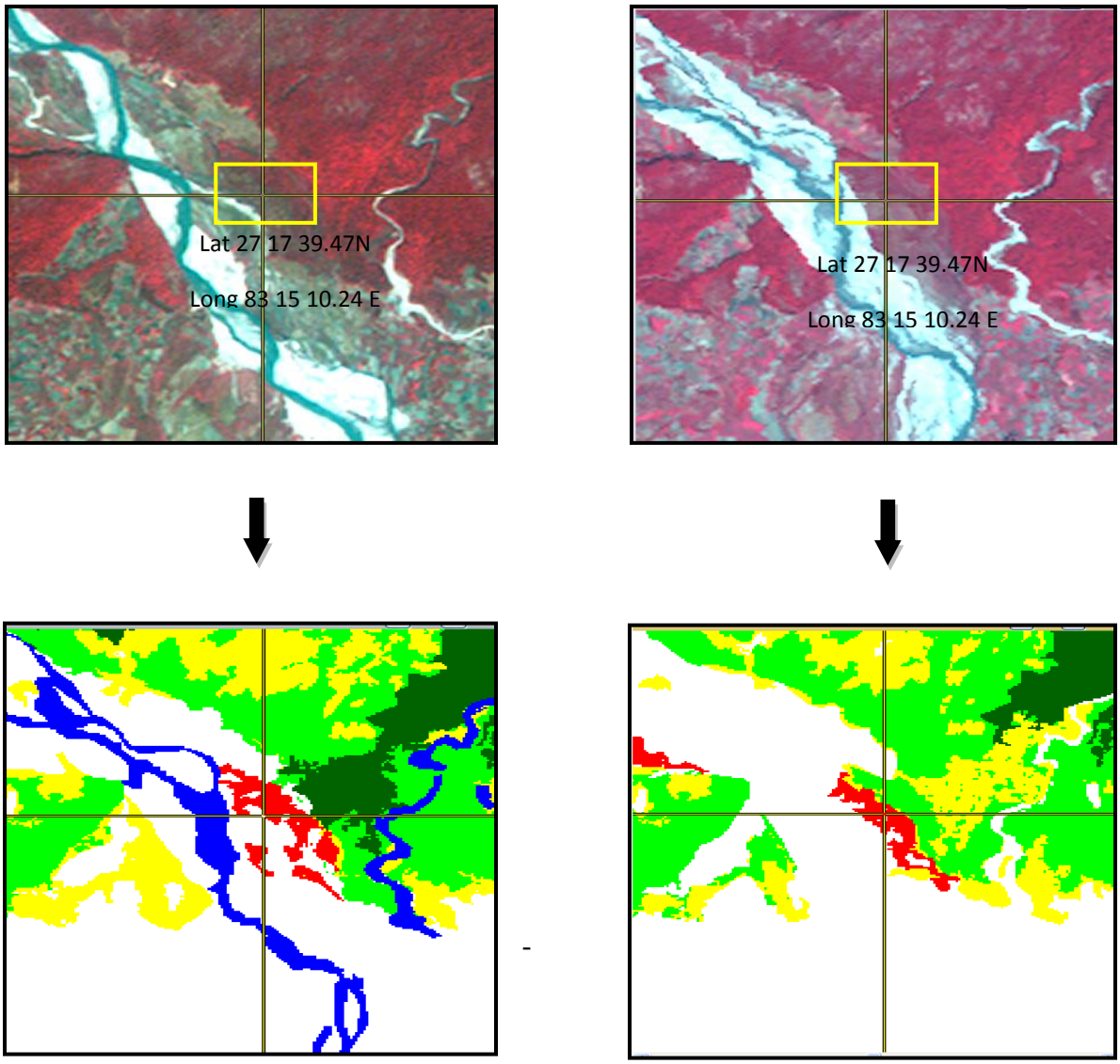


Fig. 2**: Area showing in maps falling in Buffer area of the reserve**

Imagery date October 1990

Imagery Date October 2000

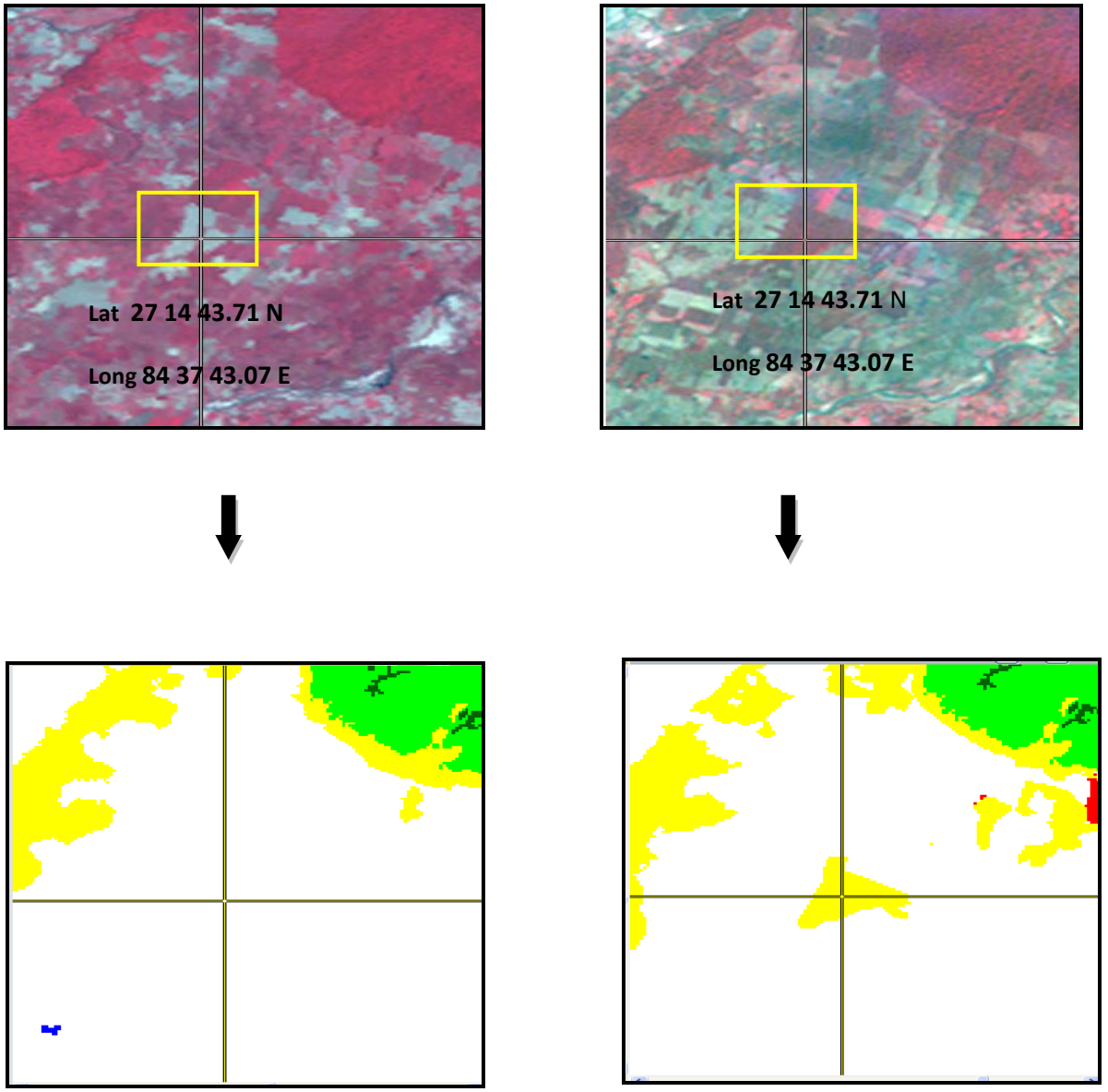


Fig. 3: **Area showing in maps falling in AUTKBTR of the reserve**

\Imagery date October 1990

Imagery Date October 2000

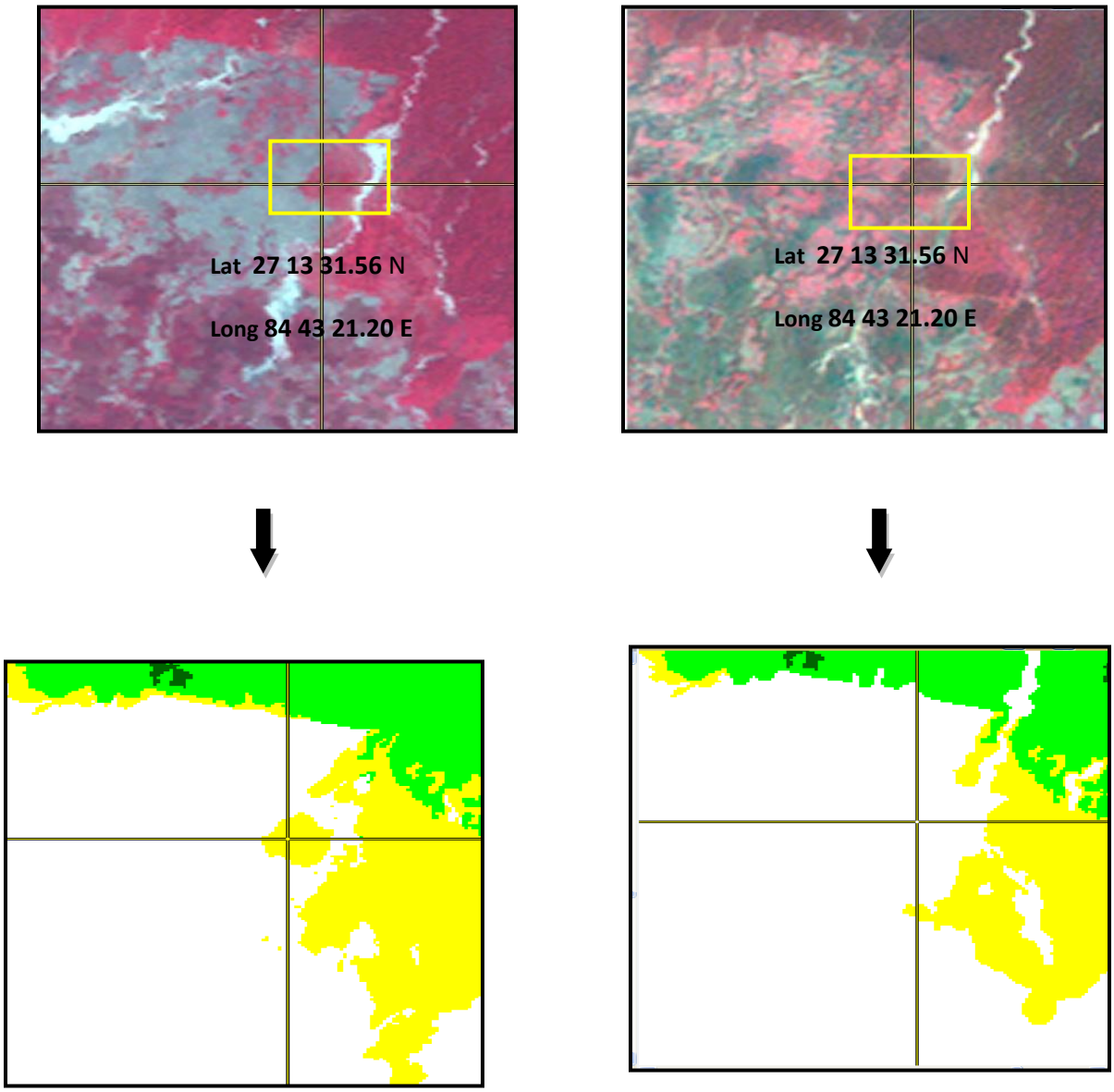
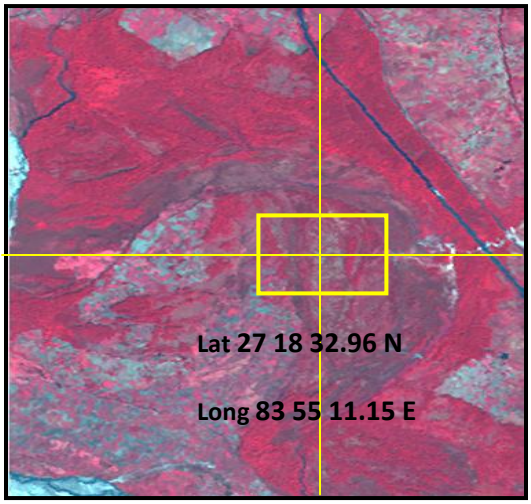


Fig.4: **Area showing in maps falling in Buffer area of the reserve**

Imagery date October 1990



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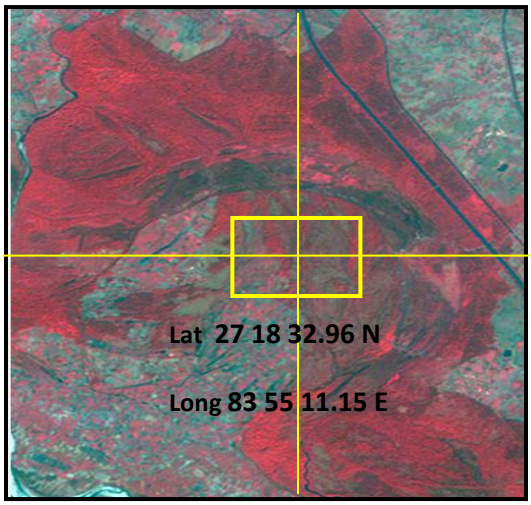
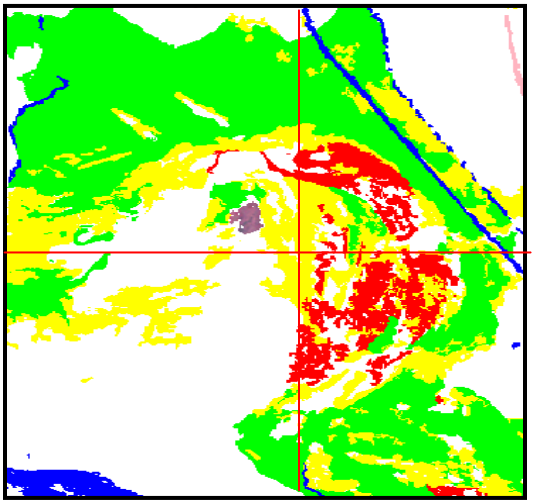




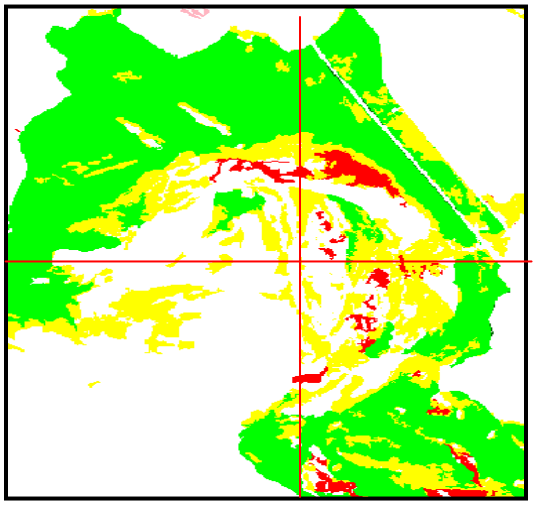


Fig. 5: **Area showing in maps falling in Buffer area of the reserve**

Imagery date October 1990 **Imagery Date October 2000**

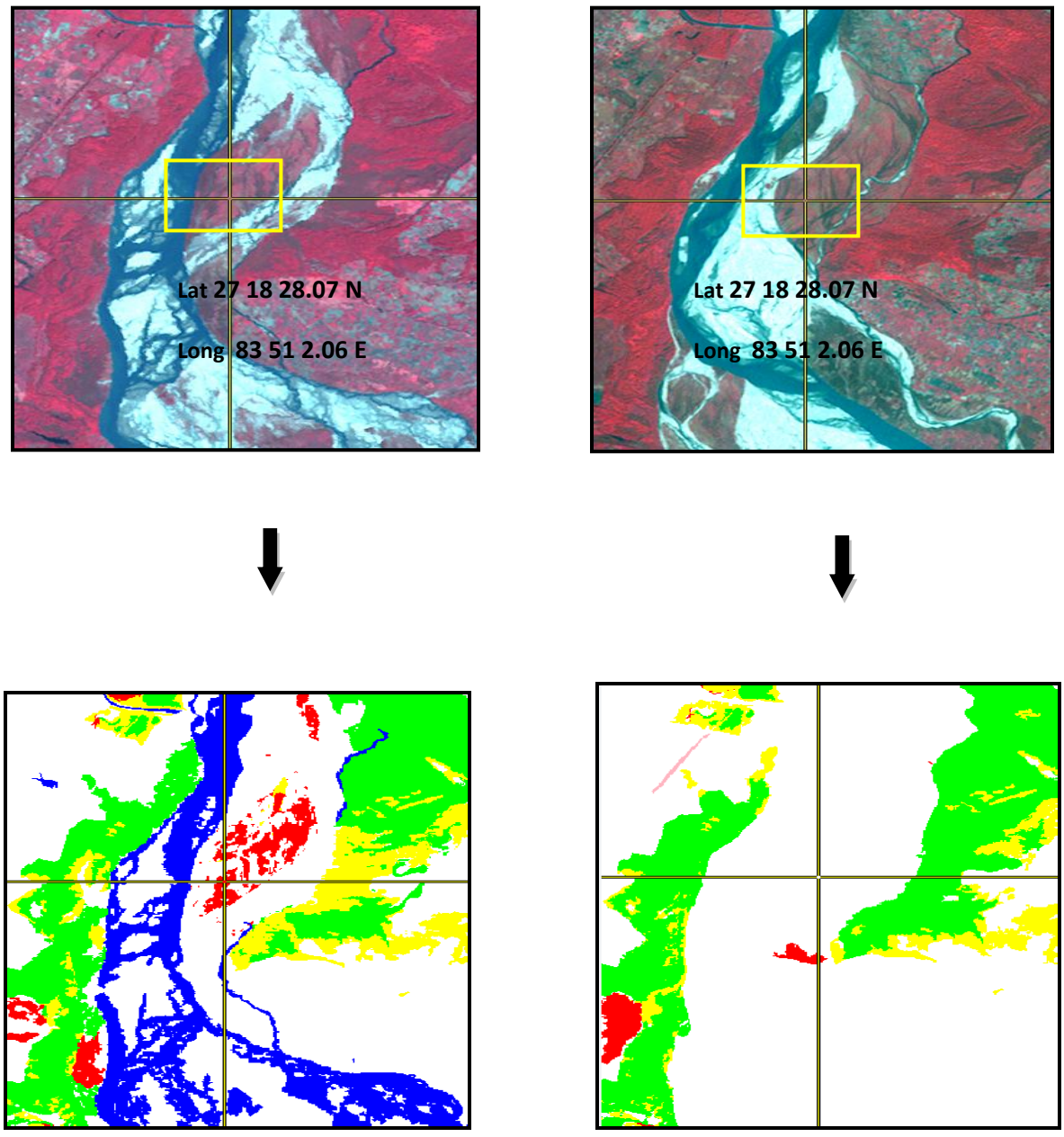


Fig. 6: **Area showing in maps falling in Buffer area of the reserve**

4.11.2 Changes in Forest Cover during 2000-2010

- **Core Area:**

During the period of 2000 to 2010 total forest cover decreased by **7.78 sq km** in the core area of Valmiki Tiger Reserve. It reveals that there is positive change in very dense forest as it has been changed from **193.61 sq km** (2000) to **194.54 sq km** (2010). Moderately dense forest shows a negative change from **314.68 sq km** to **311.68 sq km** during 2000 to 2010 and Open forest cover decreased from **51.47 sq km** to **45.76 sq km** during that period of time. The net change in very dense forest has a positive change **of 0 .93 sq km**, moderately dense forest has a negative change of **3.00 sq km** and open forest has negative change of **5.71 sq km**.

The changes have been observed mainly due to the increased population inside the villages located in the Doon valley. Increase in Very Dense Forest is due to the overall qualitative improvement in the Forest stock and decrease in Moderately dense forest is after effect of river course change .

Table4.11.2a: Forest Cover changes in Core Area of Valmiki Tiger Reserve (2000-2010)

(Area in sq km)

Category	Assessment Year		Change
	2000	2010	
Very Dense Forest	193.61	194.54	0.93
Moderately Dense Forest	314.68	311.68	-3.00
Open Forest	51.47	45.76	-5.71
Total Forest	559.76	551.98	-7.78
Scrub	0.09	2.39	2.30
Non Forest	38.60	44.08	5.48

- **Buffer Area:**

During the period of 2000 to 2010 total forest cover decreased by **15.89 sq km** in the buffer area of Valmiki Tiger Reserve. It reveals that very dense forest in 2000 was **33.68 sq km** and in 2000 it has been increased up to **33.69 sq km**., Moderately dense forest shows a negative change from **148.12 sq km** to **144.26 sq km** during 2000 to 2010 and Open forest cover area figure have been decreased from **41.09 sq km** to **29.05 sq km** during that period of time.The net change in very dense forest has a Positive change of **0.01 sq km**, moderately dense forest has a negative change of **3.86 sq km** and open forest has a negative change of **12.04 sq km**.

The changes have been observed mainly due to flood in Gandak river, changes in river course flowing through the reserve. Increase in anthropogenic activities in southern part of periphery of the reserve has resulted in degradation of forest cover.

Table4.11.2b: Forest Cover changes in Buffer Area of Valmiki Tiger Reserve (2000-2010)

(Area in sq km)

Category	Assessment Year		Change
	2000	2010	
Very Dense Forest	33.68	33.69	0.01
Moderately Dense Forest	148.12	144.26	-3.86
Open Forest	41.09	29.05	-12.04
Total Forest	222.89	207.00	-15.89
Scrub	1.92	5.13	3.21
Non Forest	77.86	90.54	12.68

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

During the period of 2000 to 2010 total forest cover decreased by **20.16 sq km** in the AUTKBTRof Valmiki Tiger Reserve. It reveals that very dense forest in 2000 was **1.84 sq km** and in 2000 it has been decreased up to **1.80 sq km**, Moderately dense forest shows a negative change from **50.37 sq km** to **47.16 sq km** during 2000 to 2010 and Open forest cover area figure have been decreased from **41.61 sq km** to **24.70 sq km** during that period of time. The net change in very dense forest has a negative change of **0.04 sq km**, moderately dense forest has a negative change of **3.21 sq km** and open forest has a negative change of **16.91 sq km.**

The changes have been observed mainly due to increase in population inside the villages as well as increasing anthropogenic activities in the area.

Table4.11.2c: Forest Cover changes in AUTKBTRArea of Valmiki Tiger Reserve (2000-2010)

(Area in sq km)

Category	Assessment Year		Change
	2000	2010	
Very Dense Forest	1.84	1.80	-0.04
Moderately Dense Forest	50.37	47.16	-3.21
Open Forest	41.61	24.70	-16.91
Total Forest	93.82	73.66	-20.16
Scrub	1.54	3.30	1.76
Non Forest	1590.91	1609.31	18.40

CHANGES OF FOREST COVER DURING 10YEARS (2000-2010)

Imagery Date Oct 2000

Imagery Date Nov 2010

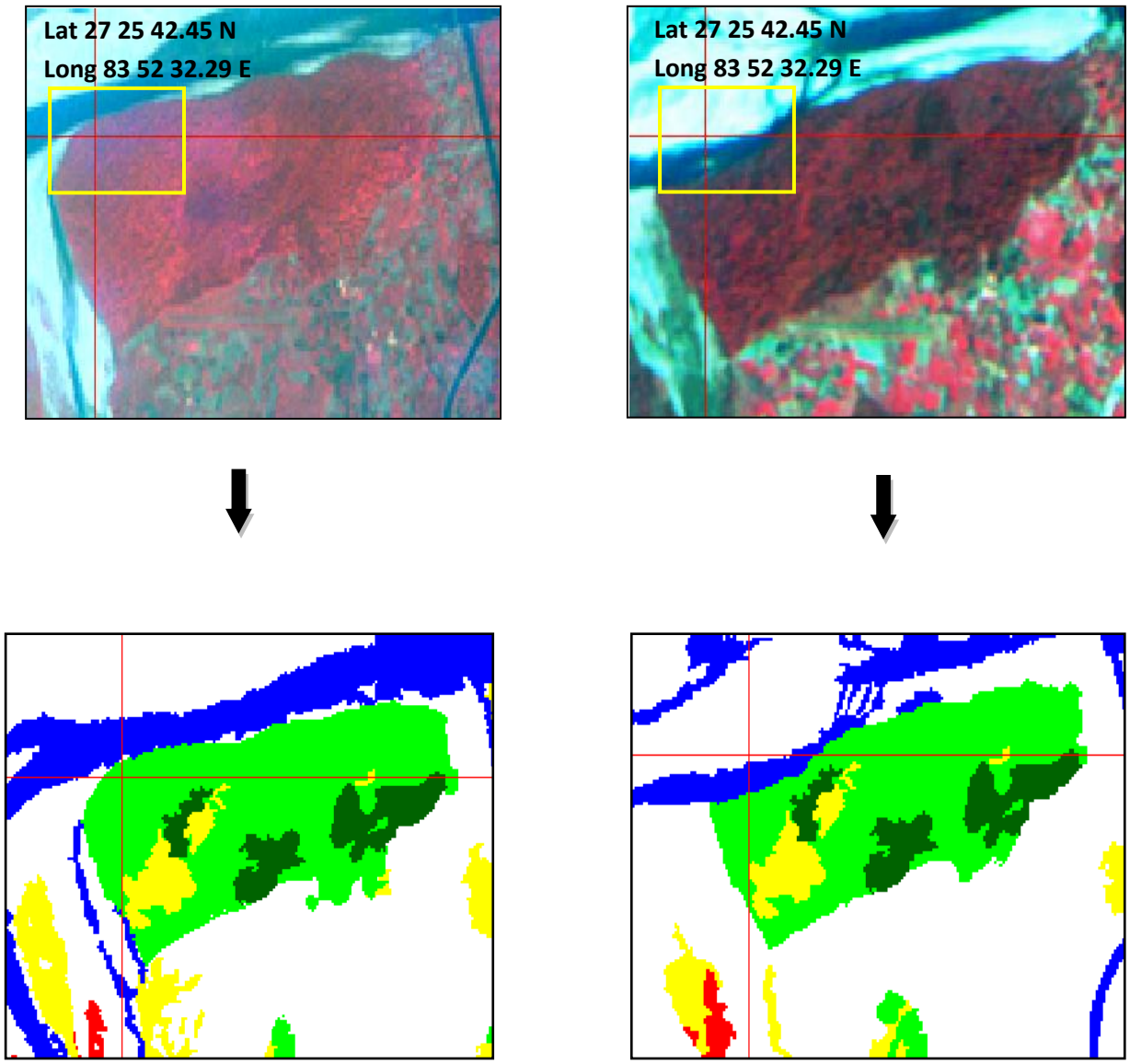


Fig. 1**: Area showing in maps falling in Buffer area of the reserve**

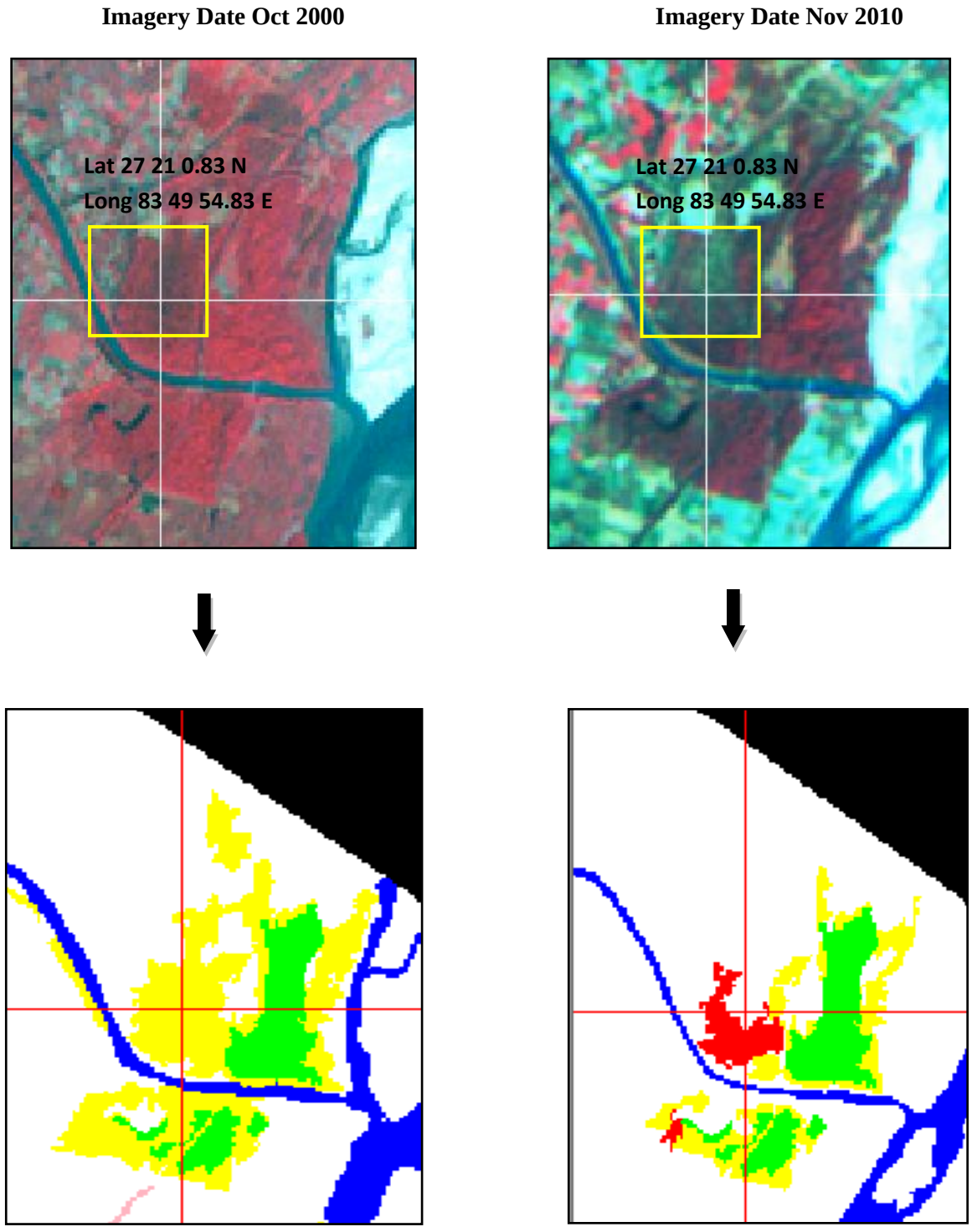


Fig. 2: **Area showing in maps falling in AUTKBTR of the reserve**

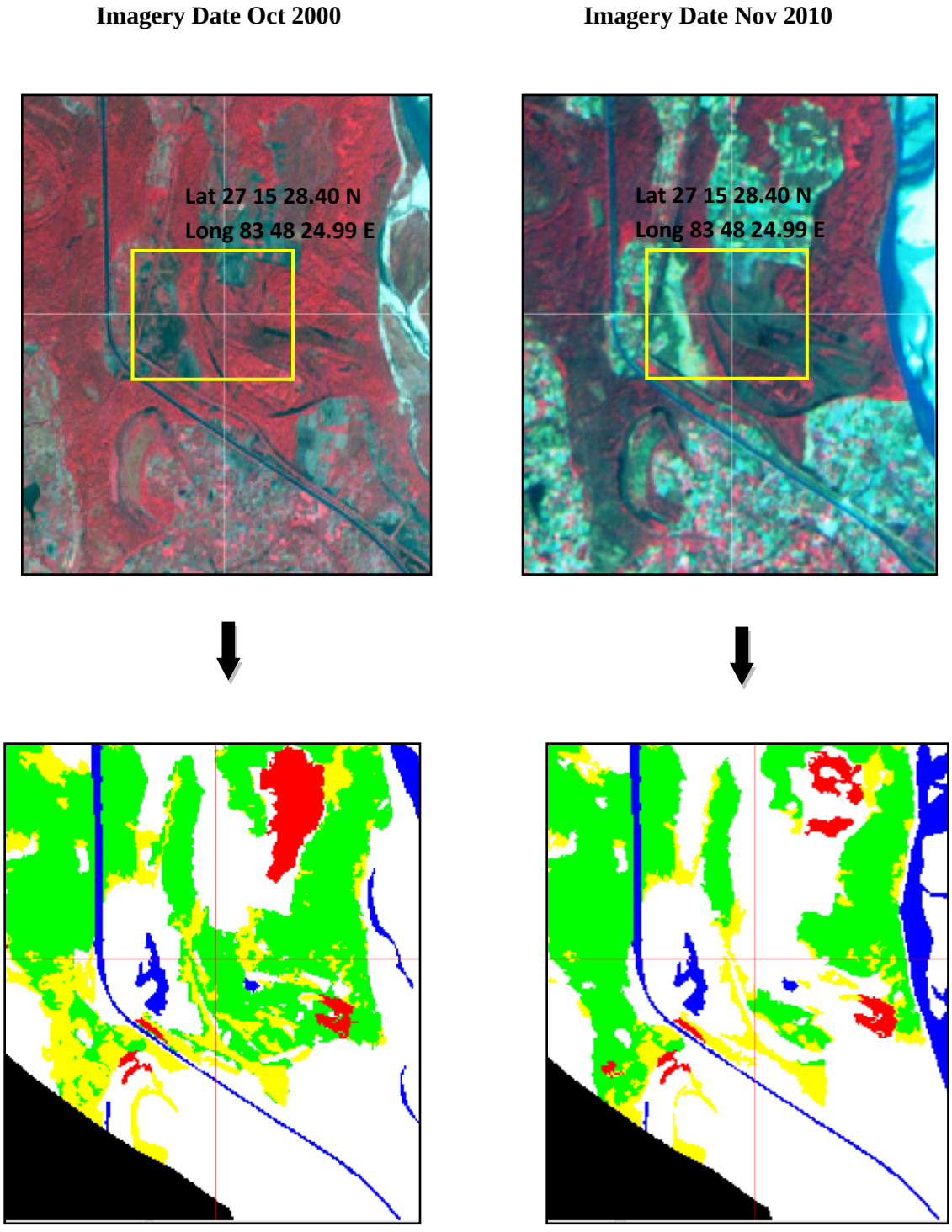


Fig.3: **Area showing in maps falling in AUTKBTR of the reserve**

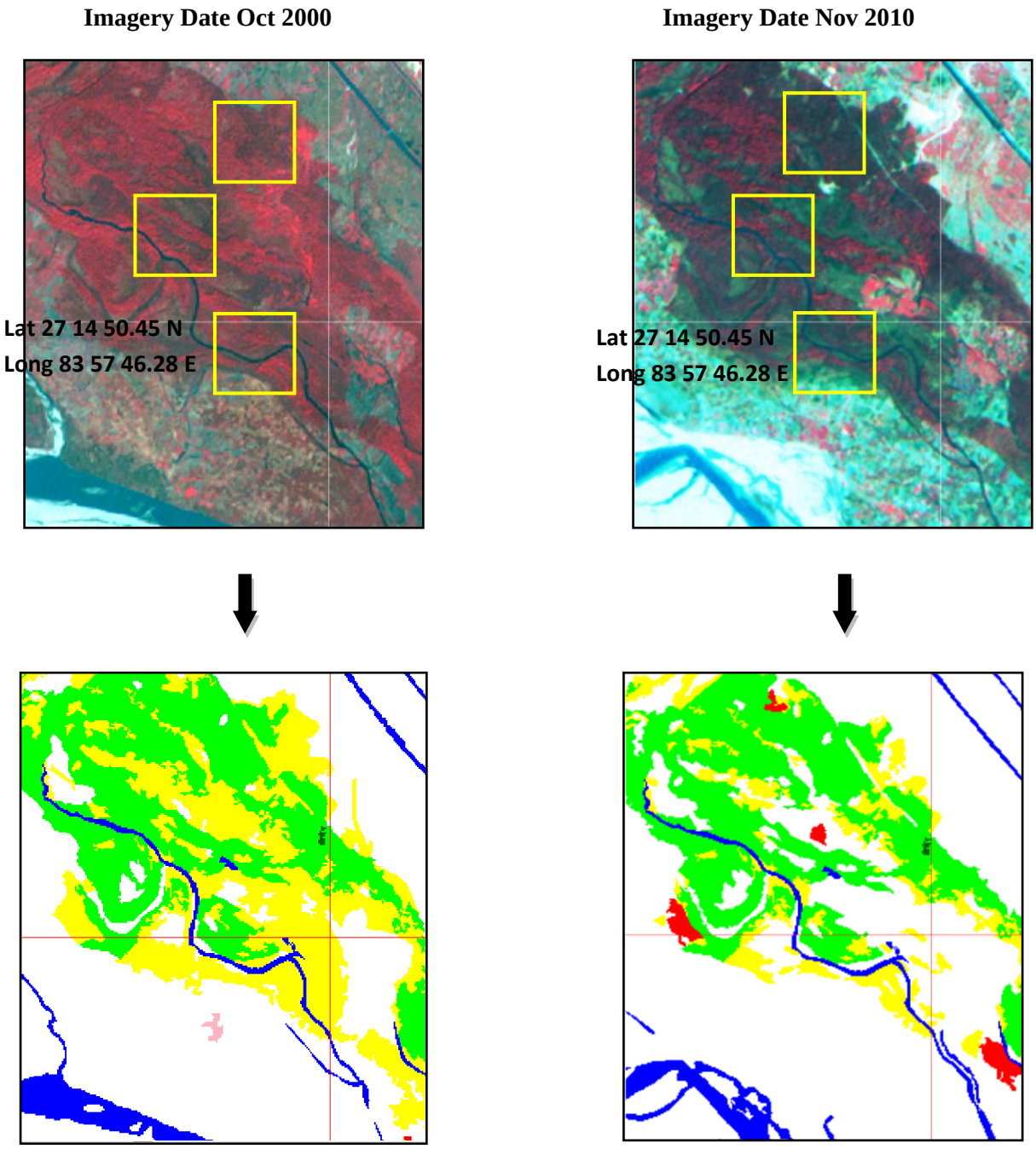


Fig.4: **Area showing in maps falling in Buffer area of the reserve**

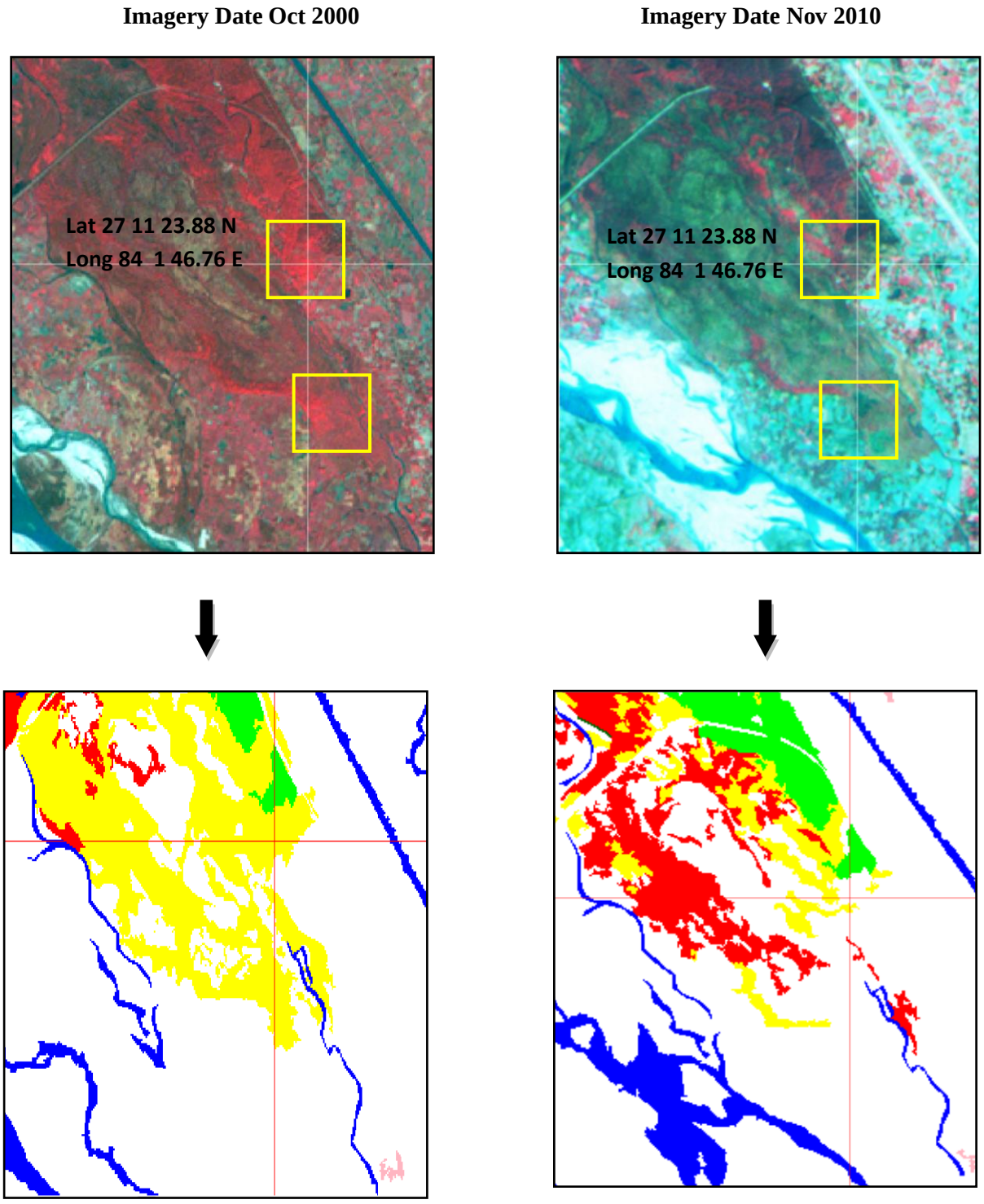


Fig.5: **Area showing in maps falling in Buffer area of the reserve**

Imagery Date Oct 2000 **Imagery Date Nov 2010**

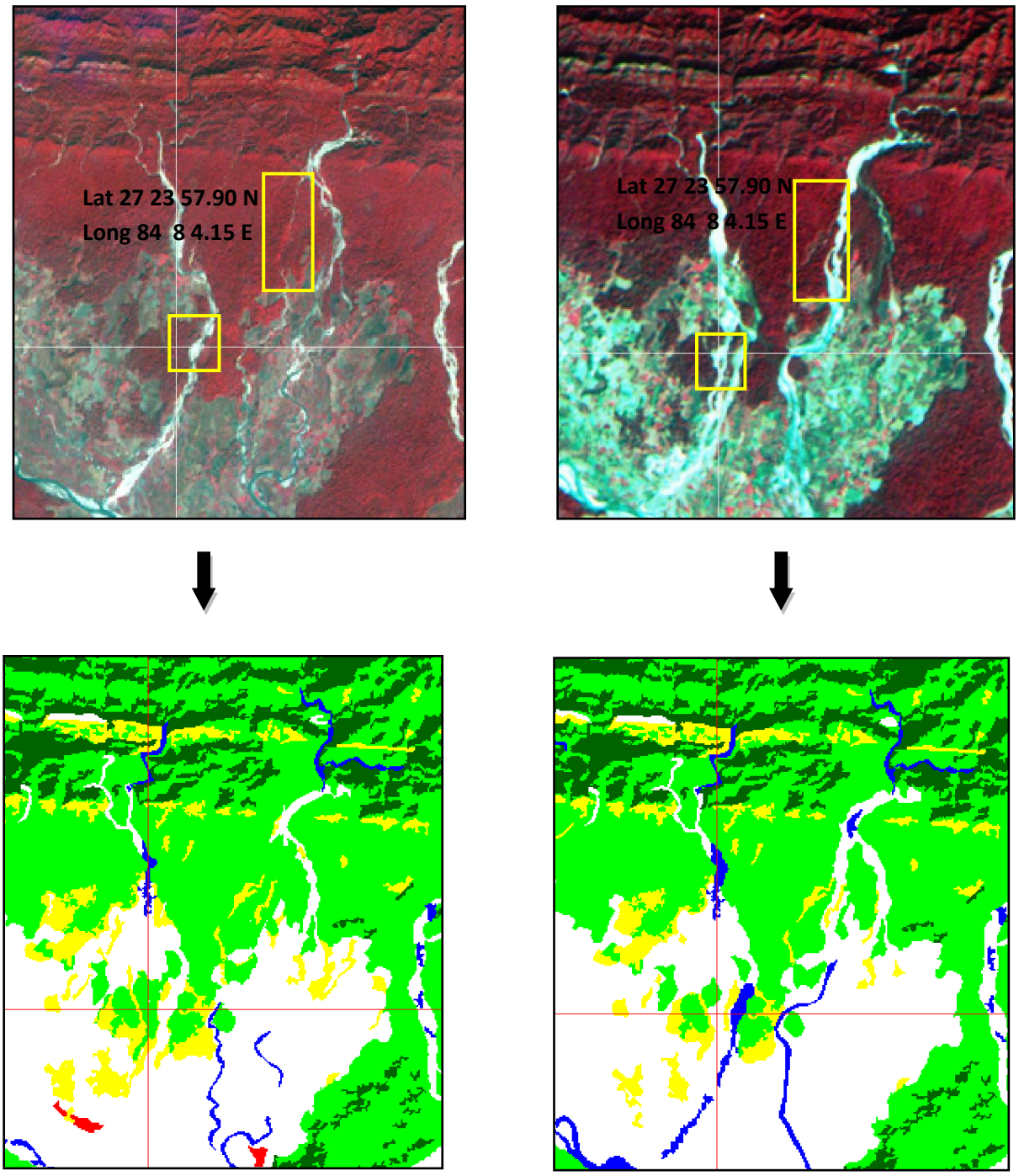


Fig 6**: Area showing in maps falling in Buffer area of the reserve**

4.11.3 Changes in Forest Cover during 1990-2010

- **Core Area:**

During the period of 1990 to 2010 total forest cover decreased by **12.36 sq km** in the core area of Valmiki Tiger Reserve. It reveals that there is positive change in very dense forest as it has been changed from **194.48 sq km** (1990) to **194.54 sq km** (2010). Moderately dense forest shows a negative change from **311.81 sq km** to **311.68 sq km** during 1990 to 2010 and Open forest cover decreased from **58.05 sq km** to **45.76 sq km** during that period of time. The net change in very dense forest has a positive change of **0.06 sq km,** moderately dense forest has a negative change of **0.13 sq km** and open forest has a negative change of **12.29 sq km.**

The changes have been observed mainly due to flood and consequently the change in river coarse in the Tiger Reserve. The decrease in Open forest area has been seen mainly near the Doon Valley and the negative change in forest is due to build up/shift of human settlements in t he area. Increase in Very Dense Forest is due to the overall qualitative improvement in the Forest stock.

Table4.11.3a: Forest Cover changes in Core Area of Valmiki Tiger Reserve (1990-2010)

(Area in sq km)

Category	Assessment Year		Change
	1990	2010	
Very Dense Forest	194.48	194.54	0.06
Moderately Dense Forest	311.81	311.68	-0.13
Open Forest	58.05	45.76	-12.29
Total Forest	564.34	551.98	-12.36
Scrub	0.00	2.39	2.39
Non Forest	34.11	44.08	9.97

- **Buffer Area:**

During the period of 1990 to 2010 total forest cover decreased by **21.25 sq km** in the buffer area of Valmiki Tiger Reserve. It reveals that very dense forest in 1990 was **33.53 sq km** and in 2010 it increased up to **33.69 sq km**. Moderately dense forest shows a negative change from **150.12 sq km** to **144.26 sq km** during 1990 to 2010 and Open forest cover area figure have been decreased from **44.60 sq km** to **29.05 sq km** during that period of time.The net change in very dense forest has a positive change of **0.16 sq km**, moderately dense forest has a negative change of **5.86 sq km** and open forest has a negative change of **15.55sq km**.

The decrease in forest cover has been observed mainly due to the change in river coarse of Gandak River. The main decrease in the Madanpur Range of Valmiki Tiger Reserve is because of increase in anthropogenic activities from three sides of the range.

Table4.11.3b: Forest Cover changes in Buffer Area of Valmiki Tiger Reserve (1990-2010)

(Area in sq km)

Category	Assessment Year		Change
	1990	2010	
Very Dense Forest	33.53	33.69	0.16
Moderately Dense Forest	150.12	144.26	-5.86
Open Forest	44.60	29.05	-15.55
Total Forest	228.25	207.00	-21.25
Scrub	1.82	5.13	3.31
Non Forest	72.60	90.54	17.94

- **Area upto 10km from the boundary of Tiger Reserve (AUTKBTR):**

During the period of 1990 to 2010 total forest cover decreased by **25.36 sq km** in the AUTKBTRarea of Valmiki Tiger Reserve. The study shows that very dense forest in 1990 was **1.79 sq km** and in 2010 it has been increased up to **1.80 sq km**, Moderately dense forest shows a negative change from **52.72 sq km** to **47.16 sq km** during 1990 to 2010 and Open forest cover has decreased from **44.51 sq km** to **24.70 sq km** during that period of time. The net change in very dense forest has a Positive change of **0.01 sq km**, moderately dense forest has a negative change of **5.56 sq km** and open forest has a negative change of **19.81 sq km**.

Extensive human pressure for fuel wood and timber resulted in decrease in forest cover during this period of time. Flood in Gandak river and also changes in river course flowing in the reserve have also played a significant role in decreasing forest cover in the area.

Table4.11.3c: Forest Cover changes in AUTKBTR Area of Valmiki Tiger Reserve (1990-2010)

(Area in sq km)

Category	Assessment Year		Change
	1990	2010	
Very Dense Forest	1.79	1.80	0.01
Moderately Dense Forest	52.72	47.16	-5.56
Open Forest	44.51	24.70	-19.81
Total Forest	99.02	73.66	-25.36
Scrub	0.55	3.30	2.75
Non Forest	1586.70	1609.31	22.61

CHANGES OF FOREST COVER DURING 20 YEARS (1990-2010)

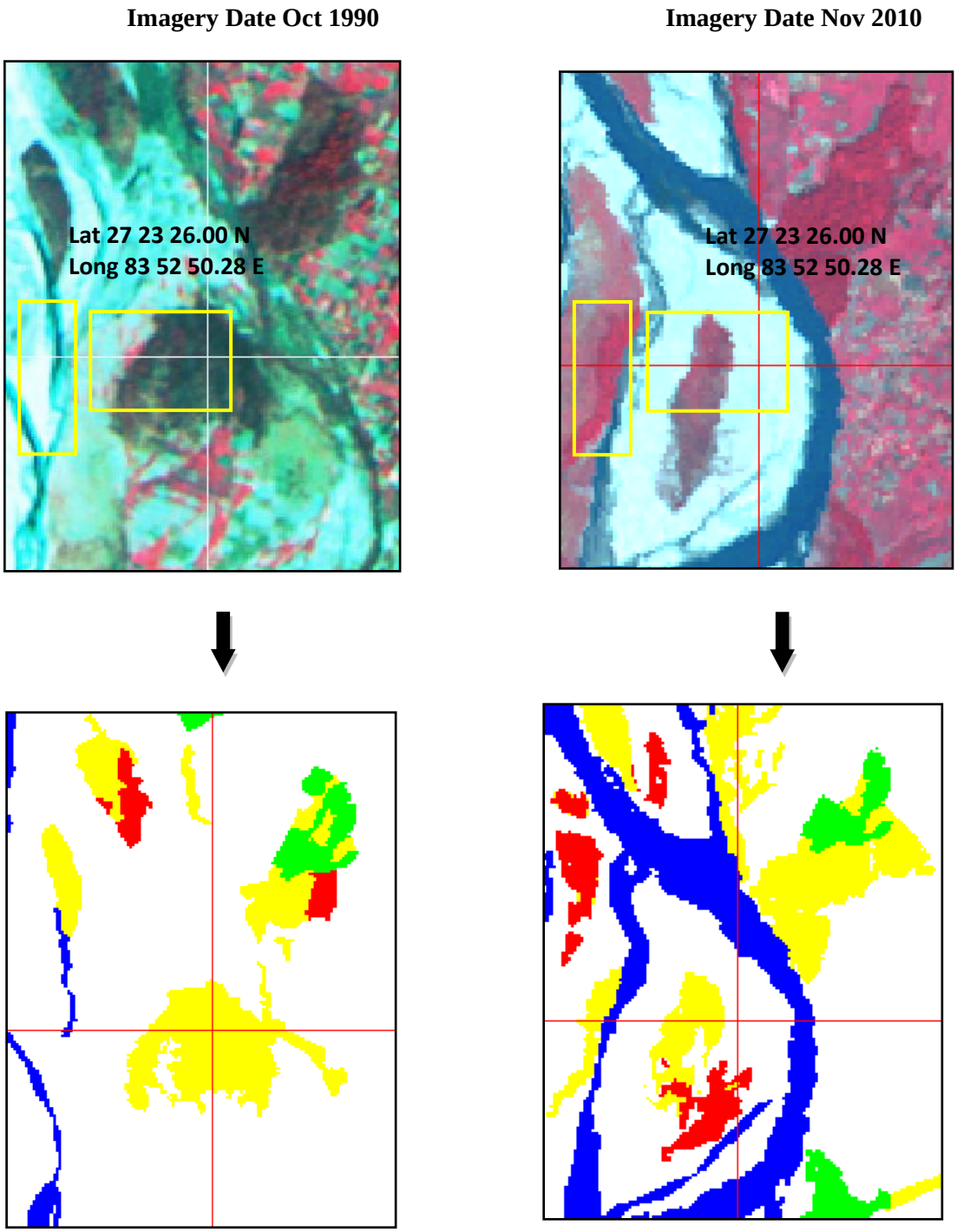


Fig.1: **Area showing in maps falling in Core area of the reserve**

Imagery Date Oct 1990 **Imagery Date Nov 2010**

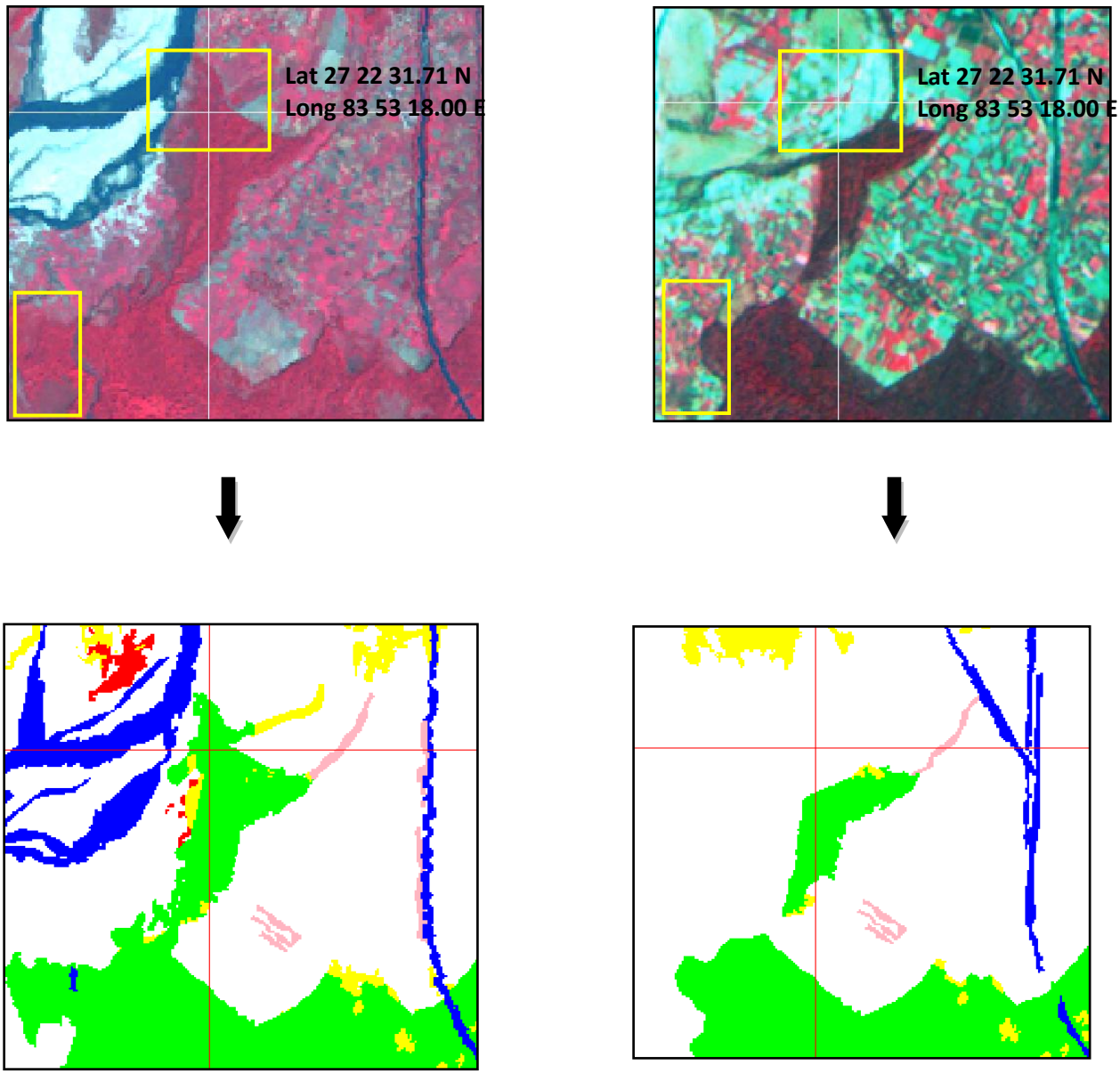


Fig: 2**: Area showing in maps falling in Core area of the reserve**

Imagery Date Oct 1990 **Imagery Date Nov 2010**

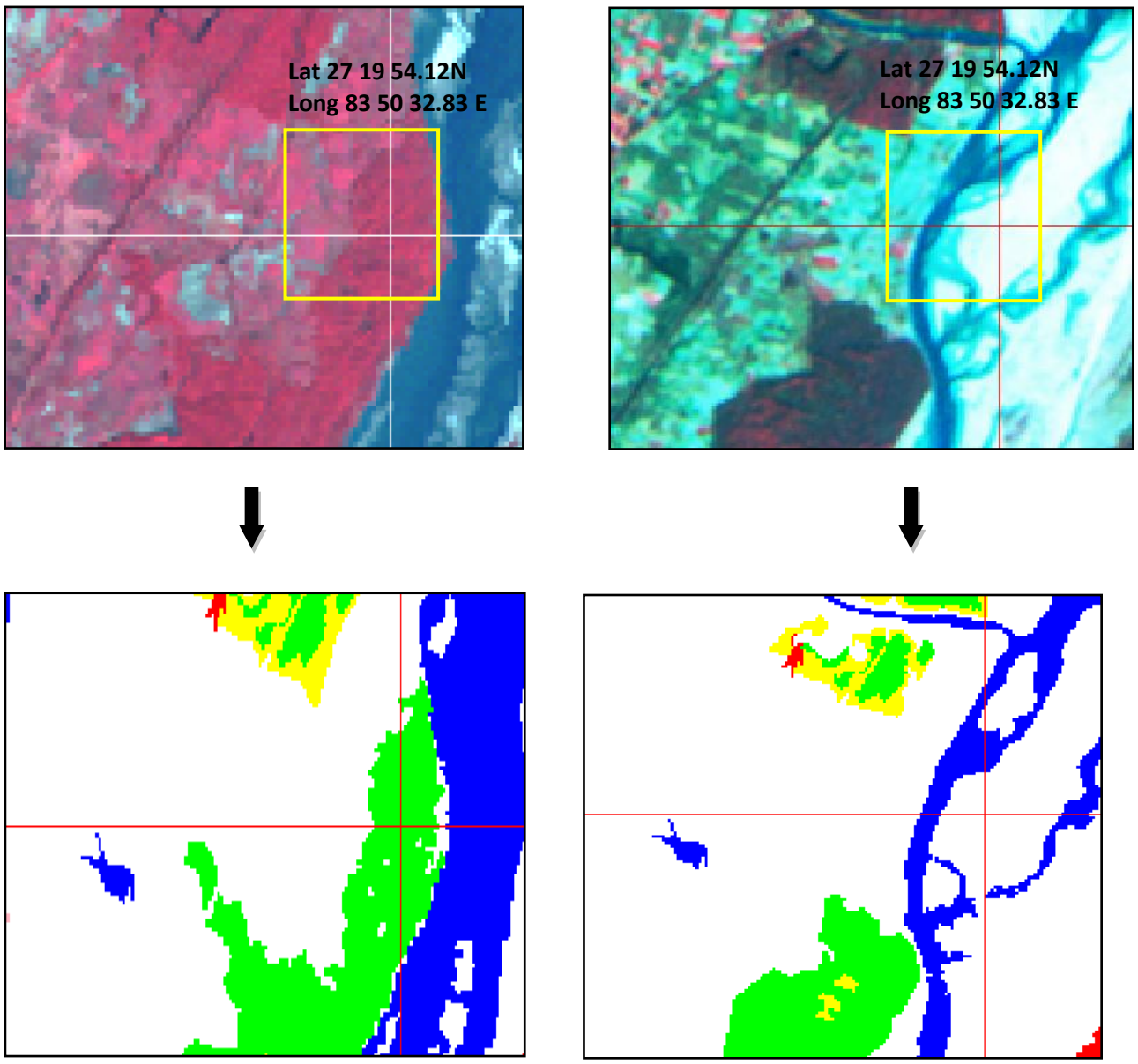


Fig.3: **Area showing in maps falling in AUTKBTR of the reserve**

Imagery Date Oct 1990 **Imagery Date Nov 2010**

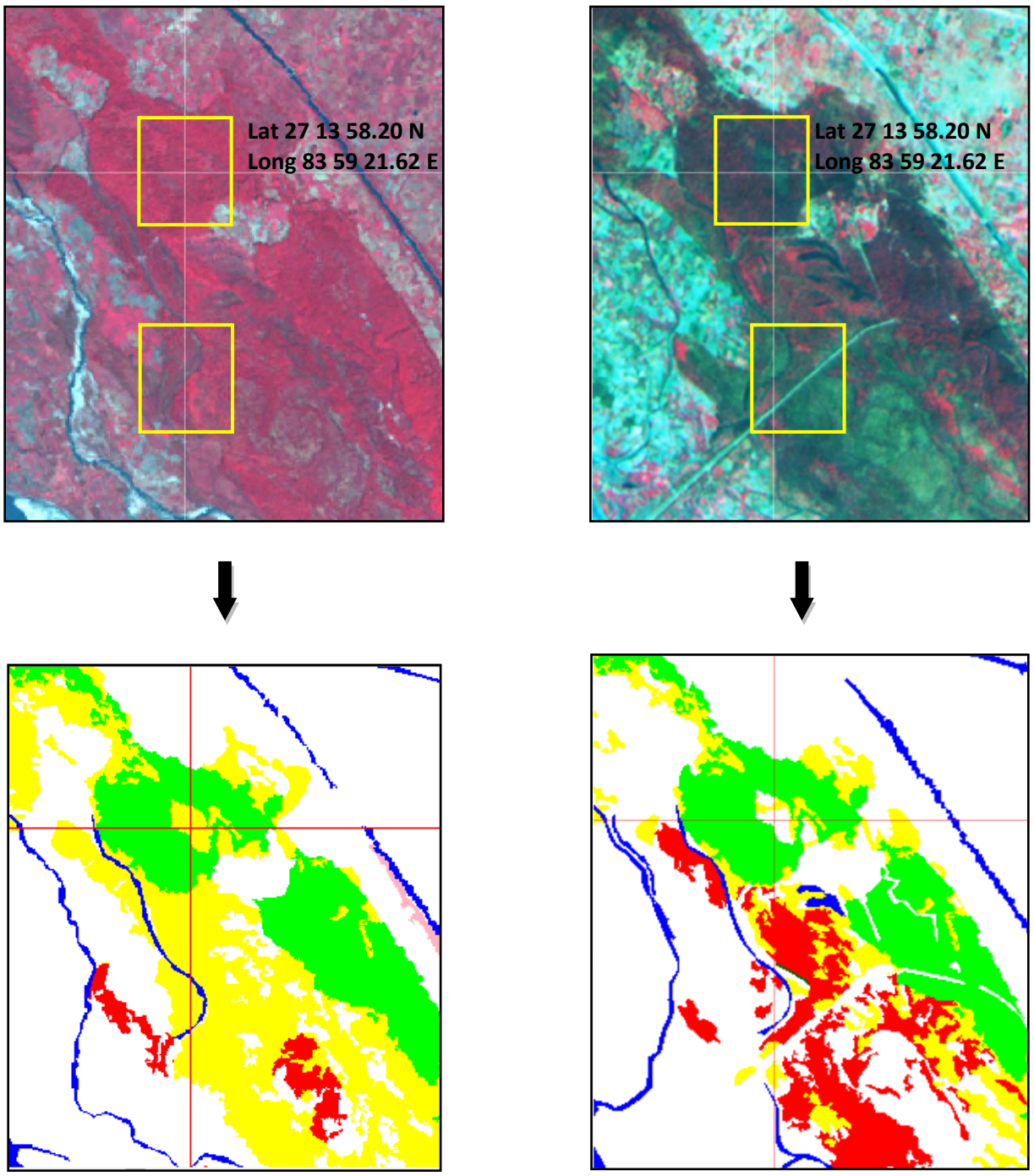


Fig 4: **Area showing in maps falling in Buffer area of the reserve**

Imagery Date Oct 1990 **Imagery Date Nov 2010**

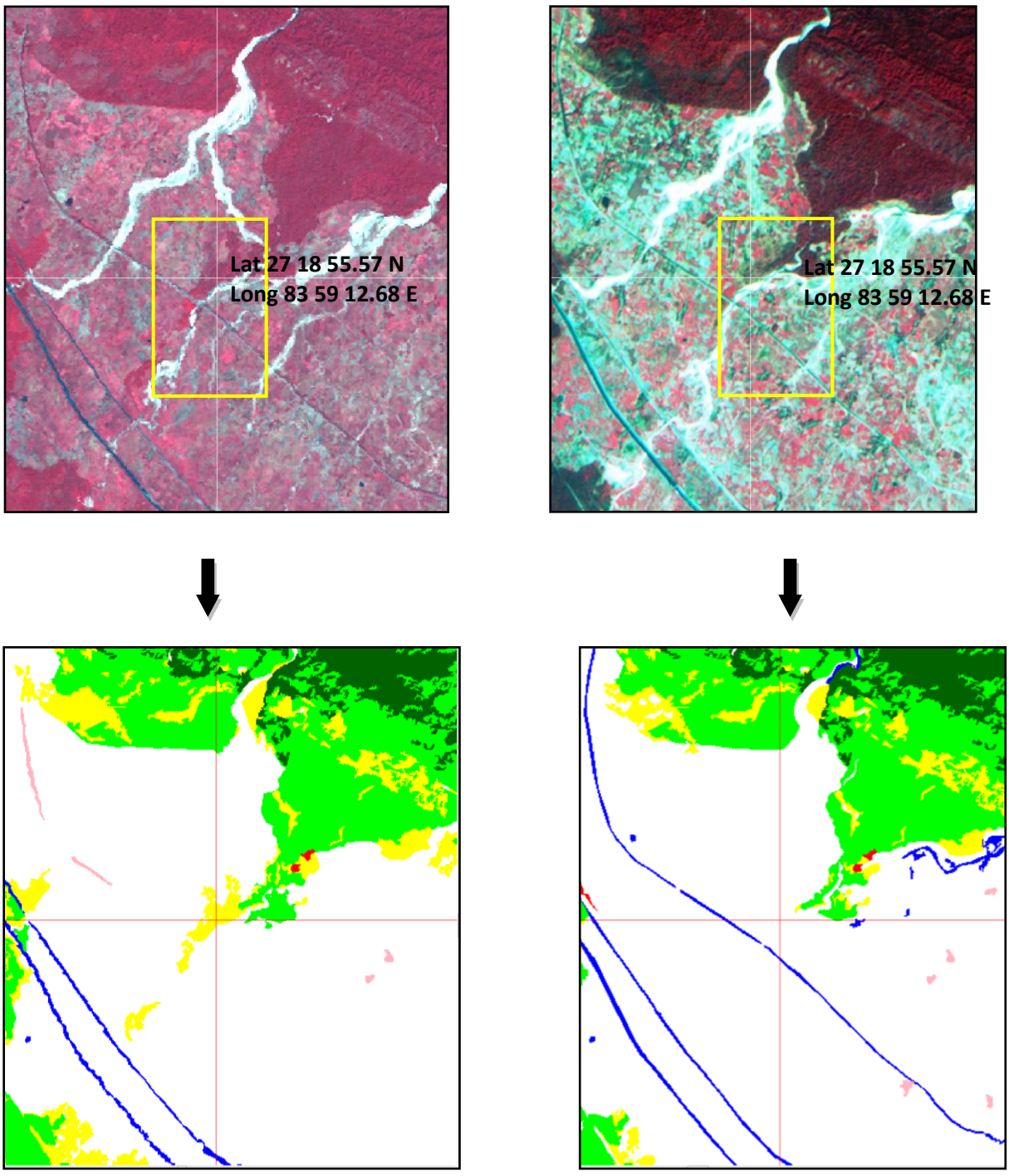


Fig.5: **Area showing in maps falling in Buffer area of the reserve**

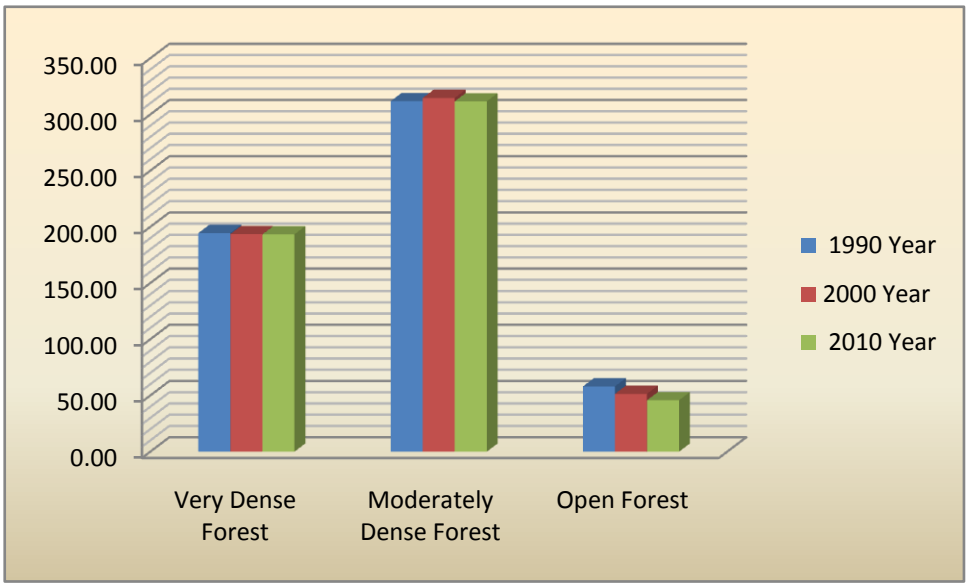


Fig4.11.1: Comparative Bar diagram showing Forest Cover Area in Valmiki Tiger Reserve (Core Area)

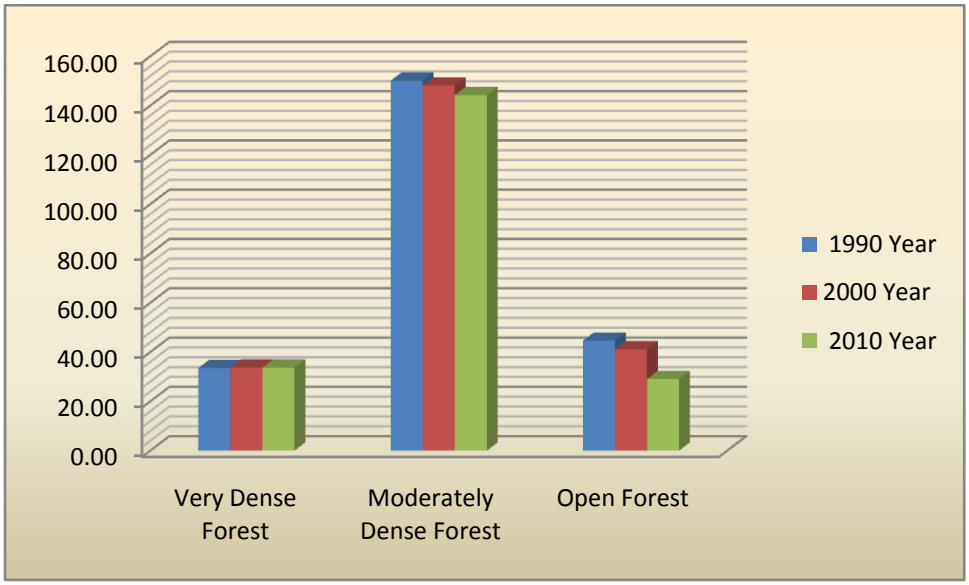


Fig4.11.2: Comparative Bar diagram showing Forest Cover Area in Valmiki Tiger Reserve (Buffer Area)

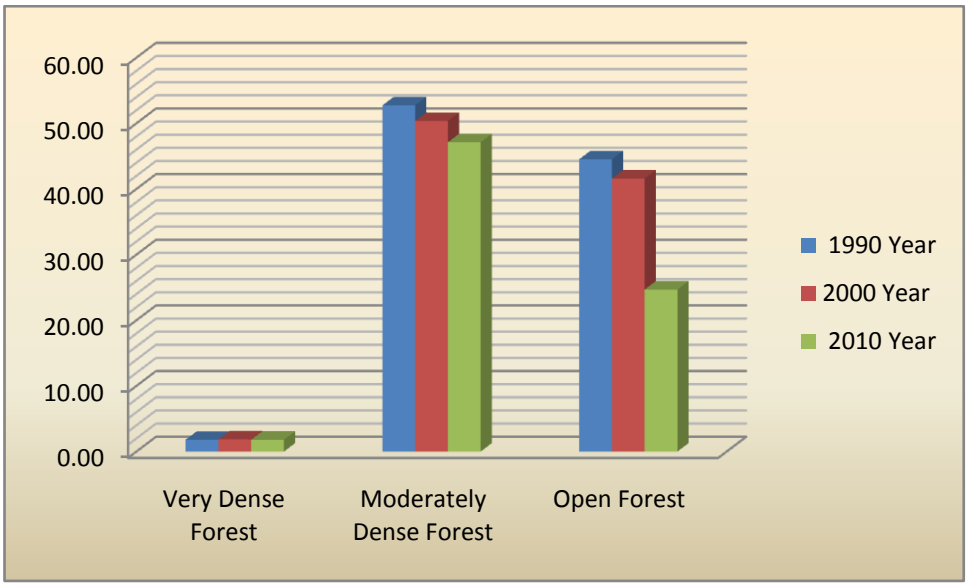
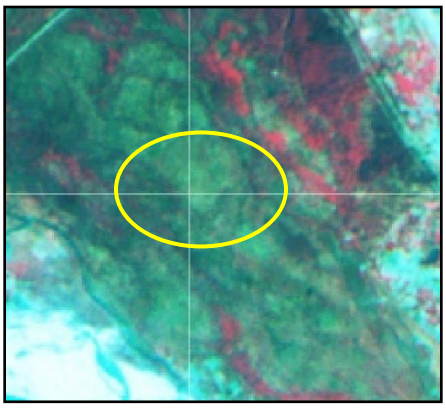


Fig 4.11.3: Comparative Bar diagram showing Forest Cover Area in Valmiki Tiger Reserve (AUTKBTR)

Plates showing satellite images and corresponding ground photos captured during ground truth verification of Valmiki Tiger Reserve



IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 27 11 31.30 N; Long 84 00 39.28 E)

Madanpur (Compartment M2)

(Grass land)

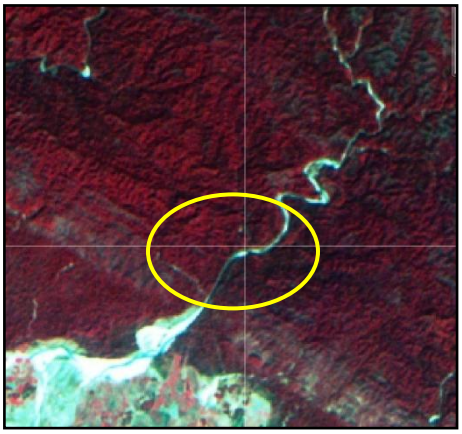
IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 27 14 06.14 N; Long 83 59 05.12 E

Madanpur (Compartment M9)

(Mix patch of *Bombax ceiba, Mallotus philippensis, Dalbergia sissoo*)

Plate1

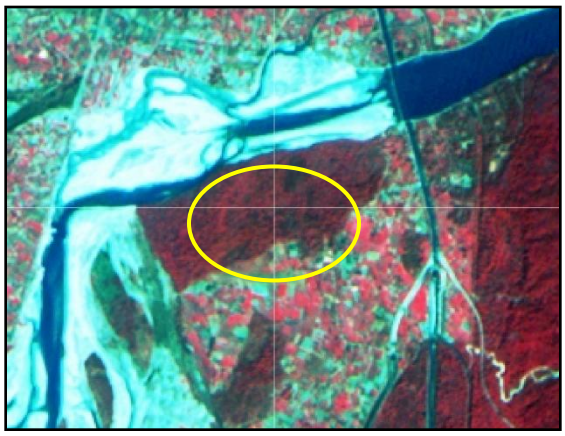


IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 27 14 06.14 N; Long 83 59 05.12 E

Mahadeva (Compartment T17

(Mix patch of *Shorea robusta, Mallotus philippensis ,Terminalia belerica,Anogeissus latifolia*)



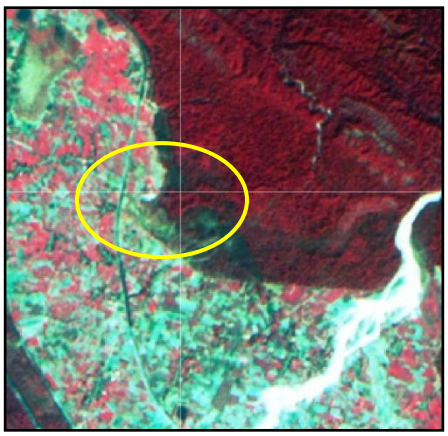
IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 27 25 30.8 N; Long 83 53 27.1 E)

Pipar Khala (Compartment M29)

(Mix patch of *Trewia nudiflora, Mallotus philippensis, Syzygium cumini*)

Plate 2

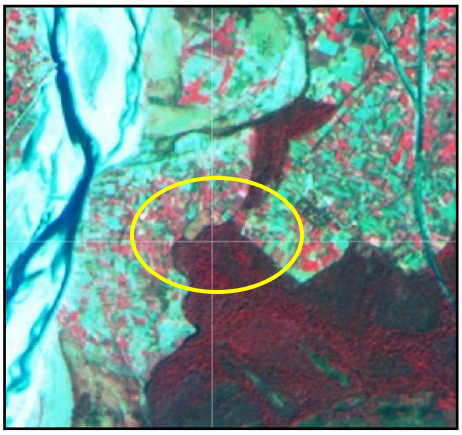


IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 27 21 38.6 N; Long 83 57 15.9 E)

Shivnaha (Compartment T22)

(*Shorea robusta* Plantation)



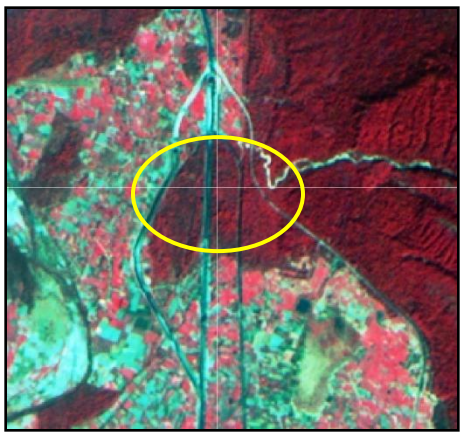
IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 27 21 10.63 N; Long 83 52 48.16 E)

Chakdhawa (Compartment M23)

(Patch of *Putranjiva roxburghii, Bauhinia malaberica, Mallotus phillippensis*)

Plate 3

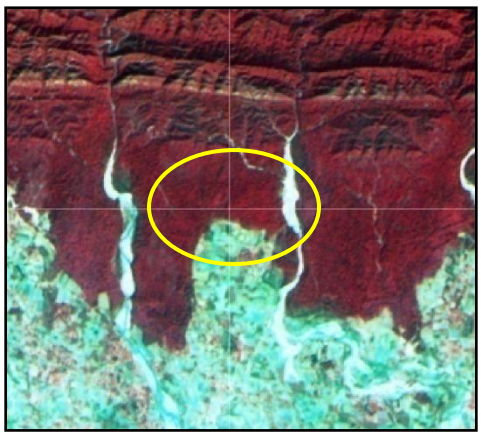


IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 27 24 08.68 N; Long 83 54 51.94 E)

Lakshmipur (Compartment M27)

(Patch of *Bombax ceiba, Syzygium cumini Terminalia tomentosa, Adina cordifolia)*



IRS – P6 LISS III (2011) image on 1:25000 scale

(Lat 27 18 46.20 N; Long 84 23 14.50 E)

Lakshmipur (Compartment S19)

(*Shorea robusta* Plantation)

Plate 4

TIGER CORRIDORS

5.1 INTRODUCTION

Tiger Corridors are the connection between different Protected Areas and Forest Divisions and are essential to ensure movement of tigers across the entire landscape. They can vary greatly in size, shape and composition. The main goal of corridor is to facilitate movement of individuals, through both dispersal and migration, so that gene flow and diversity are maintained between local populations. By linking populations throughout the landscape, there is a lower chance of extinction and greater support for species richness. When a corridor is present, however, it presents an unbroken path of suitable habitat that can provide safe passage for animals or plants without being hindered as they travel through agricultural or urban landscapes.

The **Dudhwa - Corbett Tiger Corridor** that connects **Dudhwa Tiger Reserve** in Uttar Pradesh and **Corbett Tiger Reserve** in Uttarakhand is spread over an area of **993.54 Sq km** having a width of **3 km** and length of **208.17 Km** (approx)**.** Parts of corridor falling in Buffer area of both the Tiger Reserve has been excluded from study area of Corbett-Dudhwa Tiger Corridor.

There is no geo-referenced data available with FSI for corridor connecting Valmiki and Dudhwa Tiger Reserve. It has been found from various sources that area between Valmiki and Dudhwa Tiger Corridor is densely populated and vegetative area is fragmented. In the past there have been cases reported in which there is movement of tigers between Dudhwa and Valmiki tiger corridor.

5.2 CORRIDORS CONNECTING DUDHWA AND CORBETT TIGER RESERVES

- **Kosi River Corridor:**

  The Kosi river corridor connects Corbett Tiger Reserve to the Ramnagar Forest Division and onwards to the Forest Division of Terai West, Terai East and Haldwani. The connectivity between Corbett Tiger Reserve and the forests east of River Kosi, towards the plains, is impacted by the city of Ramnagar.

- **Nihal -Bhakra Corridor and Gadgadia-Terai Central Corridor:**

  The connectivity through the plains (Gadgadia-Terai Central) forests, south of the city of Haldwani is now deteriorated beyond recovery due to growth of Lal Kuan and Haldwani urban infrastructure, along with agriculture and industry. The plains/foot hills corridors

from east of Haldwani passes north of Chorgalia town through the forests of Terai East Division. Though the least cost pathway defines the corridor across the Shivalik Hills in the East Terai Forest division, the forests in the terai belt (plains) that are currently fragmented patches are extremely important for movement of elephants that are unlikely to use the Shivalik corridor. The Nihal-Bhahra corridor north of Kamala and Kaladhungi is important for tiger movement.

- **Gola River Corridor-Plains:**

The Gola river corridor comprises of the north Kosi and south Kosi corridors that connect south west of Rampur village and continue eastwards through the forests of Choti Haldwani and Kaladhungi upto the townships of Haldwani and Kathgodam. It is at this juncture that severe bottleneck exists across the Gola.

- **Kilpura-Khatima Corridor:**

In Terai East, south-west of the township of Tanakpur (Kilpura range) the corridor bifurcates into two branches: the Kilpura corridor going nortrh of Tanakpur top cross River Sharda above the barrage going into Nepal(Churia Hills-Bhramgiri Forests), and the Khatima-Surai corridor going south via Khatima and Surai Range into Pilibhit connecting further to Kishanpur (Dudhwa Tiger Reserve).

- **Dudhwa -Katerniaghat Corridor:**

The connectivity between Dudhwa-Kishanpur Wildlife Santuary and River Sharda is highly fragmented with oxbow lakes and forest fragments in a primarily agricultural matrix. To the north it is connected to the Churia hill forests patches connect it to Suklaphanta. The Mohana river acts as a corridor connecting Dudhwa to Katerniaghat in the east and to Bardia National Park of Nepal in the north.

The Dudhwa-katerniaghat corridor along the Mohana has been greatly deforested and needs to be restored to allow movement of wildlife.The other important corridors in this region,essential for movement of animals between Nepal and India are the Basantha and Khata corridors. The Khata corridors along the Girwa river also connects Katerniaghat to Bardia and is often used by elephant, tigers and rhinos. The river channels in this landscape are also a conduit for the movement of gharials, crocodiles and Gangetic dolphins.

- **Pilibhit -Suklaphanta-Dudhwa Corridor:**

The other important forested area in the state is Pilibhit Forest Division which is connected to the Corbett Tiger Reserve in the north-west by the Surai Range and Suklaphanta National Park in Nepal to the north-east via forests of Lagga-Bagga.It forms a continous narrow corridor along the Sharda canal that stretches south-east into Kishanpur Wildlife Sanctury.This corridor is well used by Tigers forming a contiguous population from Surai Range in Uttarakhand to Pilibhit and Kishanpur.The sharda river forms a minor corridor.It is used by tigers and elephants to move between Dudhwa-Kishnapur-Lagga Bagga-Suklaphanta.

5.3 FOREST TYPES

- **Moist Shiwalik Sal forests:**

This type of forest occurs in the lower Shiwalik (Sand Stone) with light soil. At places the terrain is simply undulating and not too rugged.The top canopy consists of Sal (*Shorea robusta*), Sain (*Terminalia alata*), occasionally Jhingan (*Lannea coromandelica*), Bahera (*Terminalia bellerica*), Jamun (*Syzygium cumini*), etc. and rarely Chir (*Pinus roxburghii*), on northern slopes and higher ridges tops. The middle storey contains Sandhan (*Ougeinia oojeinensis*), Rohini (*Mallotus philippensis*), Bhilawa (*Semecarpus anacardium*), Karhbhillawa (*Buchanania lanzan*), Kura (*Hollarhena antidysenterica*), Chilla (*Casearia tomentosa*), Amaltas (*Cassia fistula*), Aonla (*Emblica officinalis*), Bauhinia spp. etc. and in moister valleys Gair (*Olea glandulifera*), Kaula (*Machilus odoratissima*), Garhmahua (*Engelhardtia colebrookiana*) etc.

Bamboo occurs in patches and is dense at places. The undergrowth is moderate and consists chiefly of Bindu (*Colebrookia oppositifolia*), Gandhela (*Murraya koenigii*), Karu (*Clerodendrum viscosum*), Raudera (*Pogostemon plectranthoides*), Dhaula (*Woodfordia fruticosa*), Daia (*Callicarpa macrophylla*), etc. and occasionally Kilmora (*Berberis spp*.), Tushiari (*Debregesia velutina),* Tilphara (*Cocculus laurifolius*), Sakina (*Indigofera spp*.) etc. The common climbers are Maljhan (*Bauhinia vahlii*), Gauj (*Milletia auriculata*). Grasses are scarce. The common being Ullansu (*Thysanolaena maxima*) in shady places and Guria (*Chrysopogon montanus*), Kumeria (*Heteropogon contortus*) etc. on exposed parts.

- **3C/C2c Moist Tarai Sal Forest**

This subtype occurs on grey clayey alluvium with wet subsoil and perhaps best characterized with the presence of *Calamus*. The Sal is of Q.C. III-IV and there is fair

coppice regeneration. The top canopy consists of *Shorea robusta*, *Adina cordifolia*, *Trewia nudiflora*, *Syzygium cumini*. The understory is mainly of *Lagerstremia parviflora*, *Litsea glutinosa*, *Elaeagnus latifolia*. *Bambusa arundinacea* and *Calamus tenuis* is found in plenty.

- **5B/C1a-Dry Shiwalik Sal Forest:**

This type occurs on the Middle Siwalik Sand-rock formation, which gives rise to shallow, dry and completely drained sandy soils. Humus is scanty. The ground is very broken up, generally steep, stony and rugged. Knife- edge ridges are numerous and the terrain is cut up by many *nalas*. Denudation is active and there are signs of erosion at many places. The distribution of Sal in this type is governed chiefly by aspect and gradient. On the northern, western and irregular groups and patches of varying extent and density, grading off into badly formed single Sal trees on the steep slopes. The top canopy consists of Sal, Bankuli, Khair, Sain, Tendu, Bhilawa, Kathbhilwa, Jhingan, Pula, Kusum,Chir etc, with an under story of Sandan, Amaltas, Aonla, Bel, Ber, Kathber, Kura, Khoda, Grewia species; Bauhinia species etc. Bamboo is common. The undergrowth is scanty, mainly of Bindu, Harsingar, Dhaula etc. but grasses like Guria, Baib, Kumeria, Nathlia, Bichhroo, Siru etc, are plentiful. The southern slopes carry an open but similar crop of a more xerophytic nature, with a very low proportion of Sal which usually occurs in patches or as single trees in sheltered and favorable localities. Bamboo is dense at places and grasses like Guria, Baib, and Kueria are dense and distributed throughout the area. In this type, Sal is of poor quality. Sal regeneration is generally deficient and very slow growing and is difficult to obtain, except in hollows and moist places, where it is good.

- **5B/C1 b Dry Plains Sal Forest**

This subtype is commonly found on flat grounds in the area occupied by moist bhabhar sal (3C/C2b) and moist plains Sal (3C/C2d). It occurs at the bhabhar, slightly above the bhabhar-tarai transition and spring levels are usually low. The rainfall is at the lower limit for moist type and maximum temperatures higher. The top soil may be rather clayey, the subsoil also clayey often with dense clay layers almost forming a pan, underlain by gravel or coarse sand. There is superficial water logging in the rains, the surface drainage also being sluggish. Recurring waves of mortality are characteristic of this forest type, reducing the forest to a mixed dry deciduous type.

The top storey is made up with species like *Shorea robusta*, *Terminalia tomentosa*, *T.bellerica*, *Diospyros tomentosa*, *Anogeissus latifolia* having an under storey of *Miliusa velutia*, *Buchanania lanzan*, *Semecarpus anacardium*, *Acacia catechu*, *Zizyphus xylopyrus*, *Z.mauritiana*, *Mallotus philippensis*, *Aegle marmelos*. The undergrowth is mainly constituted by *Clerodendrum viscosum* and *Glycosmis pentaphylla*. Grasses are in plenty mainly *Imperata cylindrica* and *Eulaliopsis binata*.

- **5B/C2 Northern Dry mixed Deciduous Forest**

  In most localities the forest type is under heavy anthropogenic pressure, therefore scattered trees and small groups are now typical. In the climax state, however, it would appear that this upper canopy would be thin but fairly complete, most trees having low spreading crowns. Transitions to the still dryer types would be characterized by a broken top canopy. Many tracts are occupied almost exclusively by large shrubs and small trees such as *Nyctanthes arbor-tristis*. It is found mostly on sites with southern aspect, flat hill tops, eroded ground and high intensively drained gravel terraces. Species composition found in this forest type is chiefly of *Anogeissus latifolia, Acacia catechu, Shorea robusta, Bauhinia spp., Terminalia tomentosa, Garuga pinnata, Kydia calycina, Mitragyna parviflora, Bridelia retusa, Nyctanthes arbor-tristis, Ougeinia oojeinensis, Ehretia laevis, Aegle marmelos, Emblica officinalis, Hollarrhena antidysentrica, Cordia dichotoma, Zizyphus xylopyrus, Cassia fistula, Butea monosperma, Flacourtia indica, Woodfordia fruticosa, Eulaliopsis binata* etc.

- **5/DS1 Dry Deciduous Scrub**

  A low broken soil cover of shrubby growth 3 to 6m high including some tree species reduced to similar conditions usually many stemmed from the base. Some bamboo is often present. Many of the shrubs are distasteful to cattle (Holarrhena, Dodonea) or thorny (*Randia, Carissa*). Thin grass occurs throughout. It is found throughout the dry deciduous area where biotic interference is more. Species composition is mainly of *Nyctanthes arbor-tristis, Zizyphus nummularia, Dodonea viscose, Woodfordia fruticosa, Flacourtia indica, Aegle marmelos, Cassia fistula, Acacia catechu* etc.

- **5/1S2 Khair Sissoo Forest**

  It is a deciduous forest type in which *Dalbergia sissoo* predominates. The canopy is light but usually complete. Acacia catechu is usually but not always present and is very inconspicuous but sometimes it occurs in pure patches. This forest type has one peculiar feature that resembles to the moist deciduous more, that they are in new foliage in March and remain in full leaf throughout the hot weather. However, this feature is specific of the dominant *Dalbergia* and is not shared by most of its associates. It is distributed on river banks and on new sandy and gravelly alluvium soil. The top soil is very porous and surface runoff is seen. Humus is almost nil. The forest type is characterized by the composition of species such as *Dalbergia sissoo, Acacia catechu, Holoptelea integrifolia, Grewia oppositifolia, Cassia tora,* Canabis sativa, *Murraya koenigii, Adhatoda vasica, Helicteres isora, Saccharum spontaneum, Chrysopogon fulvus, Vetiveria zizanoides, Pogostemon plectranthoides* etc.

- **12/C1 a Ban Oak Forest (Q.incana)**

  The trees in this forest type form a closed canopy when well developed otherwise they form somewhat open forests with short boles and extensive branching. *Rhododendron arboreum* and *Lyonia ovalifolia* are its associates below the oak canopy. It is found at elevations between 1800 to 2300m on southern aspects and lower on northern aspects by 150 to 300m. The soil is rich in humus and well drained. They experience heavy anthropogenic pressures of lopping, grazing and browsing. The ban oak forests suffer forest fires spreading from the lower pine zone. *Quercus incana* is by far the commonest oak and *Quercus glauca* is locally abundant along shady ravines. Other species found are *Carpinus viminea, Cedrela serrata, Rhododendron arboreum, Lyonia ovalifolia, Viburnum cotinifolium, Desmodium tiliaefolium, Rubus niveus, Vitis spp., Hedera* etc.

- **9/C1 b Upper or Himalayan Chir Pine Forest**

  This type is represented by high forests of Chir pine where the trees (20-35m height) form a canopy from one third to two third complete and in some case lighter than this. No other species reach the top canopy and only few scattered trees form the second storey. Annual fires are common in these areas which prevent the under growth to flourish. The ground has a rich grass cover during the monsoon season which dries up in winters and till the next rains the land has no vegetation except the cover of fallen needles. This type overlaps the tropical deciduous forest at the lower elevation and temperate forests at the higher elevations. Pine forests are rarely found on level ground and experience heavy grazing. The general floristics of the forest type is *Pinus roxburghii, Syzygium cumini, Quercus incana, Lyonia ovalifolia, Rhododendron arboreum, Pyrus pashia*. The Shrub storey is comprised mainly of *Berberis lycium, Rubus ellipticus, Moghania fruticulosa*. The herbs and grasses found in this forest type are *Plectranthus strictus, Rosocea, Eulalia mollis, Arundinella intricata* etc.

- **3C/C 2d(i) - Western Light Alluvium Plains Sal Forests:**

  These forests generally occur on sandy alluvium with a dry sub-soil. These forests are met with in Dingania 2a, 9, Masankhamb 4b,10, Sohnaha 3, 4a, 7b, and 9, Barbatta 1, 4a, 6a, 7, Rehta 1a, 1d, Ludaria 9a-c, Mohrania 2, 4a, 5, 8a, 9a-c, and Nagra 2. The proportion of miscellaneous species is significantly higher in these forests as compared to other areas. The over-wood consists of scattered old Sal trees with a few middle aged trees. Most of the old trees are hollow and crooked. Regeneration of Sal is absent over most of the area. *Terminalia tomentosa* makes up about 15% of the crop being more profuse on the edges of damars and the banks of nalas. The other species of the top canopy are *Terminalia bellerica, Lagerstroemia parviflora, Adina cordifolia, Kydia calycina, Schleichera oleosa* and various species of figs.

Teak has been introduced by gap planting in Mohrania 2, 5a, 5b, and by clear felling in Rehta 1a, Ludaria 9a, 9c, and Mohrania 2, 8a and 9b. The plantations are successful.The South Kheri Type of Western Light Alluvium Plains Sal occurs in Kishanpur Sanctuary – Mailani Central 4, 5 & 6.

- **3C/C3 a West Gangetic Moist Mixed Deciduous Forest:**

This type of forest occurs sporadically throughout the Moist Siwalik Sal forests and is confined to favorable localities where Sal is unable to establish itself and is characterized by good growth of Sain ,Bahera, Tun *(Toona ciliata),* Kharpat , Safed siris *(Albizzia procera),* in the top canopy, with an under storey of Rohini, Sandan, Aonla etc. with scattered bamboo clumps. Maljhan climber is occasionally present.

Table 5.3:Area according to Forest Types of the Dudhwa-Corbett Tiger Corridor

FOREST TYPES	AREA IN (%) ASSESSMENT YEAR 2004
3C/C2 a Moist Siwalik Sal Forest	25.21
3C/C2 c Moist Tarai Sal Forest	8.77
3C/C2 d (i) Western Light Alluvial Plain Sal	9.34
3C/C3 a West Gangatic Moist Mixed Deciduous Forest	13.45
5B/C1 a Dry Siwalik Sal Forest	0.57
5B/C1 b Dry Plains Sal Forest	0.95
5B/C2 Northern Dry Mixed Deciduous Forest	4.10
5/DS1 Dry Deciduous Scrub	0.75
5/1S2 Khair Sissoo Forest	4.69
9/C1 a Lower or Siwalik Chir Pine Forest	0.67
9/C1 b Upper or Himalayan Chir Pine Forest	5.02
12/C1 a Ban Oak Forest (Q.incana)	2.52
Plantation/TOF	4.13

5.4 FOREST COVER IN CORBETT-DUDHWA TIGER CORRIDOR

5.4.1. Forest Cover in the year of 1990

The assessment of forest cover in Dudhwa –Corbett Tiger Corridor is **801.51 sq km** which is about **80.67 %** of the Dudhwa –Corbett Tiger Corridor. The study of 1990 image interpretation is based on the satellite data of Landsat-5TM. The study reveals that **256.32 sq km** of forest falls in Very Dense Forest category, **326.38 sq km** of forest lies in Moderately Dense Forest category and **218.81 sq km** forest is in Open Forest category.

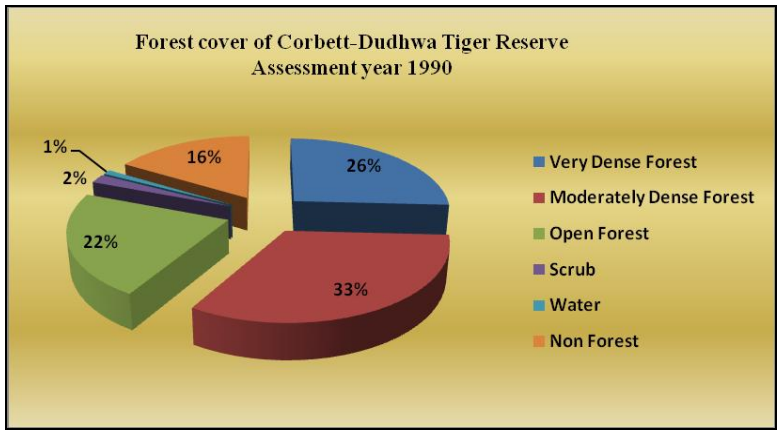


Fig 5.4.1 Pie chart showing percentage of Forest Cover in Corbett-Dudhwa Tiger Corridor (1990)

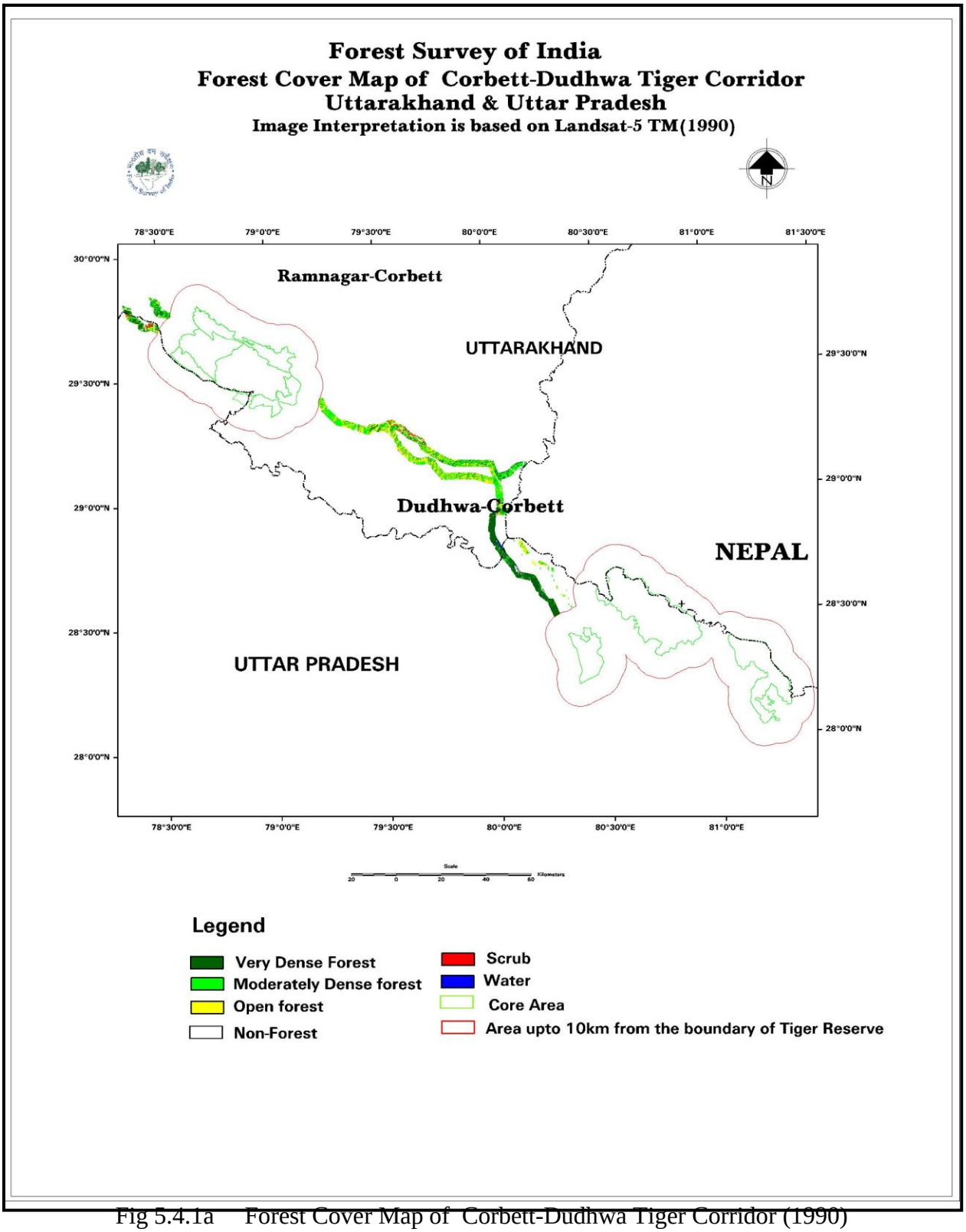


Fig 5.4.1a Forest Cover Map of Corbett-Dudhwa Tiger Corridor (1990)

5.4.2. Forest Cover in the year of 2000

The assessment of forest cover in Dudhwa –Corbett Tiger Corridor is **789.32 sq km** which is about **79.45 %** of the Dudhwa –Corbett Tiger Corridor. The study of 2000 image interpretation is based on the satellite data of IRS – 1C/1D LISS III. The study reveals that **254.84 sq km** of forest falls in Very Dense Forest category, **320.70 sq km** of forest lies in Moderately Dense Forest category and **213.78 sq km** forest is in Open Forest category.

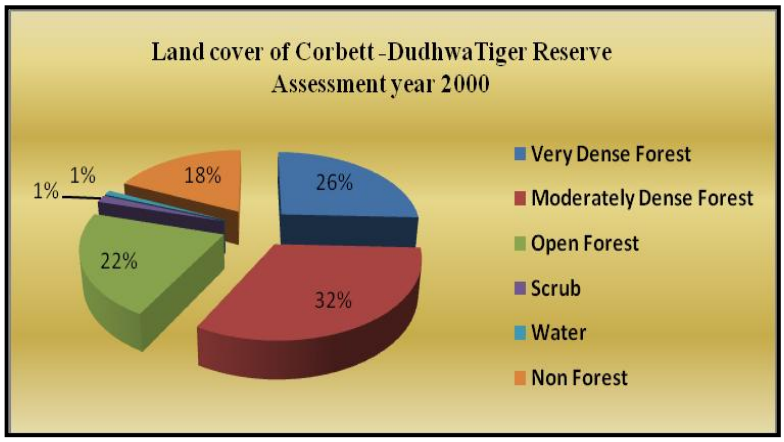


Fig 5.4.2 Pie chart showing percentage of Forest Cover in Corbett-Dudhwa Tiger Corridor (2000)

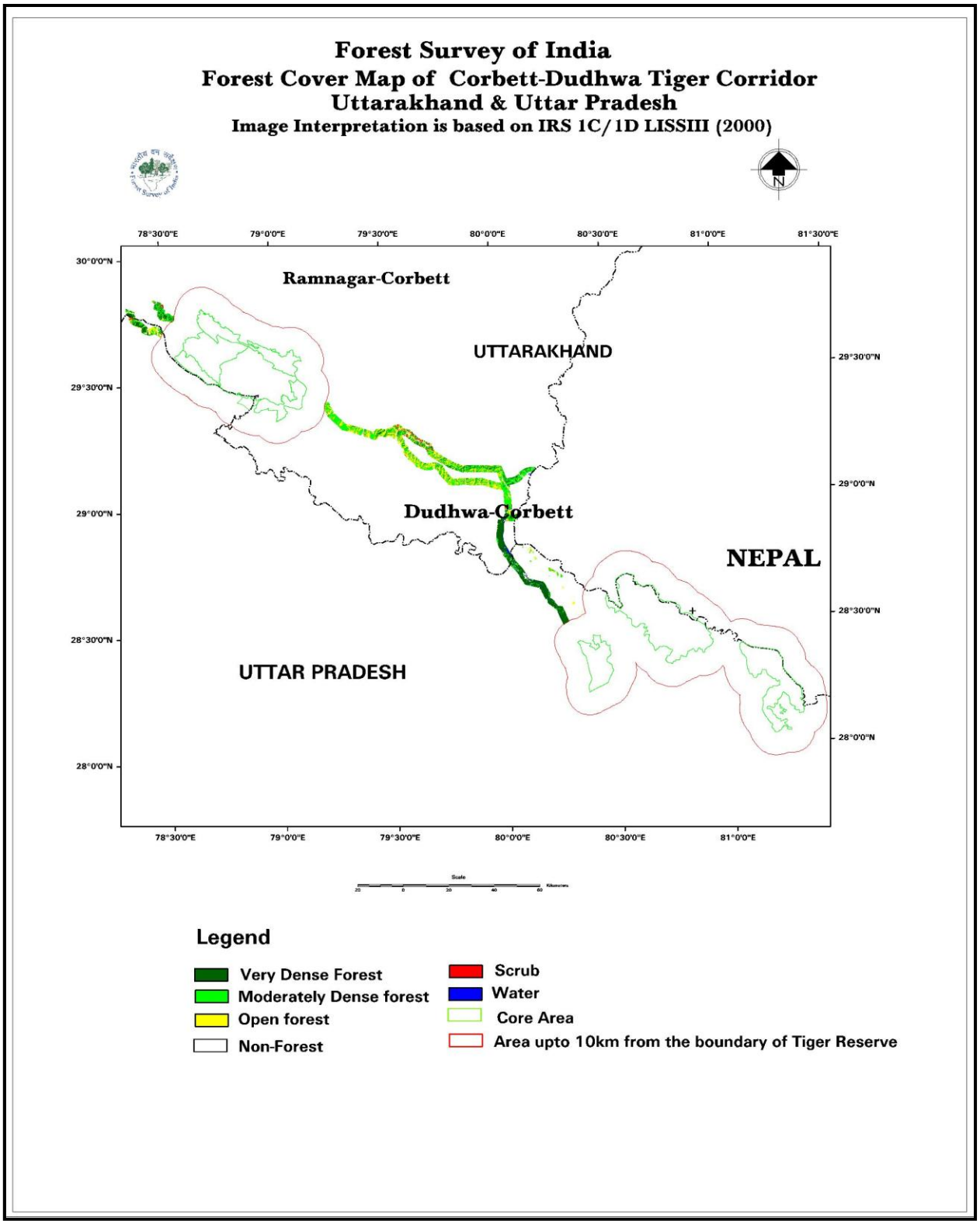


Fig 5.4.2a Forest Cover Map of Corbett-Dudhwa Tiger Corridor (2000)

5.4.3. Forest Cover in the year of 2010

The assessment of forest cover in Dudhwa –Corbett Tiger Corridor is **780.70 sq km** which is about **78.58 %** of the Dudhwa –Corbett Tiger Corridor. For the study of 2010 image interpretation is based on the satellite data of IRS – P6 LISS III. The study reveals that **253.22 sq km** of forest falls in Very Dense Forest category **319.25 sq km** of forest lies in Moderately Dense Forest category and **208.23 sq km** forest is in Open Forest category.

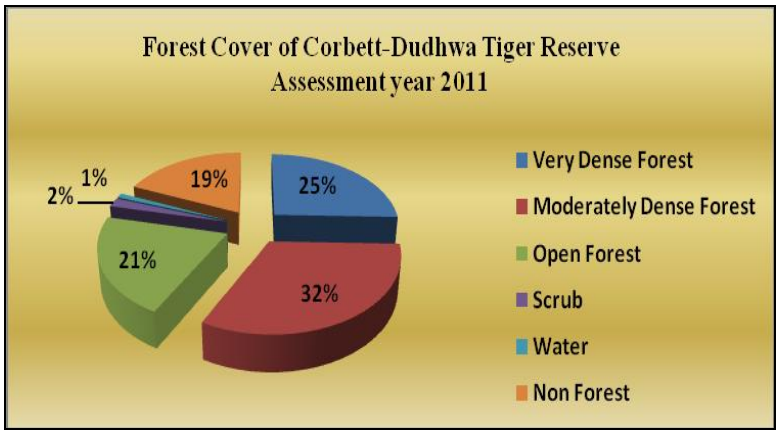


Fig 5.4.3 Pie chart showing percentage of Forest Cover in Corbett-Dudhwa Tiger Corridor (2010)

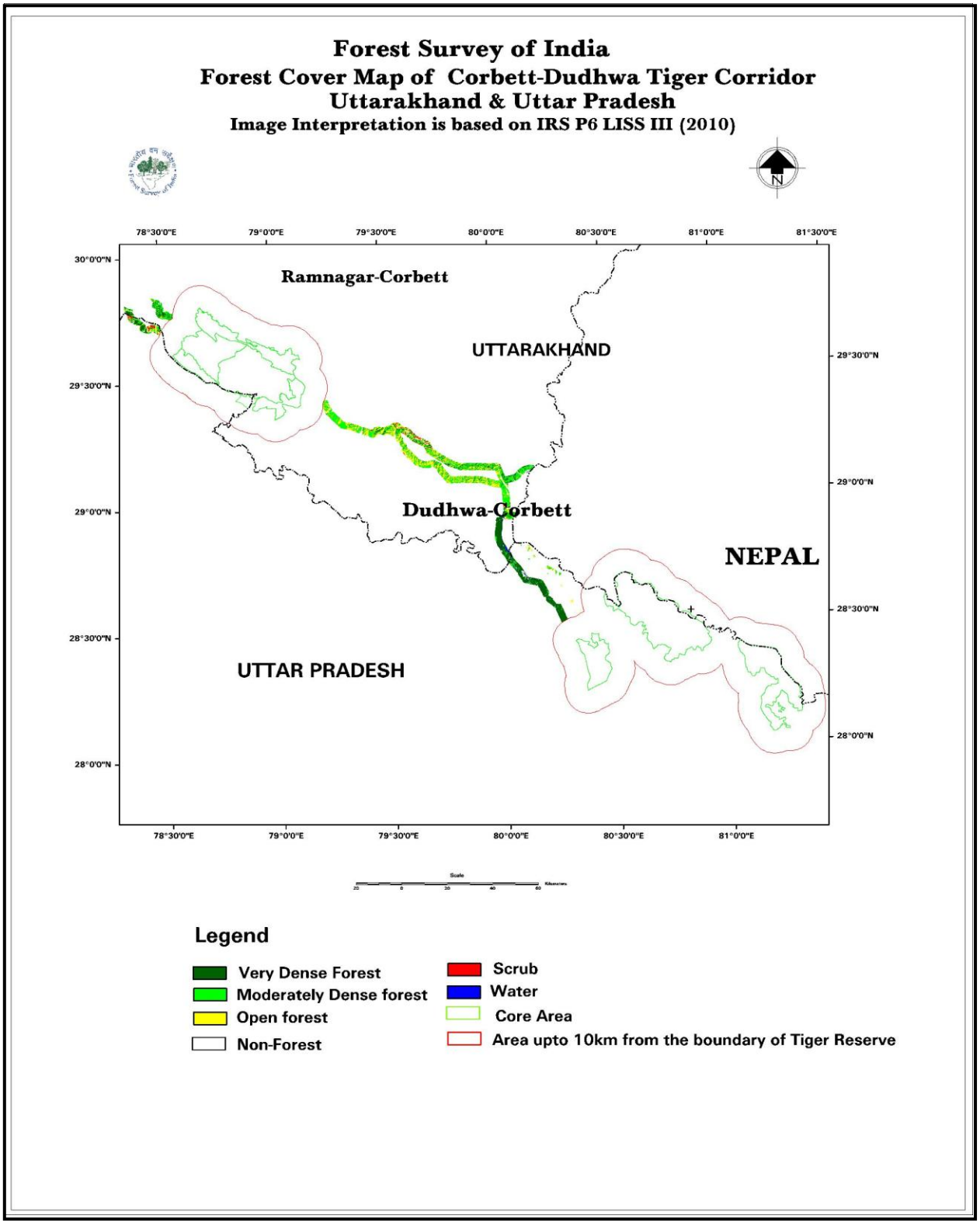


Fig 5.4.3a Forest Cover Map of Corbett-Dudhwa Tiger Corridor (2010)

Table 5.4: Forest Cover in Corbett-Dudhwa Tiger Corridor

(Area in sq km)

ASSESSMENT YEAR	VDF	MDF	OF	TOTAL FOREST	SCRUB	WATER	NON FOREST
1990	256.32	326.38	218.81	801.51	18.77	9.89	163.37
2000	254.84	320.70	213.78	789.32	14.76	10.10	179.36
2010	253.22	319.25	208.23	780.70	18.89	10.10	183.85

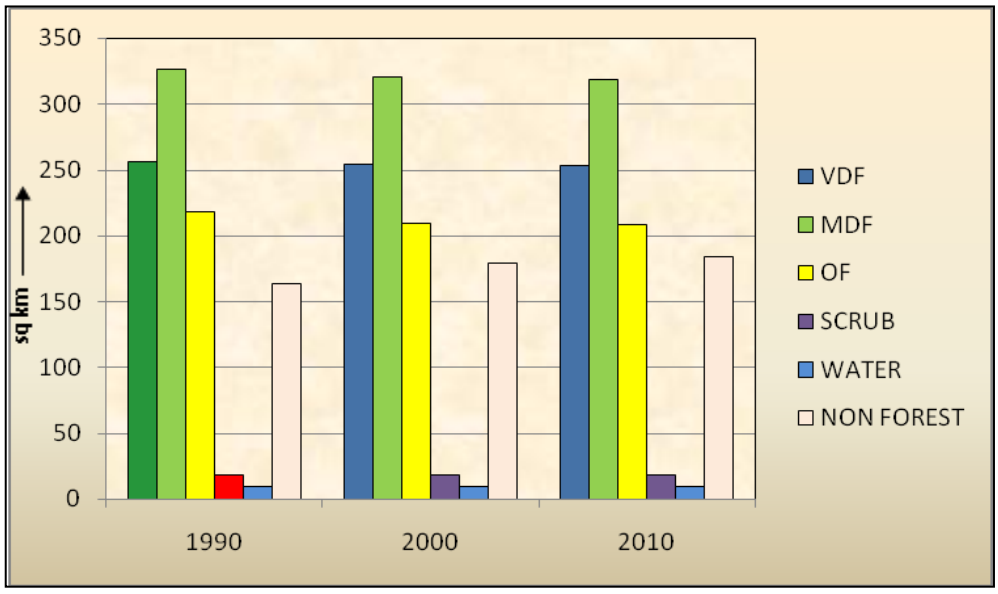


Fig 5.4 Bar diagram showing Land Cover of Corbett-Dudhwa Tiger Corridor (1990-2010)

5.5. CHANGE OF FOREST COVER IN CORBETT-DUDHWA TIGER CORRIDOR DURING 1990-2010

5.5.1. Changes in Forest Cover during 1990-2000

During the period of 1990 to 2000 total forest cover decreased by **12.19 sq km** in the Corbett-Dudhwa Tiger Corridor. It reveals that very dense forest in 1990 was **256.32 sq km** and in 2000 it has been decreased to **254.84 sq km**. Moderately dense forest shows a negative change from **326.38 sq km** to **320.70 sq km** during 1990 to 2000.Open forest cover have been decreased from **218.81 sq km** to **213.78 sq km** during that period of time.

The net change shows that very dense forest has a negative change of **1.48 sq km**, moderately dense forest has a negative change of **5.68 sq km** and open forest has a negative change of **5.03 sq km**.

Table 5.5.1: Forest Cover changes in Corbett-Dudhwa Tiger Corridor (1990-2000)

(Area in sq km)

Category	Assessment Year		Net Change (1990-2000)
	1990	2000	
Very Dense Forest	256.32	254.84	-1.48
Moderately Dense Forest	326.38	320.70	-5.68
Open Forest	218.81	213.78	-5.03
Total Forest	**801.51**	**789.32**	**-12.19**
Scrub	18.77	14.76	-4.01
Non Forest	173.26	189.46	16.20

CHANGES OF FOREST COVER DURING 10 YEARS (1990-2000)

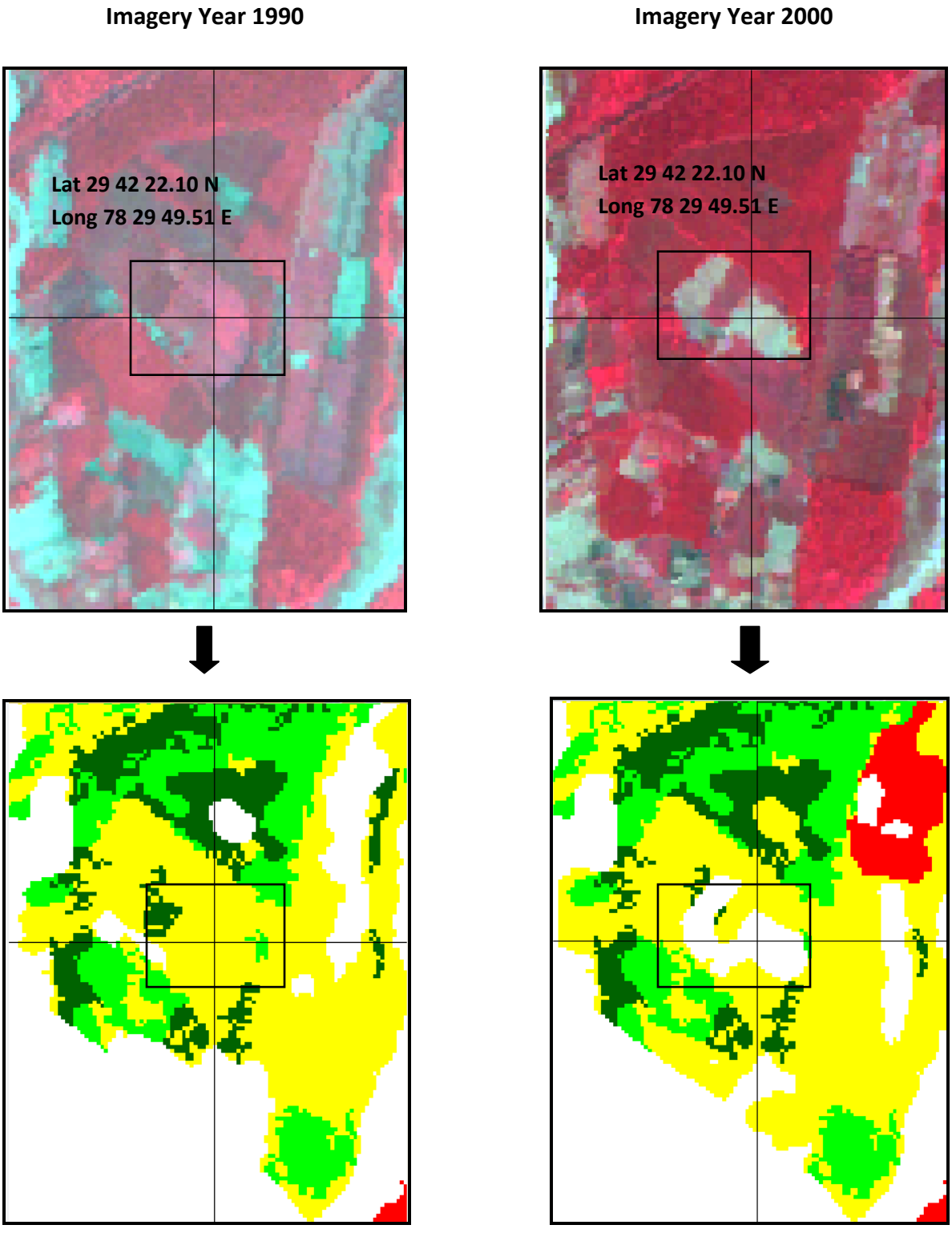


Fig: 1 Area showing in maps falling in Shankerpur, Uttar Pradesh

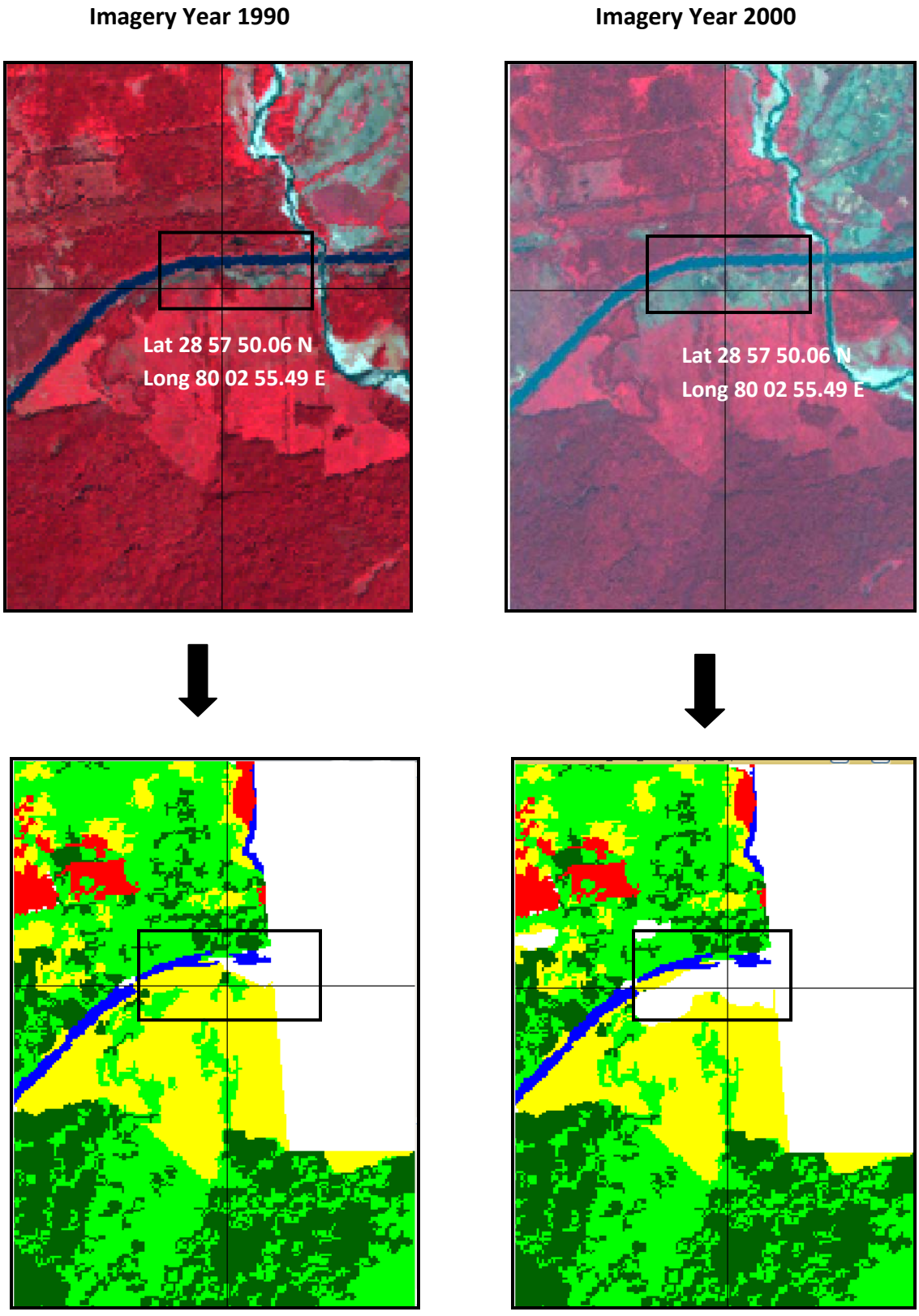


Fig :2 Area showing in maps falling in Khatima Range, Uttarakhand

5.5.2. Changes in Forest Cover during 2000-2010

During the period of 2000 to 2010 total forest cover decreased by **8.62 sq km** in the Corbett-Dudhwa Tiger Corridor. It reveals that very dense forest in 2000 was **254.84 sq km** and in 2010 it has been decreased to **253.22 sq km**. Moderately dense forest shows a negative change from **320.70 sq km** to **319.25 sq km** during 2000 to 2010.Open forest cover have been decreased from **213.78 sq km** to **208.23 sq km** during that period of time.

The net change shows that very dense forest has a negative change of **1.62 sq km**, moderately dense forest has a negative change of **1.45 sq km** and open forest has a negative change of **5.55 sq km**.

Table 5.5.2: Forest Cover changes in Corbett-Dudhwa Tiger Corridor (2000-2010)

(Area in sq km)

Category	Assessment Year		Change (2000-2010)
	2000	2010	
Very Dense Forest	254.84	253.22	-1.62
Moderately Dense Forest	320.70	319.25	-1.45
Open Forest	213.78	208.23	-5.55
Total Forest	789.32	780.70	-8.62
Scrub	14.76	18.89	4.13
Non Forest	189.46	193.95	4.49

CHANGES OF FOREST COVER DURING 10YEARS (2000-2010)

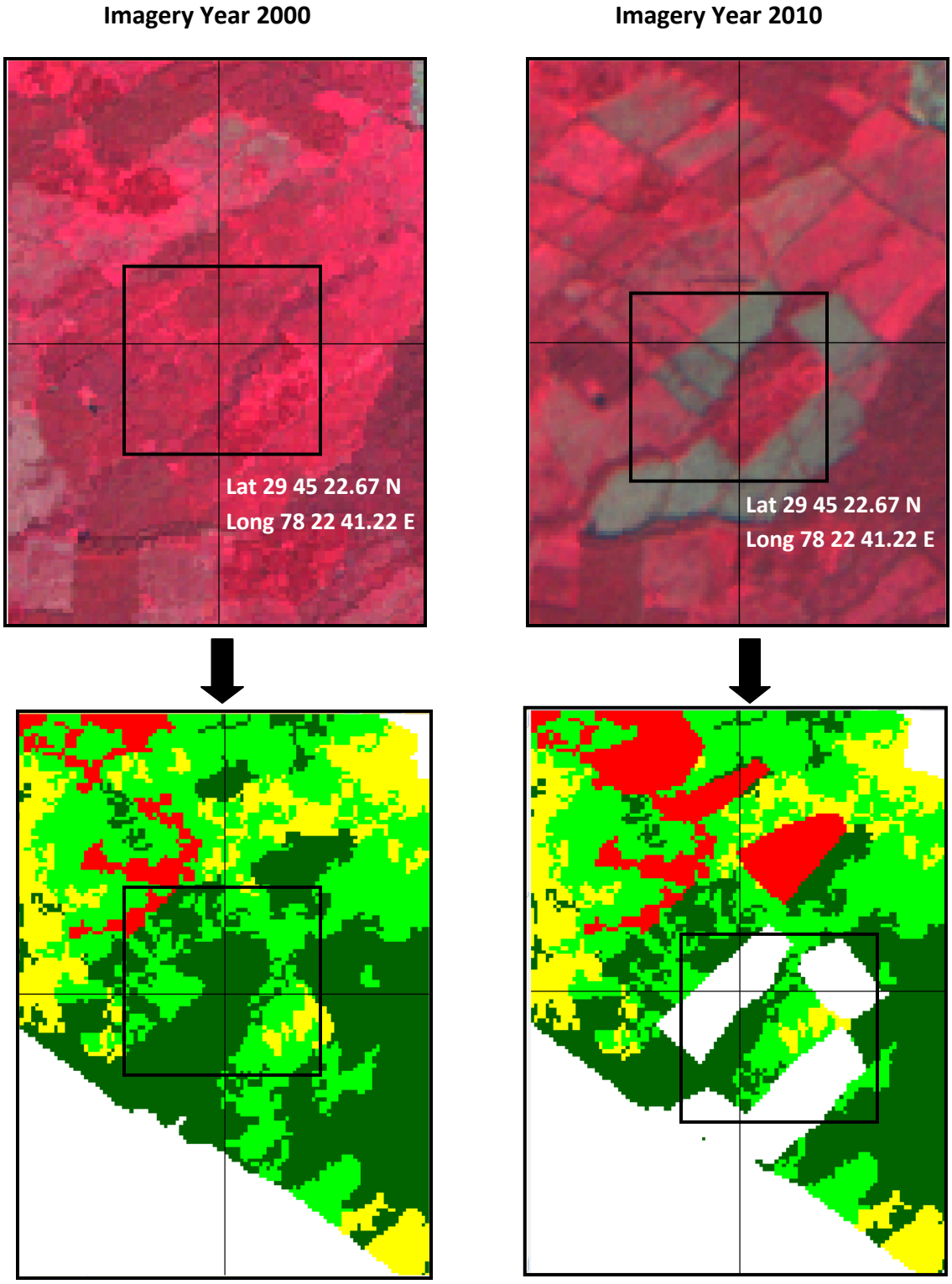


Fig: 1 Area showing in maps falling in Ramnagar, Uttar Pradesh

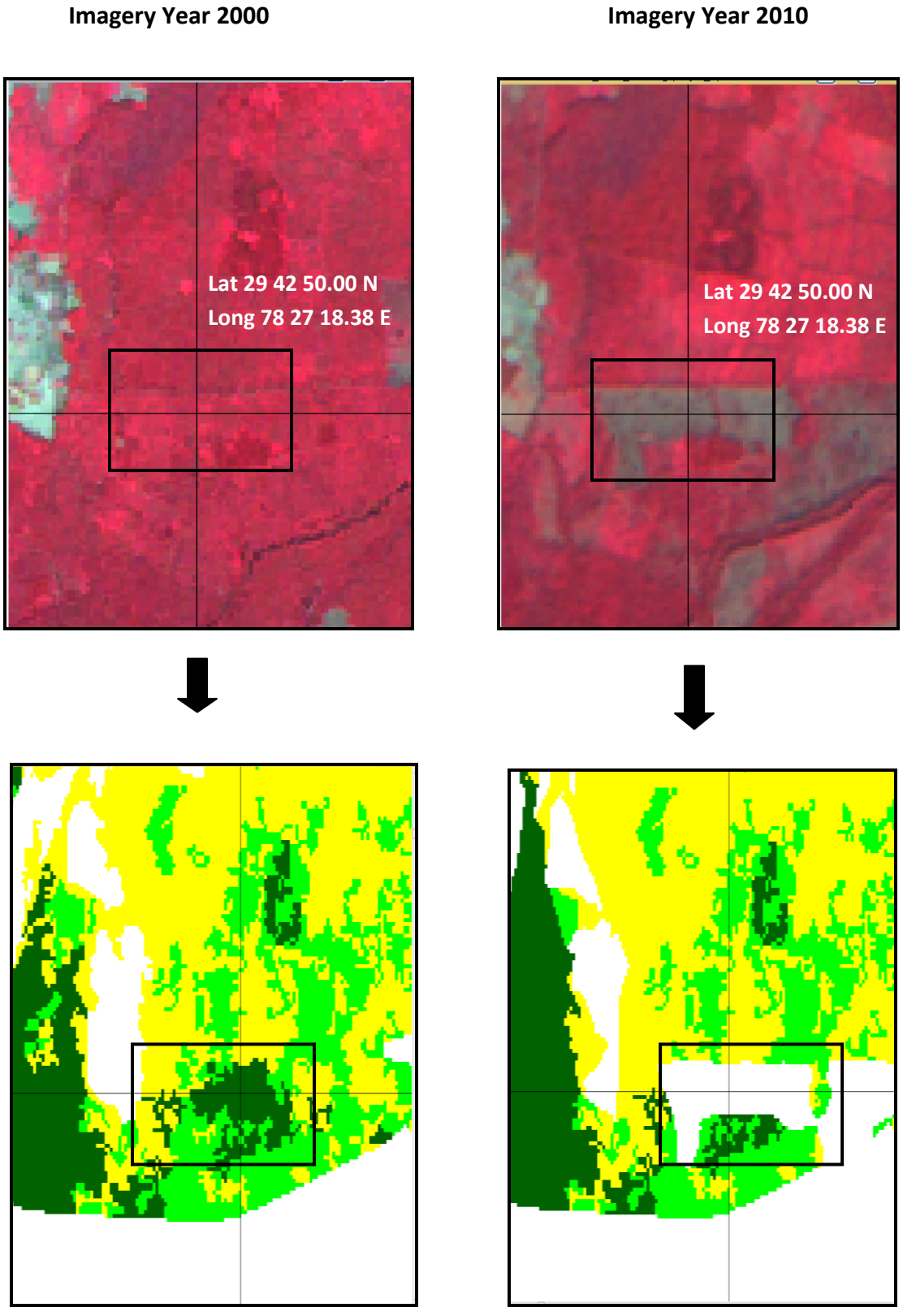


Fig: 2 Area showing in maps falling in Chatruwala, Uttar Pradesh

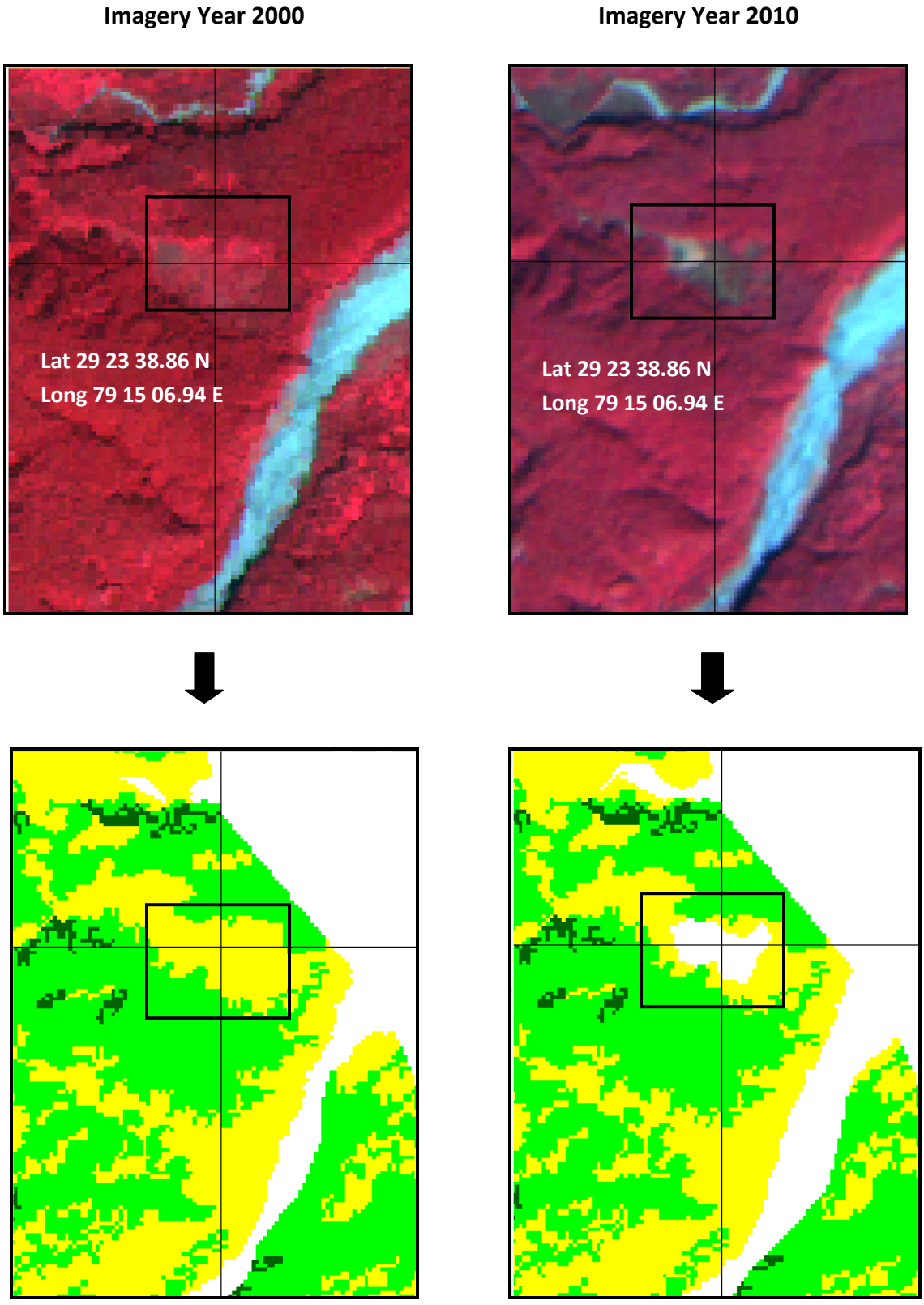


Fig: 3 Area showing in maps falling in Kota Range, Uttarakhand

5.5.3. Changes in Forest Cover during 1990-2010

During the period of 1990 to 2010 total forest cover decreased by **20.81 sq km** in the Corbett-Dudhwa Tiger Corridor. It reveals that very dense forest in 1990 was **256.32 sq km** and in 2010 it has been decreased to **253.22 sq km**. Moderately dense forest shows a negative change from **326.38 sq km** to **319.25 sq km** during 1990 to 2010.Open forest cover have been decreased from **218.81 sq km** to **208.23 sq km** during that period of time.

The net change shows that very dense forest has a negative change of **3.10 sq km**, moderately dense forest has a negative change of **7.13 sq km** and open forest has a negative change of **10.58 sq km**.

The corridors are lined by intensive agricultural activities which plays an important role for the negative changes in forest cover. The area experiences high anthropogenic pressure due to urban development along with establishment of different industries during 1990 to 2010 with limited protection level. As a result decreasing figures in forest cover is being observed over the period of two decades.

Table 5.5.3: Forest Cover changes in Corbett-Dudhwa Tiger Corridor (1990-2010)

(Area in sq km)

Category	Assessment Year		Change (1990-2010)
	1990	2010	
Very Dense Forest	256.32	253.22	-3.10
Moderately Dense Forest	326.38	319.25	-7.13
Open Forest	218.81	208.23	-10.58
Total Forest	801.51	780.70	-20.81
Scrub	18.77	18.89	0.12
Non Forest	173.26	193.95	20.69

CHANGES OF FOREST COVER DURING 10 YEARS (1990-2010)

Imagery Year 1990 **Imagery Year 2010**

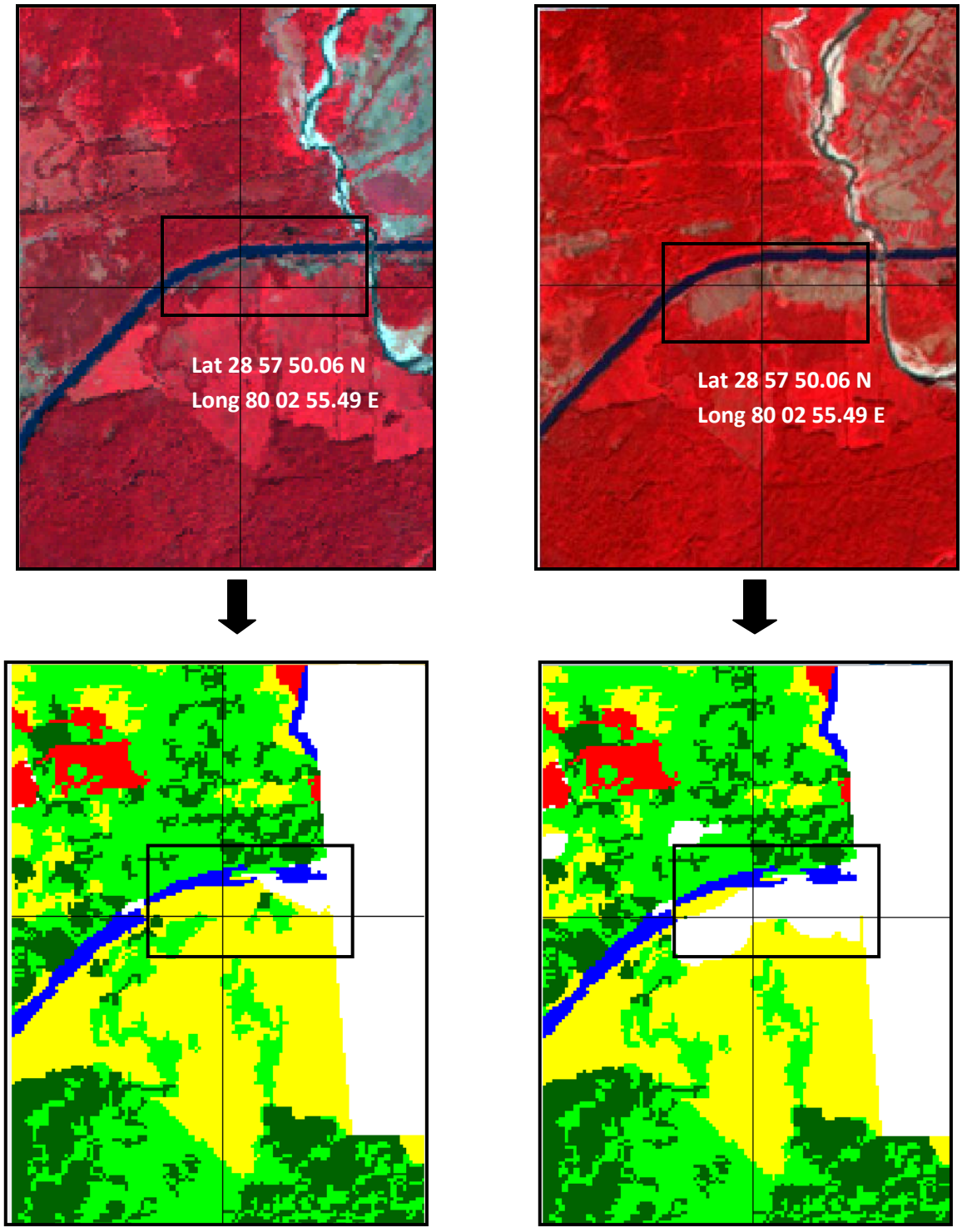


Fig: 1 Area showing in maps falling in Khatima Range, Uttarakhand

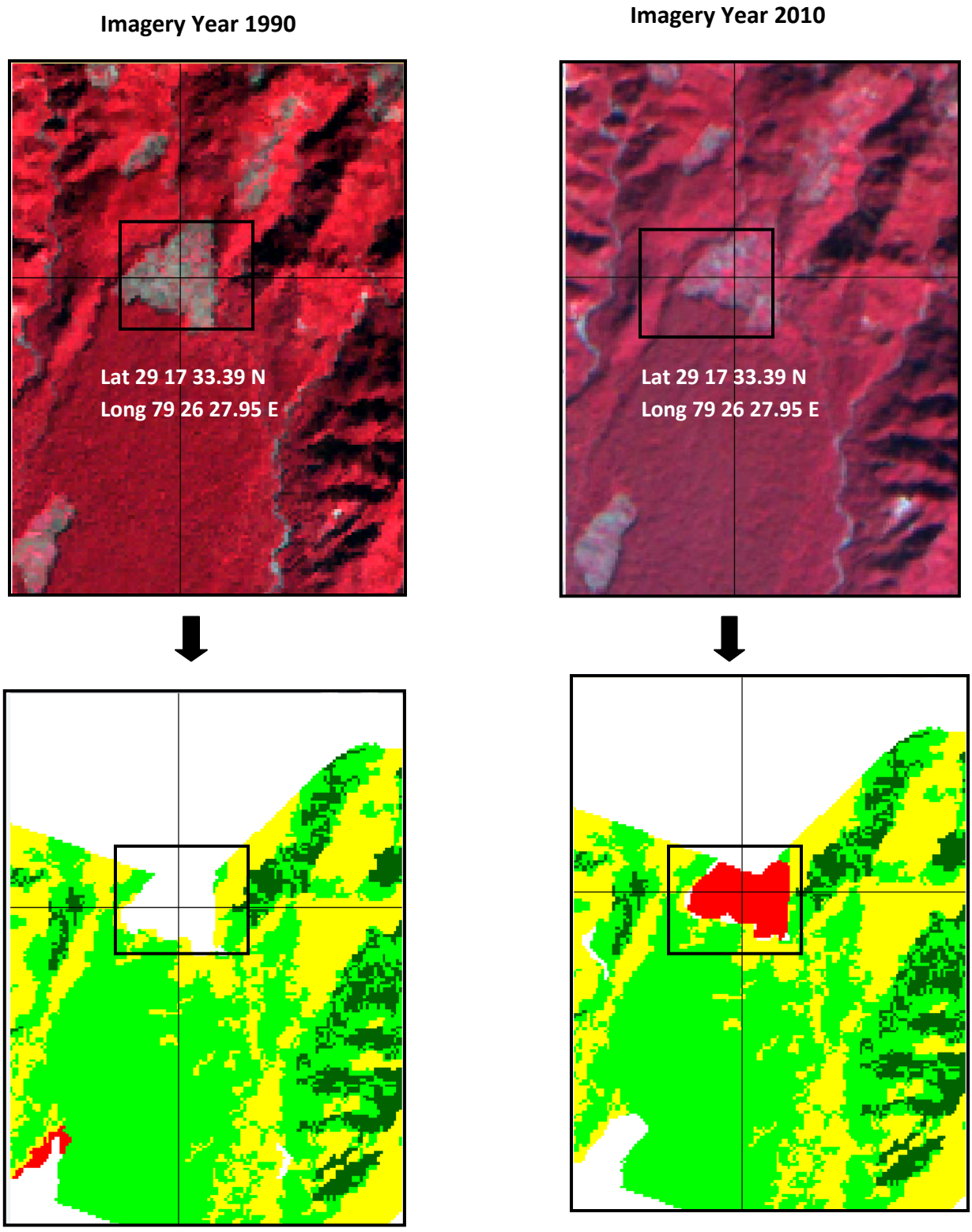


Fig: 2 Area showing in maps falling in Basani Village, Uttarakhand

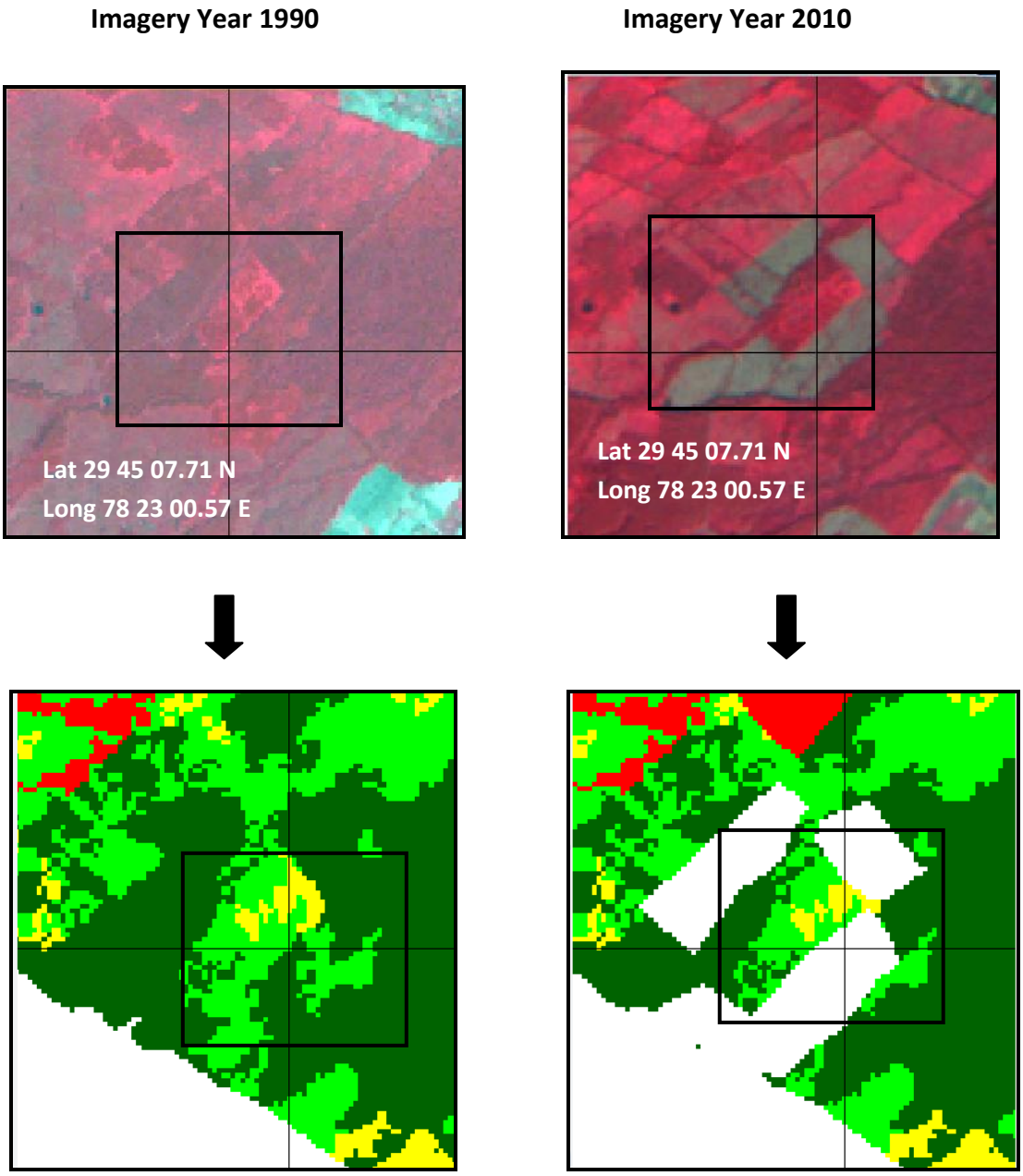


Fig: 1 Area showing in maps falling in Ramnagar, Uttar Pradesh

COMPARATIVE BAR DIAGRAM SHOWING FOREST COVER AREA IN DUDHWA-CORBETT TIGER CORRIDOR

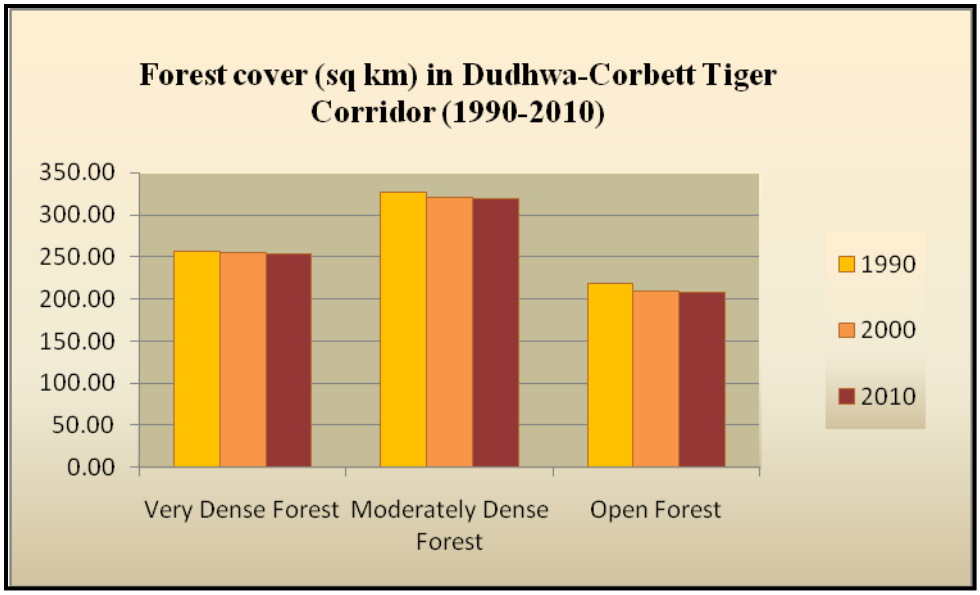


Fig 5.5: Forest Cover Area in Dudhwa-Corbett Tiger Corridor

CARBON STOCK

6.1 Introduction

Forests play an important role in environment and economic sustainability providing numerous goods and services, and maintaining life support systems essential for life on earth. The role of forests in carbon sequestration has significantly increased the importance of forestry as a climate change mitigation strategy. Management of terrestrial carbon sinks are of paramount importance to capture and contain the carbon dioxide from the atmosphere as it is the main Green House Gas (GHG) responsible for global warming. Thus, forests play very significant role in the dynamics of global carbon cycle. Forest not only sustains its own carbon but also has the potential to absorb carbon from the atmosphere. Globally forests store more than 55% of the carbon stored in vegetation and more than 45% of that is stored in soils. Approximately, 1 trillion tons of CO_2 is stored in the biomass of living trees and plants. Reduction of photosynthesizing biomass through indiscriminate deforestation constitutes damage to the self-regulating mechanism that removes carbon dioxide from the atmosphere. Carbon sequestration in trees depends not only on climatic conditions but also on their growth and age. However, the estimation of net carbon uptake and storage by the forest ecosystem is very complex due to various factors that influence growth of trees and respiration of CO2. This study helps to understand the present status of carbon stored and sequestered in forest ecosystem. In the present study the biomass densities and carbon stocks at different period of years in the Tiger Reserve falling in Shivalik Gangetic Plain, was estimated using standard carbon inventory methods. Present methodologies used to obtain carbon stock estimates for large forest areas are mostly based on forest inventory information, as well as, various factors, such as volume equations, specific gravity (wood density), biomass equations which transform diameter or volume data into biomass estimates.

In forest ecosystem, enormous amount of carbon is stored which is classified in five pools by GPG. The living portion of biomass carbon is classified in two carbon pools: the 'Above Ground Biomass' (AGB) and 'Below Ground Biomass' (BGB) and are stores of significant amount of carbon. The 'Dead Organic Matter' (DOM) is also classified in two pools: 'dead wood' and 'litter'. The fifth pool is 'Soil Organic Matter' (SOM) which contains substantial amount of organic carbon.

Table 6.1: Different Forest Carbon Pools

Pools		Description
Living Biomass	Above ground biomass (AGB)	All living biomass above the soil including stem, stump, branches, bark, seeds and foliage.
	Below ground biomass	All living biomass of live roots. Fine roots of less than 2mm diameter (country specific) are often excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead Organic Matter	Dead wood	Includes all non-living woody biomass not contained in the litter, either standing or lying on the ground. Dead wood also includes dead roots and stumps larger than or equal to 10cm in diameter or any other diameter used bythe country
	Litter	Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country (for FSI 5 cm), lying dead, in various states of decomposition above the mineral or organic soil
Soil	Soil organic matter	Includes organic carbon in mineral and organic soils (including peat) to a specific depth chosen by the country (for FSI30 cm) and applied consistently through the time series.

Stratification of Forest Area

For any heterogeneous population stratification is required to gain precision of estimates by dividing it into relatively homogeneous sub-population based on certain stratification variables. Since, in this case, carbon stored in the vegetation is principal variable which largely depends upon canopy density and forest type; these two were considered as stratification variables.

Forest Type Mapping

Forest type-wise extent of forest cover is useful information which provides a basis for characterizing forests in terms of floristic composition and ecological value. Recently, FSI has done mapping of forest types of India, in accordance with Champion &. Seth classification (1968) on 1:50,000 scale. Using the forest type maps, distribution of forest cover in different forest types has been determined for regrouping of board forest type groups. Accordingly, fourteen forest type groups and one plantation group were considered for SNC.

Canopy density-wise spatial information was available from the forest cover mapping. This was supplemented with the forest type-wise information generated under the National Forest Type mapping project carried out by FSI. This gave three canopy density classes and fifteen forest type groups classes; thus resulting forty-five classes in all.

6.2 Methodology for Estimating Carbon Stock

- **Above Ground Biomass (AGB) of trees having diameter 10 cm& above and Bamboo**

  At each sample plot all trees of diameter 10 cm and above were measured. The woody volume of trees for each sample plot was calculated using volume equations developed by FSI for various species. The volume equation provides above ground woody volume, i.e. above ground volume, which includes volume of main stem with diameter 10 cm& above and volume of all branches having diameter 5 cm or more. Data on specific gravity and carbon content percentage of most of the tree species have been obtained from different published literature. For some species, percentage carbon content was ascertained by experimentation and for remaining species; an average of cc% of all other species was used. Standard formulae were used to calculate biomass and carbon content of each tree.

  The estimates of bamboo biomass and carbon stocked in this resource have also been calculated from NFI data. For estimating volume of the bark, the double bark thickness of trees measured during forest inventory and volume equation of trees have been used. Using species-wise dbh and bark thickness, bark volume equations were developed and were adjusted for 'bark void factor' which were utilized to estimate bark volume. Multiplying specific gravity of bark with the volume of bark, small wood & foliage biomass was obtained. Using carbon content percent of wood, carbon stored in bark was estimated.

- **Above Ground Biomass of trees having diameter less than 10 cm**

  On the study of data collected between 2002- 08, 20 important tree species were identified in NFI. For each of such species, 3 trees of diameters 1-9cm (at breast height) were felled. From the felled trees, separate biomass was calculated and recorded for wood, twigs and leaves in the prescribed format. Taking the dry biomass

of wood/foliage as dependent variable and dbh as independent variable biomass equations were developed for each species. Using the plot based regeneration data from NFI, i.e. recruits, un-established, established and all trees having dbh between 5to10 cm, biomass and carbon content at plot level is calculated.

- **Above Ground Biomass of shrubs, herbs, climbers and biomass of dead organic matter (DOM: dead wood and litter)**

  For this purpose, the data of forest inventory conducted during 2002-08 was analysed to ascertain the optimum number of plots required for each combination of forest type and forest density. It revealed that about 15 clusters of 2 sample plots for each combination would suffice for estimating the biomass/carbon factors for these components if 30% permissible error is considered. This survey was conducted in the districts on randomly selected points which were already inventoried during 2002-08 and for which forest type and density were known.

  For the desired combinations of forest type and forest density, the exact geographical locations (latitude and longitude) of the optimum number of randomly selected sample plots were visited. Treating this geographical location as centre of main plot, three concentric plots of size 5mx5m, 3mx3m and 1mx1m were laidout at a distance of 30m away from the centre of sample point in North-East and South-West directions. In 5mx5m plot, all dead wood above 5 cm diameter were collected, weighed and recorded in the prescribed field format. In 3mx3m plot, all woody litter, i.e. all branches below 5 cm diameter were collected, weighed and recorded. All shrubs and climbers in 3mx3m plots were also uprooted, weighed and recorded in the prescribed format. Similarly, in 1m x 1m plot, all herbs were uprooted, weighed and recorded. Dry biomass was converted to carbon stock by multiplying biomass with cc%.

- **Above Ground Biomass of branches, foliage of trees of diameter 10 cm& above**

  As described above, 20 important tree species in each physiographic zone were identified. For each such species other than palm like trees, in each of the diameter class, three normal trees were selected. Its diameter, height, crown width in two directions, blank in canopy and shape of crown were recorded.

For the purpose of biomass calculation, one normal tree of each diameter class of each species was selected. In the selected tree, partial destructive method was used to compute biomass of woody branches up to 5 cm dia, twigs and leaves. Biomass of all these parameters was separately recorded in the prescribed formats. Taking the dry biomass of small wood/foliage as dependent variable and dbh as independent variable, biomass equations were developed for each species. Using the plot level data of NFI, the total biomass and carbon content at plot level was calculated.

- **Organic matter in soil and forest floor**

  During forest inventory, the data on forest floor (non-woody litter and humus) and soil is also collected from each sample plot. For collecting data on humus and soil carbon, two sub-plots of size 1mx1m are laid out in NE & SW direction at a distance of 21.65 m within the main plot. The forest floor from both the plots was first swept and material so collected was weighed and a portion of same was kept for carbon analysis. Further, at the center of these two sub-plots, a pit of 30cmx30cmx30cm was dug and a composite sample of soil weighing 200gm was kept for organic carbon analysis. Samples of soil and forest floor were got analysed from the standard soil labs and were used for the calculation of 50 C.

- **Below ground biomass**

  Being the most difficult pool to measure, it is generally not measured in forest inventory. It is being included using a relationship (usually a root-to-shoot ratio) to above ground biomass which have been established by various researchers. GPG also provides default ratios for six major global forest types. FSI has selectively used these as defaults to arrive at the carbon number.

6.3 Layout of Sample Plot in the Field

For laying out the sample plot,field parties are provided the latitudes & longitudes of the centre of plot to be laid.The plot centre is navigated using GPS.The plot centre may also be approached after covering desired distance and bearing from the reference point which can be observed from SOI toposheets on 1:50,000 scale. After reaching the plot centre, some of the qualitative information is to be recorded occularly from 2 ha. (area within a radius of 80m from the plot centre) without actually laying out the plot. Some important

information collected are on parameters of land use, legal status, crop composition, soil, grazing, fire etc. Centre of the plot of 0.1 ha. is the point of inter section of two diagonals i.e. NE to SW and NW to SE of the plot. The length of each diagonal measures 44.72 m.

After reaching at a nearby location of the plot, search for a reference point such as crossing, junctions, mile-stones, bench marks, old temples etc; which can be read on the map as well as located on the ground. Once reference point is reached, select two nearby prominent trees preferable at right angles from the peg for permanent referencing of the sample point. On each reference tree a blaze is given at the breast height facing the peg and the following references are written.

1. Grid code
2. Mapsheet number
3. Distance and bearing from two nearby prominent trees or structures to the plot centre. These details are also recorded on plot approach form.

After reaching the plot centre, from true north, fix the NE at 45^0, SE at 135^0, SW at $225^0$and NW corners at 315^0 of the plot by measuring 22.36 m. horizontal distance, i.e. half of the diagonal, by Steel tape in all four directions. These four corners should be marked by thin poles or bamboos of 5 cm dia. and 1.5 metre in height. If possible ranging rods also can be used as corner posts. A red colour cloth may be tied at the top end of these corner posts for getting clear visibility from different spots in the plot. Now if dimensions of the plot are checked, all sides should measure 31.62 metres horizontal distance. Care should be taken to adjust the dimensions of the plot according to slopes. In this plot of 0.1 ha, all required tree measurements are taken and recorded in the field forms.

Layout of Sub Plots

There are four sub-Plots which are to be paid-out along with main sample plots of 0.1 ha. These sub-plots are for

(a) For soil and forest floor (humus), these are two 1mX1m square plots within sample plot at NE and SW Corners. Centers of these two sub plots are at a distance of 21.65 from centre of main plot.

(b) For herbs, these are two 1 m X 1 m square small plots whose centers lie 30 m away from centre of sample plot. These will be in NE & sub directions and will form outside sample plot.

(c) For shrubs, climbers and regeneration, two sub-plots of 3 m X 3 m each in NE & SW directions and at a distance of 30m from the centre of main sample plots are to be laid out. These too, will lie outside the sample plot: for regeneration data, two more sub-plots of 3 m X 3 m in NW & SE directions are to be laid out at a distance of 30 m from the centre of plot. Thus, for regeneration data, as per inventory design, four sub-plots of 3 m X 3 m are required.

(d) For dead wood, two sub-plots of 5mX5m each in NE & SW directions, at a distance of 30m from centre of sample plot are to be laid-out.

Sub-plots for herbs, shrubs/humus/climbers/regeneration and dead wood measuring 1mX1m, 3mX3m and 5mX5m respectively will be co-centric. Their diagonals will measure 1.42m, 4.26 and 7.10m respectively. Also in case of hilly areas, the sub-plot will be taken randomly 3-10m away either side of the trail.

For biomass estimation, in 1mx 1m plot, all herbs are to be uprooted, weighed and recorded and all shrubs & climber in 3mx3m plots are to be uprooted, weighed and recorded in the prescribed field forms. In 5mx5m plot, all dead wood above 5 cm diameter is to be collected, weighed and recorded. In all the three plots, the name of the dominant species will also be recorded (Herbarium may be prepared if dominant species are not identified).

6.4 Data Collection

After demarcating the plot and after satisfying that it is correctly oriented, the Crew Leader shall collect the data in prescribed forms. This form will be filled up for every plot laid out on ground. This form describes completely the plot through various qualitative parameters like land use, legal status, topography, slope, aspect, soil, regeneration, fire, grazing, etc. An area of about 2 ha. i.e 80 m radius around the centre of the plot will be considered for filling up this form without actually demarcating it. Trees, the stems of which touch the North and West border lines of the plot (called border-line trees) will be enumerated. However, trees the stems of which touch the East and South border lines of the plot will be treated as 'out trees' and will not be enumerated. 'In' and 'out' bamboo would be similarly decided and treated. Enumeration of trees/bamboo will commence from the NW corner in North quadrant of the plot and will proceed in clockwise direction.

The diameter of trees will be measured at a height of 1.37 metres from ground level (i.e. at breast height) measuring on uphill side of the tree and will be recorded to the nearest centimetre. The axis of the callipers (i.e. the long arm of the callipers) will always be kept pointed to the centre of the plot while taking diameter measurement of trees. If there is flare at the breast height of a tree, in that case, the diameter measurement would be taken immediately above or below the flare whichever is nearer to breast height. In case of

buttressed and large sized trees diameter may be measured by tape or taking girth and converting it to diameter by multiplying with 7/22 or 0.318 factor. In case there is forking of a tree below its breast height, diameter or each forked stem will be measured at breast height (above forking) and recorded separately, as if for two trees. Dead trees, if not rotten and providing 70% of their wood as utilizable, will also be enumerated. The diameter of a bamboo clump will be measured at its base with the help of a tape and will be converted by multiplying with 7/22.

For Non-Hilly

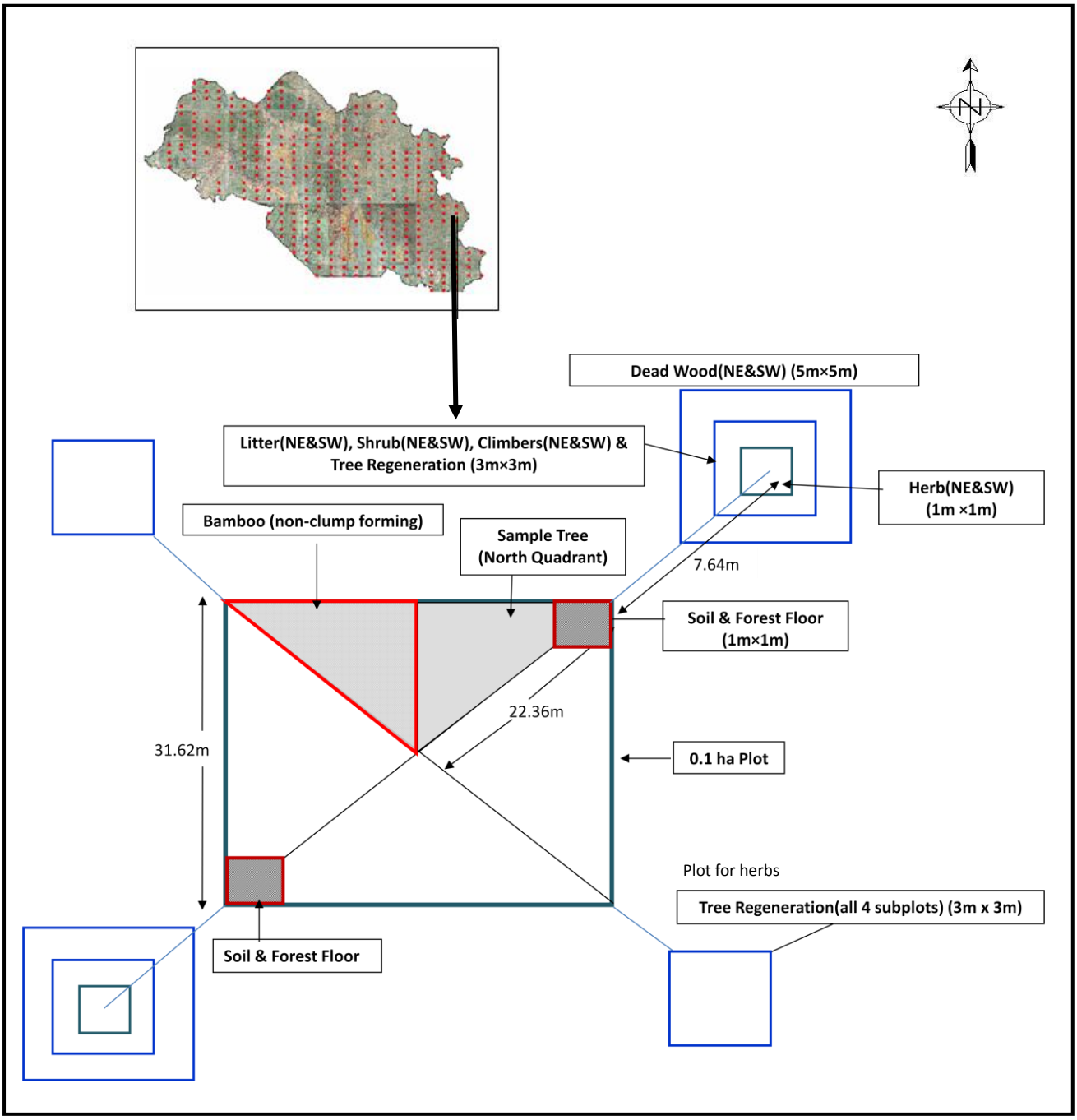


Fig 6.1: Description of Sampling Unit

6.5 CARBON STOCK IN CORBETT, DUDHWA, VALMIKI TIGER RESERVE & CONNECTING CORRIDORS

6.5.1 Corbett Tiger Reserve

Carbon stock for the Corbett Tiger Reserve has been estimated for three different period years: 1990, 2000 and year 2010. It has been estimated for core, buffer and area upto 10km from the boundary of Tiger Reserve (AUTKBTR) separately and given in Table 6.5.1a, Table 6.5.1b and Table 6.5.1c respectively.

Table 6.5.1a reveals that carbon stock in the core area of Reserve in three different periods shown above is 10.8522, 10.8629 and 10.8475 m tonnes respectively. With a rapid growth of 0.0107 m tonnes from year 1990 to 2000, year 2010 estimation shows a decrease of 0.0154 m tonnes when compared to year 2000 estimates. Net change in Carbon Stock from year 1990 to 2010 periods depicts a loss of 0.0047 m tonnes.

Table 6.5.1a: Carbon Stock (in million tonnes) in different assessment year in Core Area

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	5.9247	5.9310	5.9235
Below Ground	1.8686	1.8706	1.8683
Dead Wood	0.0654	0.0655	0.0654
litter	0.1357	0.1358	0.1357
Soil	2.8578	2.8600	2.8546
Total	**10.8522**	**10.8629**	**10.8475**

Similarly, Table 6.5.1b shows that in the buffer area of Corbett Tiger Reserve, Carbon stock in three studied periods; years 1990, 2000 and 2010 has been estimated as 6.1741, 6.2092 and 6.1766 in m tonnes respectively. While year 2000 estimation shows a positive change of 0.0351 in m tonnes when compared to 1990, there is decline of 0.0326 in m tonnes of Carbon stock in year 2010 when compared to 2000 estimates. Net change observed in 2010 estimate shows increase stock of 0.0025 in m tonnes.

Table 6.5.1b: Carbon Stock (in million tonnes) in different assessment year in Buffer Area

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	3.2971	3.3162	3.2988
Below Ground	1.0399	1.0459	1.0404
Dead Wood	0.0442	0.0444	0.0442
litter	0.0943	0.0949	0.0944
Soil	1.6986	1.7078	1.6988
Total	**6.1741**	**6.2092**	**6.1766**

Table 6.5.1c showing the Carbon stock in AUTKBTR indicates that highest estimate among the three periods is year 1990 where Carbon stock is 10.6197 m tonnes. It got decreased year after year. Accordingly, a negative change has been observed in all the years. Period of 2000-2010 indicates a greater decreased of 0.0766 m tonnes of Carbon stock in Extended buffer area of the CTR.

Table 6.5.1c: Carbon Stock (in million tonnes) in different assessment year in AUTKBTR

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	5.7133	5.6867	5.6462
Below Ground	1.8020	1.7936	1.7808
Dead Wood	0.0798	0.0795	0.0789
litter	0.1792	0.1783	0.1769
Soil	2.8454	2.8304	2.8091
Total	**10.6197**	**10.5685**	**10.4919**

6.5.2 Dudhwa Tiger Reserve

Carbon stock for Dudhwa Tiger Reserve has been estimated for two areas, core and area upto 10km from the boundary of Tiger Reserve (AUTKBTR) separately. In both the areas, estimation of Carbon stock is given for three periods of years 1990, 2000 and 2010.

Table 6.5.2a reveals that Carbon stock in core area in year 1990, 2000 and 2010 is 16.0571, 16.4754 and 16.6770 m tonnes respectively. Here stock has shown a rapid growth of 0.4183 to 0.2016 m tonnes in year 1990-2000 to periods of years 2000-2010. There is a net increase of 0.6199 m tonnes of carbon stock in year 2010 compare to estimates of year 1990.

Table 6.5.2a: Carbon Stock (in million tonnes) in different assessment year in Core Area

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	8.0955	8.2890	8.3956
Below Ground	2.5533	2.6144	2.6480
Dead Wood	0.0776	0.0798	0.0807
litter	0.1486	0.1538	0.1553
Soil	5.1821	5.3384	5.3974
Total	**16.0571**	**16.4754**	**16.6770**

Similarly, Table 6.5.2b shows that in the AUTKBTR, carbon stock in three studied period of years is 4.4546, 4.6487 and 4.6265 m tonnes. While, there is an increase of 0.1941 in tonnes of carbon in year 2000 when compare to 1990, a loss of 0.0222 m tonnes of carbon stock has come out in year 2010 compare to year 2000. Net change with positive estimate of 0.1719 m tonnes of carbon has been assessed in year 2010 when compared to year 1990.

Table 6.5.2b: Carbon Stock (in million tonnes) in different assessment year in AUTKBTR

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	2.4143	2.5178	2.5021
Below Ground	0.7615	0.7941	0.7892
Dead Wood	0.0324	0.0339	0.0335
litter	0.0646	0.0679	0.0671
Soil	1.1818	1.2350	1.2346
Total	**4.4546**	**4.6487**	**4.6265**

6.5.3 Valmiki Tiger Reserve

Carbon stock in Valmiki Tiger Reserve has been assessed for core, buffer and area upto 10km from the boundary of Tiger Reserve (AUTKBTR) separately. For all the area, carbon has been estimated for three periods of years 1990, 2000 and 2010.

In the core area of Tiger Reserve, estimated carbon stock in three assessed years is 7.3410, 7.3117 and 7.2579 m tonnes respectively. Generated estimates explain that carbon stock has decreased in subsequent years; 0.0293 in tonnes in year 2000 to 0.0538 m tonnes is assessment year 2010. There is an overall the decrease of 0.0831 m tonnes of carbon assessed in year 2010.

Table 6.5.3a: Carbon Stock (in million tonnes) in different assessment year in Core Area

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	3.6569	3.6435	3.6202
Below Ground	1.1534	1.1491	1.1418
Dead Wood	0.0307	0.0306	0.0304
litter	0.0933	0.0929	0.0926
Soil	2.4067	2.3956	2.3729
Total	**7.3410**	**7.3117**	**7.2579**

So far as Carbon stock in the buffer areas of Valmiki Tiger Reserve is concerned, it is 2.9137, 2.8552 and 2.6856 m tonnes corresponding to assessment years 1990, 2000 and 2010 respectively. It clearly shows that Carbon stock has decreased in all subsequent years of assessment; while a loss of 0.0585 m tonnes has occurred in year 2000 compared to 1990 estimates, this loss has further widened to 0.1696 m tonnes in year 2010 when compared to year 2000 stock. As a result, an overall decrease in Carbon stock is 0.2281 m tonnes between intervals of 1990-2010.

Table 6.5.3b: Carbon Stock (in million tonnes) in different assessment year in Buffer Area

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	1.3975	1.3691	1.2863
Below Ground	0.4408	0.4318	0.4057
Dead Wood	0.0106	0.0104	0.0099
litter	0.0278	0.0274	0.0262
Soil	1.037	1.0165	0.9575
Total	**2.9137**	**2.8552**	**2.6856**

Similarly, following tables indicate that in the AUTKBTR, estimated Carbon stock in assessment years 1990, 2000 and 2010 is 1.2123, 1.1495 and 0.9125 m tonnes respectively. Comparison between different assessment years reveals that there is net loss of 0.2998 m tonnes of Carbon stock between 1990-2010 intervals.

Table 6.5.3c: Carbon Stock (in million tonnes) in different assessment year in AUTKBTR

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	0.6159	0.5844	0.4684
Below Ground	0.1942	0.1843	0.1477
Dead Wood	0.0037	0.0035	0.0029
litter	0.0092	0.0088	0.0073
Soil	0.3893	0.3685	0.2862
Total	**1.2123**	**1.1495**	**0.9125**

6.5.4 Corbett-Dudhwa Tiger Corridor

Carbon stock for the corridor connecting Corbett Tiger Reserve and Dudhwa Tiger Reserve has been estimated for three different period years: 1990, 2000 and year 2010. It has been given in Table 6.5.4a which shows that the carbon stock in three studied period of years is 8.2618, 8.1184 and 8.0701 m tonnes. It clearly shows that Carbon stock has decreased in all subsequent years of assessment; while a loss of 0.1434 m tonnes has occurred in year 2000 compared to 1990 estimates, this loss has further widened to 0.0483 m tonnes in year 2010 when compared to year 2000 stock. As a result, an overall decrease in Carbon stock is 0.1917 m tonnes between intervals of 1990-2010.

Table 6.5.4a: Carbon Stock (in million tonnes) in different assessment year

POOLS	Carbon Stock in Forests in 1990	Carbon Stock in Forests in 2000	Carbon Stock in Forests in 2010
Above Ground	4.4508	4.3785	4.3527
Below Ground	1.4038	1.3810	1.3729
Dead Wood	0.0619	0.0610	0.0606
litter	0.1351	0.1328	0.1320
Soil	2.2102	2.1651	2.1519
Total	**8.2618**	**8.1184**	**8.0701**

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The present study is on the status & density changes of Forest Cover in tiger reserves, status of the Forest Cover change in forest corridors and carbon sequestered since last 20 years in Tiger Reserves falling in Shivalik Gangetic Plains viz. Corbett Tiger Reserve, Dudhwa Tiger Reserve, Valmiki Tiger .The data set used is multi date satellite imagery of IRS P6 LISS III (corresponding to the period 2010), IRS 1C/1D LISS III (corresponding to the period 2000) and Landsat-5 TM (corresponding to the period 1990). The IRS P6 LISS III, IRS 1C/1D sensor has a spatial resolution of 23.5 m and Landsat TM has a spatial resolution of 30.0 m. In the present study, the threshold of 1 ha. has been taken for forest cover mapping of the three tiger reserves. The forest cover has been classified in different density classes namely Very Dense Forest (VDF), Moderately Dense Forest (MDF) and Open Forest (OF). The output of core, buffer and area up to 10 km from the boundary of Tiger Reserve (AUTKBTR) has been given in the various categories of forest cover along with their corresponding maps.

The study of Corbett Tiger Reserve comprises assessment for core, buffer and area up to 10km from the boundary of Tiger Reserve. During the study, it was found that in the core area of Corbett Tiger Reserve the forest cover is 708.89 sq.km, 708.95 sq.km & 706.73 sq.km respectively in corresponding periods of 1990, 2000 and 2010. Subsequently, in the buffer area Forest Cover is 509.61sq.km, 512.69 sq.km & 509.62 sq.km in three different periods (1990, 2000 & 2010).The result of the study shows an increase in the forest cover in the core and buffer area of Corbett Tiger Reserve during the period of 1990-2000. This is a result of better management practices and protection level at the Corbett NP and Sonanadi WLS of CTR. Along with this enhanced conservation approach and controlled limited anthropogenic activities in the reserve resulted into the better growth and preservation of the flora and fauna. Availability of the regular funds and deployment of dedicated foresters has also played important role. The growth phase is at its optimum and beyond this point the growth tends to remain same or decline slightly and so will be the carbon sequestered. It appears that during 1990-2000 the forest crops were comparatively younger and therefore growing fast whereby the carbon sequestration was on the higher scale. In the later part of this decade, there is little decrease in the forest cover in Core and Buffer area. During this period (2000-2010) park was ravaged by flood in Ramganga & Kosi river due to which standing matured crops got dried up & some of them got buried which registered the fall in the carbon sequestered both in Above Ground Biomass (AGB) and Below Ground Biomass (BGB).

Forest Cover and Carbon stock of Dudhwa Tiger Reserve has been estimated for core and area upto 10km from the boundary of Tiger Reserve separately. In both the areas, the study shows the positive result in forest cover also reflected in increase in carbon stock for three periods of 1990, 2000 and 2010. During the study, it was found that in the core area of Dudhwa Tiger Reserve the forest cover is 892.16 sq.km, 918.72 sq.km & 928.71 sq.km respectively in corresponding periods of 1990, 2000 and 2010. The positive change shows that the forest crops were in their exponential growth form which also

resulted in the increase of carbon stock over the period of 1990 to 2000 and this continued in second decade of the study in the reserve which is a result of better management practices & conservation strategies deployed by the park management authorities for protecting flora and fauna and lesser anthropogenic activities in the core area of the reserve. The change in the river course of Sharda, Ghaghra and Suheli river flowing through the reserve and area up to 10 km from the boundary of Tiger Reserve (AUTKBTR) has shown a positive impact on forest cover. As a result, younger crop were seen over the fertile flood plain of the rivers and an overall increase in forest cover is also substantiated by the Carbon stock assessment.

The study of Valmiki Tiger Reserve has been assessed for core, buffer and area up to 10 km from the boundary of Tiger Reserve (AUTKBTR). For all the area, forest cover and carbon stock has been estimated for three periods of years 1990, 2000 and 2010. The forest cover in the core area in three subsequent period of study is 564.34 sq.km, 559.76 sq.km & 551.98 sq km and subsequently, in the buffer area it is 228.25 sq.km, 222.89 sq.km & 207.00 sq km. Result shows that forest cover in both Core and Buffer area and also the carbon stock has decreased in all subsequent years of assessment. This decrease appears to be due to the change in the course of Gandak River which swallowed vast portion of Forest Cover in Core areas of the reserve, it has also affected the carbon sequestration of the Above Ground Biomass (AGB) pool. In the buffer area of the reserve the decrease in the Forest Cover and carbon stock is a result of increased anthropogenic factors and livestock pressure. Some areas have shown qualitative enhancement in the forest cover which can be assigned to improved management techniques deployed at the local level by the park authorities and enhanced conservation strategies.

Estimation of Forest Cover in the corridors connecting Corbett Tiger Reserve and Dudhwa Tiger Reserve has been done for three different period years: 1990, 2000 and year 2010. Kosi River Corridor, Nihal -Bhakra Corridor and Gadgadia-Terai Central Corridor, Gola river Corridor-Plains, Kilpura-Khatima Corridor, Dudhwa-Katerniaghat Corridor, Pilibhit -Suklaphanta-Dudhwa Corridor have been playing an important role in dispersal and migration of tigers between Corbett Tiger Reserve and Dudhwa Tiger Reserve. The Forest Cover is 801.51 sq.km, 789.32 sq.km & 780.70 sq.km in three different periods (1990, 2000 & 2010).The corridors are lined by intensive agricultural activities which plays an important role for the negative changes in forest cover. The area experiences high anthropogenic pressure due to urban development along with establishment of different industries during 1990 to 2010 with restricted protection level.

The comparative table along with their pie- diagrams with percentage-wise Forest Cover assessment in Core, Buffer and AUTKBTR w.r.t their notified core, Buffer boundary area is given in the Table 7.1, Table 7.2 and Table 7.3.

Table7.1: Percentage-wise Forest Cover assessment in Core Area

(Area in km^2)

Year	Tiger Reserve	Forest Cover	Notified Core Area	Percentage(%) of Forest Cover w.r.t Core Area
1990	Corbett Tiger Reserve	708.89	821.99	86.24 %
	Dudhwa Tiger Reserve	892.16	1093.79	81.57 %
	Valmiki Tiger Reserve	564.34	598.45	94.30 %
2000	Corbett Tiger Reserve	708.95	821.99	86.25 %
	Dudhwa Tiger Reserve	918.72	1093.79	83.99 %
	Valmiki Tiger Reserve	559.76	598.45	93.53 %
2010	Corbett Tiger Reserve	706.73	821.99	85.98 %
	Dudhwa Tiger Reserve	928.71	1093.79	84.91 %
	Valmiki Tiger Reserve	551.98	598.45	92.23 %

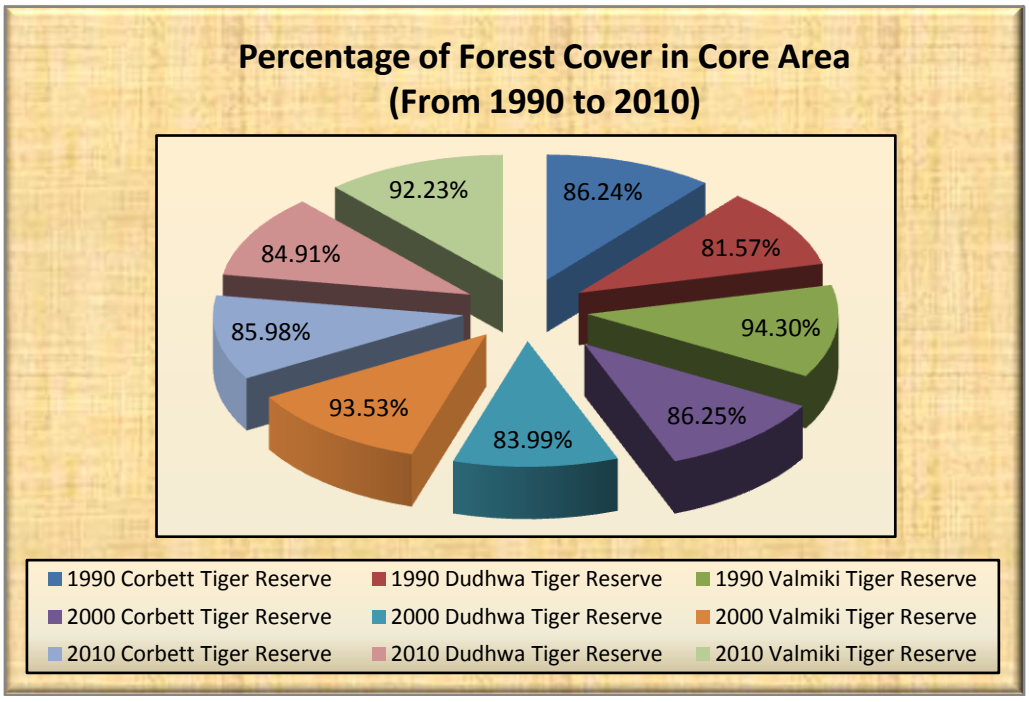


Fig. 7.1: Pie Chart showing Percentage of Forest Cover (From 1990-2010) w.r.t Notified Buffer Area

Table7.2: Percentage-wise Forest Cover assessment in Buffer Area

(Area in km^2)

Year	Tiger Reserve	Forest Cover	Notified Buffer Area	Percentage(%) of Forest Cover w.r.t Buffer Area
1990	Corbett Tiger Reserve	509.61	546.92	93.18 %
	Dudhwa Tiger Reserve *	--	--	--
	Valmiki Tiger Reserve	228.25	302.68	75.41 %
2000	Corbett Tiger Reserve	512.69	546.92	93.74 %
	Dudhwa Tiger Reserve *	--	--	--
	Valmiki Tiger Reserve	222.89	302.68	73.64 %
2010	Corbett Tiger Reserve	509.62	546.92	93.18 %
	Dudhwa Tiger Reserve *	--	--	--
	Valmiki Tiger Reserve	207.00	302.68	68.39 %

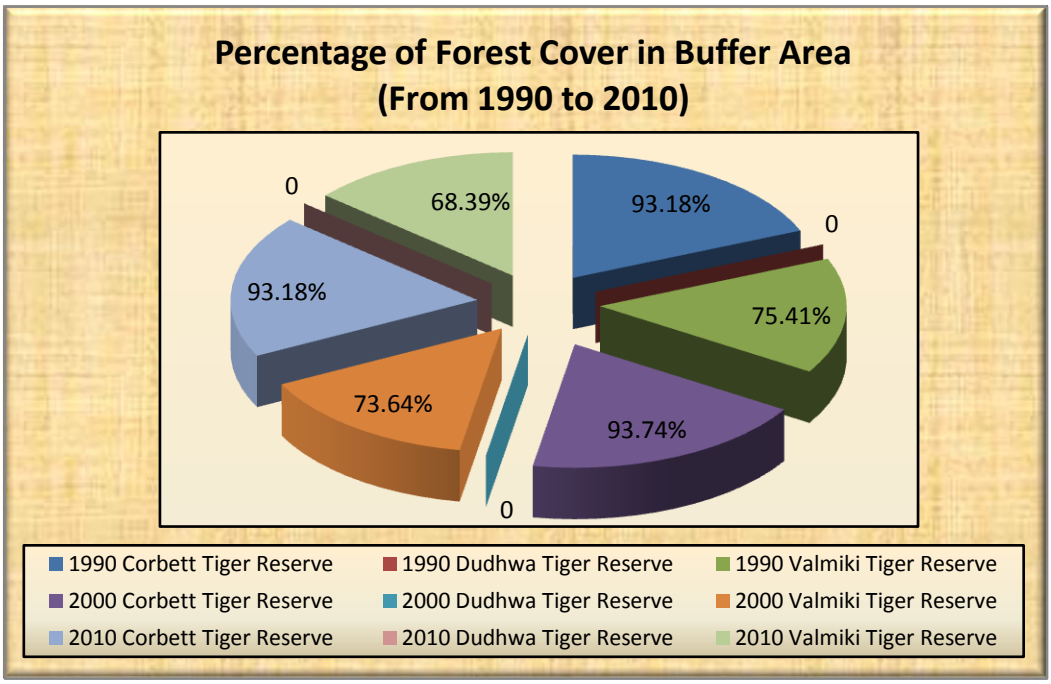


Fig. 7.2: Pie Chart showing Percentage of Forest Cover (From 1990-2010) w.r.t Notified Buffer Area

(*): FSI doesn't have notified buffer boundary of Dudhwa Tiger Reserve

Table7.3: Percentage-wise Forest Cover assessment in AUTKBTR

(Area in km^2)

Year	Tiger Reserve	Forest Cover	AUTKBTR	Percentage(%) of Forest Cover w.r.t AUTKBTR
1990	Corbett Tiger Reserve	1039.32	2082.42	49.91 %
	Dudhwa Tiger Reserve	375.54	2734.56	13.73 %
	Valmiki Tiger Reserve	99.02	1686.27	5.87 %
2000	Corbett Tiger Reserve	1033.89	2082.42	49.65 %
	Dudhwa Tiger Reserve	393.04	2734.56	14.37 %
	Valmiki Tiger Reserve	93.82	1686.27	5.56 %
2010	Corbett Tiger Reserve	1025.94	2082.42	49.27 %
	Dudhwa Tiger Reserve	392.14	2734.56	14.34 %
	Valmiki Tiger Reserve	73.66	1686.27	4.37 %

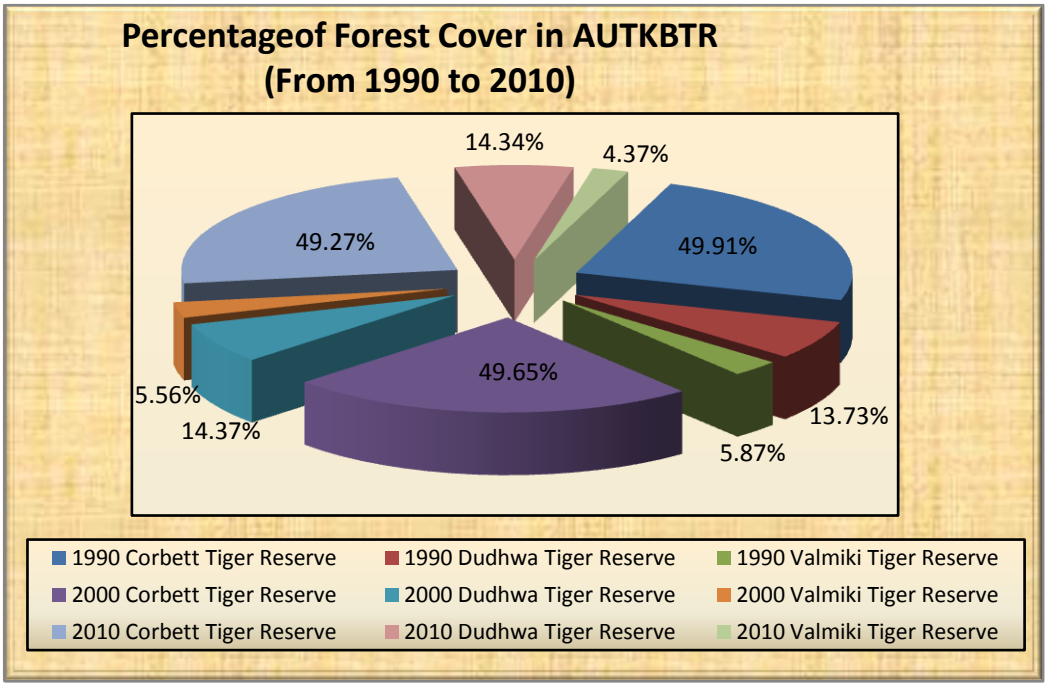


Fig. 7.3 Pie Chart showing Percentage of Forest Cover (From 1990-2010) w.r.t AUTKBTR

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