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MINISTRY OF TRIBAL AFFAIRS
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SCSTRTI
Schedule Castes and Schedule Tribes
Research and Training Institute
SC & SC Development Dept., Govt. of Odisha

Indian Institute of Forest
Management

DIAGNOSTIC STUDY ON FOREST FIRE IN SELECTED TSPAREAS OF ODISHA AND MADHYA PRADESH

STUDY BY

SCHEDULE CASTES AND SCHEDULE TRIBES
RESEARCH AND TRAINING INSTITUTE (SCSTRTI), BHUBANESWAR
SC & SC DEVELOPMENT DEPT., GOVT. OF ODISHA

TECHNICAL PARTNER

Indian Institute of Forest Management
BHOPAL, MADHYA PRADESH

WITH SUPPORT FROM

MINISTRY OF TRIBAL AFFAIRS, GOVERNMENT OF INDIA

SEPTEMBER 2022

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Glossary of Terms and Abbreviations

AAY	Antyodaya Anna Yojana
AJY	Ama Jungal Yojana
APL	Above Poverty Line
Bag (of kendu leaves)	Bag of kendu leaves (60kg) in Orissa
BPL	Below poverty Line
CF	Community forests
DPF	Demarcated Protected Forest
FA	Forest Area
FDC	Forest Development Corporation
FGD	Focus Group Discussion
GBH	Grith at Breast Height
GCH	Grith at Collar Height
GIS	Geographic Information System
GP	Gram Panchayat
GPS	Global Positioning System
ha	Hectare
HH	Household
IRS	Indian Remote Sensing
JFM	Joint Forest Management
JFMC	Joint Forest Management Committe
Kerries	Bundles of 20 kendu leaves (Orissa)
kg	Kilogram
km	Kilometer
Lakh	100,000 (rupees)
LAMPS	Large multi-purpose cooperative society
LAT	Latitude
LONG	Longitude
MDF	Moderately Dense Forest
MFP	Minor Forest Products
MODIS	Moderate Resolution Imaging Spectroradiometer
MP	Madhya Pradesh
MPMFPF	Madhya Pradesh Minor Forest Products Federation
MT	Metric tonne
NGO	Non governmental organization
NTFP	Non timber forest product
OBC	Other Backward Caste
OFDC	Orissa Forest Development Corporation
OP	Open forest
PF	Protected forest
Phadi	Temporary storage house for kendu leaves in odisha
Phal	Bundles of 30 – 40 kendu leaves
PI	Personal Interview
Pola	Bundles of 50 kendu leaves (Bihar)
PPF	Private protected forests syn CF & MK)
Quintal	Unit of weight equivalent to 100 lbs
RF	Reserve forest
SC	Scheduled Caste
SHG	Self Help Group
SNPP	Simple Network Paging Protocol
ST	Scheduled Tribe
Standard bag	Bag of kendu leaves (35 – 40 kg)
TDCC	Tribal development cooperative corporation
TRIFED	Tribal marketing federation
UFP	Utkal Forest Products
UFPL	Utkal Forest Products Ltd
VF	Village forest
VLFPC	Village Level Forest Protection Committee
VSS	Van surakhsa Samiti

DIAGNOSTIC STUDY ON FOREST FIRE IN SELECTED TSP AREAS OF ODISHA AND MADHYA PRADESH

Executive Summary

0.1 Background

Forest fires are a regular phenomenon in the forest. Tribals are closely associated with the forest regarding their cultural, economic, and social needs. During the year 2021, the states of Odisha and Madhya-Pradesh reported a high number of forest fires. In India, forest fires are of different types. For example, ground fire, surface fire, and crown fire. Different regions have faced different kinds of forest fires and, based on the intensity and severity of the fire, the impact on vegetation and on the dependent community is different. Forest fire has different impacts on forest regeneration, soil, and the distribution of various plant species. Tribals living near forests undoubtedly have an impact on forest fires, which in turn has an impact on tribal socioeconomic structures. The present study is aimed at finding various causes of forest fire and the role of tribals in the fire and the probable impact of fire on the tribals.

0.2 Rationale

Forest fires have become a global challenge in the past 5–10 years. which results in a negative impact on the ecological and social structure of any country, state or regions. Forest fire harms community sources collected from the forest. Studies on the assessment of the vulnerability of forest fringe communities to forest fire are lacking, so this study is an attempt to overcome this shortcoming in the available literature. Integration of modern tools like remote sensing techniques along with field studies may provide more details, which may be useful for site-specific planning and management.

0.3 Objectives

- ✓ To record the patterns and trends of forest fires (in last 5-10 years), extent of forest fire areas and estimated losses in sample forest areas (Study area)
- ✓ To identify and analyse the underlying causes of forest fire in the study area and the technical and organizational capacities of local community in relation to management of forest fire

- ✓ To assess the ecological vulnerability of the forest (successional stages, species diversity, regeneration, biomass, invasive species management etc.) and livelihood vulnerability of forest dependent communities (NTFP, medicinal plants and tubers availability, agriculture and farm forestry/agricultural practice, provisioning of ecological services etc.) due to forest fire.
- ✓ To map out the existing forest policies and practices of forest fire management, control and prevention.
- ✓ To identify the cultural practices and its relation to the forest fire.
- ✓ To develop an Action Plan on Forest Fire Management and recommend measures to be taken at policy and field level for effective forest fire management (including institutional set up, stakeholders' coordination, policy framework, knowledge management, technical options etc.

0.4 Sample and Methodology

For studying two states Odisha and Madhya-Pradesh were selected. In these each state three forest divisions were selected. Criterion for selection of divisions were- a) frequency of fire over past 10 years (base year 2021) b) higher percentage of tribal population c) different Forest types.

Three Forest Divisions selected as sample in Odisha area- 1) Rairangpur 2) Rayagada 3) Baliguda and in Madhya-Pradesh Forest Divisions were 1) Khandwa 2) North Betul 3) East Mandala.

Methodology followed as under

A purposive sampling method has been adopted to identify the study districts/forest areas based on the following criteria.

1. For knowing frequency of Fire help of Remote Sensing tool was taken. On the bases of this, the sampled areas were categorized into three different categories- a) High Fire Frequency (6-10 fire years) b) Medium Fire Frequency (3-5 fire Years) c) Low fire frequency (<3 fire years).
2. For assessing the impact of fire on vegetation and regeneration, sample plots were laid out of 20x20 m and 2x2 m in the selected cluster compartments.
3. Interaction with the villagers in 5 km periphery from sampled forest was done to analyse the impact of forest fire on villagers and their role in protecting and managing the adjacent forest from the forest fire.

The field study was carried out during February **2022 to August 2022**. The study is based on both primary and secondary sources of data. It covered both qualitative and quantitative data. ***Primary sources*** of data were collected by plot enumeration, interaction with forest officials, personal interview, FGDs and KIIs. ***Secondary sources*** of data were obtained from respective Forest Departments, Aanganbadi kendra, various official websites of concerned departments etc.

Parameters and Approaches/Analysis

- **Remote Sensing:** - Fire points over 10 years, land use/ land cover of study area, NDVI (Normalised Difference Vegetation Index), LST (Land Surface Temperature)
- **Ecological:** - IVI (importance value index), Simpson Index, Shannon Index, Regeneration (Established & Unestablished)
- **NTFPs:** - Seasonal Availability of NTFPs in selected villages, NTFPs loss due to fire
- **Socio-Economic:** - Dependency of TSPs village on Forest, Social structure of village, Views towards forest fire, Management adopted in sampled village to combat forest fire, Effect of fire in their livelihood. Etc.

0.5 Outcome:

- ✓ GIS map of forest fire points in sample districts and early fire detection and management mechanism
- ✓ Document the local knowledge systems and technical know-how of forest fire management
- ✓ Documentation on the site-specific causes of forest fire.
- ✓ Recommend measures to be taken at the policy and field level for effective forest fire management (including institutional set up, stakeholders' coordination, policy framework, knowledge management, technical options etc.) and
- ✓ Develop a Guideline and Action Plan for Forest Fire Management

0.6 Limitations:

1) To find the difference in the availability of NTFPs due to frequent fires we don't have the exact data of collection of NTFPs.
2) No baseline data for regeneration of various plant species in the sampled forest was available.
3) No favourable season for collecting the information related to climbers and NTFPs was available so the data related to NTFPs is collected only on the oral submission of tribal groups.

0.7 Chaptarisation and Organization of report

The Diagnostic Forest fire report is divided in five chapters. **The *first chapter*** deals with background od the study, introduction of forest fire, forest fire in India, global scenario of forest fire, forest fire, tribal community and linkage, objectives of the study and expected outcomes. ***Chapter two*** provide an idea about related review literature, study area, sampling design, parameter & indicators, tools and techniques of data collection, profile of Odisha and Madhya-Pradesh, forest coverage of Odisha and Madhya Pradesh, Profile of sampled village, profile of the community in sampled area. ***Chapter three*** gives the data related to history of fire incidences over the decade, Remote Sensing & GIS analysis and Ecological Study of sampled areas. ***Chapter IV*** emphasise on causes of forest fire in Odisha and Madhya-Pradesh, available NTFPs in the studied village of Odisha and MP, Indigenous knowledge system & health system, community economic status in both the states, community dependency and income from the forest in both the sates, community perception of forest fire in both states, community views on damage from the forest fire, community human casualties and monetary loss from forest fire, community participation in forest fire fighting squad. ***Chapter V*** conclude with the existing policies in Indian context, National Plan for Forest Fire Management, Administration and institutional framework to combat fire and in last suggesting action plan on Forest Fire.

0.8 Major Finding

- fire incidence in MP and Odisha has increased in the past 10 years. Another observation is that fire incidence in Dry deciduous forest was seen more, now it is found to be extended to Sal Forest areas which are moist**.**
- the area under barren land has increased in post-fire season and, in the same period, the area under scrub land has decreased. It proved that when the fire started, scrubland in a selected area burned very easily and got converted to barren land. The very little effect is found in dense forests, and a medium effect is found in moderately dense forests, open forests, etc.
- In the study of Madhya Pradesh and Odisha it is found that when LST increased up to 32°c- 33ºc hence, there will be a big possibility of a forest fire.
- The study revealed that fire frequency and intensity are higher in the dry deciduous forest, and because of this, it highly impacts the established and unestablished regeneration. In the moist deciduous forest, fire does not much affect the young crop, though perhaps fire helps the young crop to regenerate in the forest field.
- In Odisha, 50.6% (91) participants are found as Forest dwellers according to their primary occupation. 26.7% (48) of participants are found doing forest dwelling as their second occupation. In Madhya Pradesh, 26.7% (48) participants prefer forest dwelling as their primary occupation and 28.3% as their secondary occupation.
- In Odisha, 53.9% of people are generating amounts below 5000 from the forest annually. 2.8% of participants in Odisha are earning more than Rs 20000 yearly. On the other hand, in Madhya Pradesh, 58.9% of participants' annual earnings are below Rs 5000. When it comes to income from forest Madhya Pradesh has very less in numbers.
- The total sample size reveals that 56.4% (203) participants are earning below 5000 from the forest. Similarly, 39.4% (142) participants are earning between 5000-10000, only 2.5% (9) participants are earning between 10000-20000 and only 1.7% (6) participants are earning above 20000.
- A maximum number of people expressed that forest fire is not good under any circumstances. 86.4% of participants are agreeing that forest fire is harmful to

their life, livelihood and environment. 7.8% of people believe that forest fire is good for the reasons 1) better leaves of tendu, 2) for Hunting etc.

- Out of the total surveyed people, 67.8% are involved in extinguishing the forest fire in Odisha state. Similarly, in Madhya Pradesh out of the total participants, 55.6% of people are involved in extinguishing the forest fire.
- The annual occurrence of forest fires, and especially, the large extent to which they occur, presents a striking contradiction between fire policy, and fire reality. Given that nearly a century of the ban-and-punish approach to fires in Indian forests has no worked, a more effective approach might involve the integration of fire into existing forest management systems.
- The study is concluded with the two levels of action plan, i.e., 1) Technical Approach, 2) Social Approach should be implemented to combat forest fires, in addition to the various guidelines provided by the federal and state governments.

CHAPTER-1

Introduction

1.1 Background

Worldwide there has been increased concern about forest fires. These forest fires have caused largescale human suffering and irreparable damage to biodiversity. India is no exception to forest fires. Forest fires are one of the major causes of the degradation of the country's forests. About 21.40% of forest cover in India is prone to fires, with forests in the north-eastern region and central India being the most vulnerable, as per the 2019 report by the Forest Survey of India (FSI). As per the study, while north eastern region accounted for 10,210 fire alerts, which make up about one-third of alerts in the country, Central Indian States also recorded a high number of forest fire alerts, with Madhya Pradesh accounting for 2,723 alerts; Maharashtra 2,516; Odisha 2,213 and Chhattisgarh 1,008 alerts between November 2018 to June 2019.

More than ninety-five per cent of forest fires are caused either by negligence or unknowingly by a human being. The rest of the fires are caused by natural reasons i. e. lightening, extreme rise in the temperature etc., which are very rare. In general, all over the world, the main causes of forest fires are anthropogenic. According to the FAO report "Fire Management- Global Assessment 2006", regional estimates of human-induced forest fires are as follows: a. Mediterranean- 95% b. South Asia 90 % c. South America 85 % d. North America 80 % e. Balkan countries 59 % The natural causes of forest fires are common in remote areas only.

About more than 36% of forest cover in India is prone to frequent forest fire fires. Forests in the north-eastern region and central India are the most vulnerable, as per the 2019 report by the Forest Survey of India (FSI,2019). India has **713,789 sq. km**. (21.71 %) of the total geographical area of the country (ISFR, 2021). Dry deciduous forest is the major forest type in central India. This forest is vulnerable to forest fire due to long periods of dryness and available combustible materials. Thus, forest fire causes wide-ranging adverse effect on the livelihood of the 65 million tribes in India, who directly depends on Forest. Forest fires are quite common all over India but during the period November 2020 to January 2021 highest number of fire incidences were observed in Odisha 51968 followed by M.P.47795 as recorded by FSI.

The population of tribal in Odisha is 22.85% and in Madhya Pradesh, it is 21.1% as per the 2011 census (Census, 2011). There are 49 tribal communities residing in Madhya Pradesh with three PVTGs namely Shararia in Sheopur District, Bharia in Chindwara district and Baiga in Eastern districts. Most of them reside in Forest Fringe Villages (FFY). Tribal communities are highly connected with forests regarding food, shelter and various cultural activities. *Mahua* (*Madhuca Indica*) flowers, Achar

(*Bucnaina Legen*) / Chironji, Mahul Patta (leaf), and Tendu Patta (leaf) are some of the important NTFPs which add to the annual income of tribal families. Forest produce may also help them in healing ailments. Over all dependency of tribal is high on forests. Economically tribal are weak hence they cannot afford costly allopathic medicines so they have to depend on local herbal practitioners. In 2011, nearly 40.6 per cent of tribals were living below the poverty line, the proportion among the rest was 20.5 %, (Narain, et al, 2019).

Forests are highly vulnerable to fires. Behind most forest fires human beings are involved (Narendran, K., 2001). Joint Forest management committees play an important role in forest protection. Tribals are an integral part of these committees. The two states, Odisha and Madhya Pradesh are having a high percentage of tribal populations and are facing high incidences of fire (2020-2021). Forest fire enhances the vulnerability of forest dependents or people living in the proximity of forests. Hence, it is important to know various causes of forest fires and possible remedies at the planning as well as execution level, so that the number and extent of forest fires could be reduced.

Forest fires cause various damages to the forests which include depletion of forest biodiversity (flora and fauna). A lot of damage is done to the top soil which becomes devoid of the binding material, humus. (Jiaying et al 2021). This soil which is devoid of humus becomes vulnerable and the topsoil gets washed away with rain water in the sloppy area. This again reduces the reproductive power of soil thereby reducing the regeneration in that area. Damage done by the forest fire has been ascertained approximately in India. In the present project, researchers have tried to find out the extent of damage caused by fire to the growing stock, and regeneration, especially in terms of NTFPs, and production. Based on the project outcome, the study will suggest various measures to control the forest fire or reduce the extent of damage due to fire.

1.2 Introduction to Forest Fire

A forest fire is a large uncontrolled fire in a forested area that includes, grassland, brushland, etc. They are, destructive when it spreads over a forest or area of woodland. When they become so severe even helicopters have been put to use, besides field equipment to extinguish. A forest fire can be categorized into three major categories, viz. ground fire, surface fire and crown fire.

Fire is a prominent disturbance factor and is an agent of environmental change with local to regional impacts on land use, productivity, carrying capacity, biodiversity, and regional to global impacts on hydrological, biogeochemical and atmospheric processes (Roy et al. 2005). Small trees and regeneration are often affected very adversely. Even big trees are not spared if the fire is severe. Ground fire destroys the

organic matter, which is needed to maintain an optimum level of humus in the soil. Annual fires may decrease the growth of grasses, herbs, and shrubs.

1.3 Forest Fire in India

The mean annual temperature in India has increased by 0.72°C (as per the India Meteorological Department) over the period from 1901 to 2019. However, the rate of temperature rise has been especially rapid in the last three decades. Globally, about 98 million ha of forest were affected by fire in 2015, which comprises 3% of the global forest area (FSI, 2020). It is estimated that 75% of world forest fires are human-induced, and much of the increase in forest fires is directly linked to human actions. In April 2020, fire alerts across the globe rose by 13% as compared to last year, which was a record year for fires over the years.

The recent forecast report of the Indian Meteorological Department (IMD) stated that April 2022 was the hottest month for Central India in the last 122 years. A sum of about Rs 125 crore has been released to the States in the last three years (2018-19 to 2020-21) under the scheme, informed the Union Minister.

At an event, Dr Harsh Vardhan, former Hon. Minister of Environment, Forest, and Climate Change said: *"Forest fire management is part of our long-term vision for sustainable forest management." It is also crucial for sustaining progress towards our global pledge of creating additional sinks of 2.5 billion to 3 billion tonnes of CO2 stored in our forests by 2030.*

In India, the importance of NTFP is immense. NTFP, which is economically significant, have been recorded from over 3,000 plant species extracted from forests and associated ecosystems in India (Tewari, 1994). NTFP contribute up to 40 per cent of the household income in certain areas (Chopra, 1997). Extraction of NTFP is widespread both within and outside the protected areas. (Kothari et al. 1995), it is reported that 36% of NTFP collected from extracted from Wildlife sanctuaries in India, (although NTFP extraction is not permitted in national parks and is allowed only with special sanction inside sanctuaries; extraction is permitted in reserved and other categories of forests). Therefore, NTFP extraction from forests constitutes an attractive economic incentive for local people (A Kothari and F.V., 1997), But Forest fire destroys the source of NTFP and plays a major role in influencing the livelihood of local peoples. Apart from the damaging impact of forest fires, there is a positive impact also mentioned by a few researchers, which includes reduction of weeds and treatment of seeds like seeds of Teak. Teak seeds have a hard seed coat which after slight burning gets ruptured allowing better regeneration. But overall, there is more harm than benefits due to forest fire.

The total reported loss from the states of the union is around Rs 35 crores (US$ 7.3 million) annually. This estimate does not include the loss suffered in the form of loss

of biodiversity, nutrient and soil moisture and other intangible benefits. Based on the UNDP project evaluation report of 1987, the benefits of a pilot project at today's prices are if 40 million ha of forests are saved annually from forest fires due to the implementation of modern forest fire control methods the net amount saved at today' prices would come to be Rs 280 crores (US$ 6.8 million).

The ecological impacts of forest fires are specific to the different types of forests, situated in different climates and geographies and subject to other disturbances, particularly from people. Forests that are affected by fire may also be affected by agriculture, grazing, harvesting fuelwood and other NTFPs, encroachment or fragmentation from road building and construction, illicit felling, invasive species, and numerous other pressures.

Table 1.1. Types of Forest Fires and their Impact in India

Sl No	Category	Forest Cover (in sq km)	% Of Total Forest cover
1.	Extremely Fire Prone	20, 074, 47	2.81
2.	Very Highly Fire Prone	56, 049, 35	7.85
3.	High Fire Prone	82,900.17	11.61
4.	Moderately Fire Prone	94, 126.68	13.19
5.	Less Fire Prone	4, 60,638.36	64.54
	Total	7, 13, 789.03	100.00

(Reference: ISFR, 2021, Forest Survey of India)

1.4 Global Scenario of Forest Fire

Forest fires are a serious concern worldwide. We have read about the recent incidents in Australia and the Amazon, how severe they were, and how they resulted in the deaths of many creatures on the planet, including humans. A large forest fire usually occurs in Siberia, the Amazon, the United States, Australia, Russia etc. The California wildfire, burnt more than 2, 59, 823 acres of land which was estimated as an economic loss of about $80 billion (Goodman and Robinson, 2019).

Amazon reported more than 80,000 fire incidences in 2019, which is a 75% increase from the 2018 fires (The Verge, 2019). The causes of the fire are mostly beef and soy farming. The calculation has been done by researchers at Maryland University and concluded that there is a 3-million-hectare loss of tree cover per year as compared to 2001(World Resource Institute).

1.5 Forest fire, Tribal community and Livelihood linkages

Similar to other parts of the world, people are the main driver of fires in India as well. Population pressures, current and historic land management practices, demand for forest resources, the use of fire as a tool, negligence, and anthropogenic climate change all influence and shape the forest fire regime today. One of the driving factors for forest fires is the use of fire during the collection of non-timber forest products (NTFPs) such as Tendu leaves, Mahua flower and honey collection and to make way or for getting a better yield of fodder etc. Some forest fires are beneficial, but not all. Fire has been a part of India's landscape since time immemorial and can play a vital role in healthy forests. Many of India's forests have evolved with fire and rely on fire to regenerate. Occasional fires can also keep down fuel loads that feed larger, more destructive conflagrations. Today, however, large areas of degraded forest are subject to burning on an annual or even semi-annual basis. **The current pattern of fire is no longer beneficial to forest health, yet the extent to which fires are having a longer-term impact on India's forest ecology and its wider economy is still poorly understood.**

The ecological impacts of forest fires are specific to the different types of forests, situated in different climates and geographies and subject to other disturbances, particularly from people. Forests that are affected by fire may also be affected by agriculture, grazing, harvesting fuelwood and other NTFPs, encroachment or fragmentation from road building and construction, illicit felling, invasive species, and numerous other pressures. The ability of forests to withstand and recover from fires will depend largely on how these other pressures are managed.

Further, the livelihood of around 1.6 billion people in India, mostly tribals and other traditional forest dwellers, depends on the forest for a variety of goods (food, fodder, agriculture, housing, and an array of marketable minor forest produces) and services (amelioration of microclimate, water and air purification). Approximately 300 – 400 million people (MoEF, 2006) depend on forests directly for their survival, including about 60 million people of indigenous and tribal groups, who almost rely on forests. The tribal population has an intimate relationship with forests. Socio-cultural and socioeconomic patterns of the tribal population are inextricably linked with forests. Forests are a source of subsistence and livelihood for the tribal communities and which are increasingly getting vulnerable due to forest degradation and other developmental reasons. The vulnerability is further compounded due to its susceptibility to forest fires.

Community Forest Management Committees under FRA, Joint Forest Management committees, Eco Development Committees etc have been formed at the village level to involve people in forest protection and conservation. These committees have been given responsibilities to protect the forest from fire. The local communities also have traditional knowledge and capacities to manage and control the forest which needs to

be recognized and communities need to be engaged and involved at every stage of forest management.

The forest fires cause air pollution (Miranda et al., 2008), degrade the quality of stream water (USGS, 2012), harm the soil dynamics and structure in long-term (Verma, 2012), threaten agriculture (Ladrach, 2009), augment erosion (Sharma et al., 2008; Kumar, 2010), degrade forest and spoil the aesthetics of an area. In totality, forest fire enhances the vulnerability of forest dependents or people living in the proximity of the forest. The present study is designed to assess the vulnerability of communities due to forest fires living in proximity to the forest with the help of an index-based approach. The present methodological approach is intended to bridge the gap between community requirements and priorities at the micro level and policy processes at the macro level, with an emphasis on the fact that higher-level policy development and planning must be informed by lessons learned and insights gained at the local level. The proposed index based on a bottom-up approach aims to provide recommendations for setting priorities for action while helping to develop a robust, integrated model approach to increase resilience to natural as well as anthropogenic risks at local levels. The developed social vulnerability may also be adjusted with inputs from the existing biophysical vulnerability assessments to create holistic and integrated scrutiny of the potential impacts of a forest fire in regional settings.

In this context, SCSTRTI undertook a collaborative Diagnostic study of Situational analysis of forest fires in these two Tribal dominated central Indian states - Odisha and Madhya Pradesh. The present study has been sanctioned by the Ministry of Tribal Affairs, Government of India during FY 2021-22 and the study was conducted in collaboration with the Indian Institute of Forest Management Bhopal M. P.

The study has been sanctioned by the Ministry of Tribal Affairs, Govt. of India during FY 2021-22 and is taken up in collaboration with the Indian Institute of Forest Management (IIFM), Bhopal.

1.6 Objectives of the project

The study aims to map and assess the impact of forest fires on the local community and document the local wisdom to manage the fires sustainably. Specific study objectives are:

1. To record the patterns and trends of forest fires (in the last 5-10 years), the extent of forest fire areas and estimated losses in sample forest areas (Study area)
2. To identify and analyse the underlying causes of forest fire in the study area and the technical and organizational capacities of the local community concerning the management of forest fire
3. To assess the ecological vulnerability of the forest (successional stages, species diversity, regeneration, biomass, invasive species management etc.) and livelihood vulnerability of forest-dependent communities (NTFP, medicinal plants and tubers availability, agriculture and farm forestry/agricultural practice, provisioning of ecological services etc.) due to forest fire.
4. To map out the existing forest policies and practices of forest fire management, control and prevention.
5. To identify the cultural practices and their relation to the forest fire.
6. To develop an Action Plan on Forest Fire Management and recommend measures to be taken at the policy and field level for effective forest fire management (including institutional set up, stakeholders' coordination, policy framework, knowledge management, technical options etc.

1.7. Expected Outcomes:

- GIS map of forest fire points in sample districts and early fire detection and management mechanism
- Document the local knowledge systems and technical know-how of forest fire management
- Recommend measures to be taken at the policy and field level for effective forest fire management (including institutional set up, stakeholders' coordination, policy framework, knowledge management, technical options etc.) and
- Develop a Guideline and **Action Plan for Forest Fire Management**

CHAPTER-II

Study Area and Methodology

The study will be carried out in two Tribal Dominated Central Indian States viz Odisha and Madhya Pradesh. These states have been selected based on rich forest cover, high incidences of recorded forest fires and a high concentration of tribal/forest dwellers dependent on the forest for their livelihoods.

2.1 Review of related literature

Fires are major features of forest disruption as well as renovation. It is widely investigated that role of fire in altering floristic composition encouraging tree regeneration (Martinez- Sanchez, 1999), increasing timber production (Vinanek, 1988) and conditioning human ecology (N, 2002). Numerous findings on the effects of fire on soil properties are available in the literature.

The extent and duration of fire effects depend upon fire severity, controlled by several environmental factors that affect the combustion process, such as amount, nature, and moisture of live and dead fuel, air temperature and humidity, wind speed, and topography of the site. Fire severity consists of two components: intensity and duration. Intensity means the rate at which a fire produces thermal energy. Although the heat in moist soil is transported faster and penetrates deeper, latent heat of vaporization prevents soil temperature from exceeding 95^0C until the water completely vaporizes (Campbell, 1994), the temperature then typically rises to 200–300^0C (Franklin, 1995). The greatest belowground damage is due to perhaps fire duration. Intense but fast-moving fires at well-fuelled sites do not transfer much heat down to more than a few centimetres below the surface. After several days of the fire, the soil remains high temperature beneath the soil fires.

Fire plays an important role in soil nutrient status. The nutrients in the soil (Soil Organic Carbon, Nitrogen, Phosphorus, Potassium) decreased after the fire with increasing altitude and soil depth (Munesh Kumar, 2012).

India is having majorly three seasons (Summer, Monsoon & Winter), but forest fire is more prone in the summer season. In India, various parts of the country have different normal and peak fire seasons, which normally vary from January to June. With the prospect of central India, most forest fires occur between February and June. Forest fires in India have various impacts on ecological and socio-economic consequences such as loss of flora and fauna, global warming, soil alteration, loss of fuel wood and fodder, loss of organic matter & humus, damage to water and other natural sources and consequently leading to loss of natural regeneration. There is a study which

identifies that forest fires pollute the atmosphere by emitting harmful gases and result in the alteration of atmospheric chemistry, which is leading to an increase in surface albedo and sea level rise (Jhariya, 2012).

Hiremath, (2007), has studied that forest fire decreases the structural and biological complexity and impacts plant diversity negatively as compared to normal conditions if a fire is severe.

Kittur (2014), has assessed the historic post-fire affected area in the moist deciduous forest of Chhattisgarh and found that there is a change in the regeneration of seedlings when compared to the pre-fire site. This study has been evaluated through vegetation structure and diversity by layers, and also quantified fuel wood load by fire frequency level. this study is carried out by classifying fire-affected areas into four groups, i.e. High, Medium, low and No- fire zones. They found that there were uneven changes in species distribution across these classes. The nutshell of the study was that High and medium fire frequency have a high density of shrub species and less in low and No fire frequency sites. They also found that there is lower regeneration of tree species in the post-fire region, due to forest fire. Net Fuel load change was determined and trends were positive in High and medium classes but negative in the low and no-fire zone.

Anthropogenic reasons for forest fire are also documented by some researchers who found that low-intensity fire, affects juvenile tree species below 75 cm in height mostly. Surface fire affects leaf litter and many soil macro & micro fauna. This study was carried out by Saha in Deciduous Forest, managed by the Gond tribe of Maharashtra (Saha, 2002).

In a study of Woody tree species in seasonally dry tropical forests, were known to have traits that help to recover from recurring disturbances such as fire. They studied that two such traits were re-sprouting and rapid post-fire growth. they compared survival and growth rates of regenerating small-sized individuals (juveniles) of woody tree species after dry season fire (February–March) at eight adjacent pairs of burnt and unburnt transects in a seasonally dry tropical forest in southern India. Juveniles were monitored at 3-month intervals. High juvenile survivorship was observed in both burnt and unburnt areas. Growth rates of juveniles, analysed at the community level as well as for a few species individually (especially fast-growing ones), were distinctly higher in burnt areas compared to unburnt areas after a fire event, particularly during the pre-monsoon season immediately after a fire. Rapid growth by juveniles soon after a fire might be due to lowered competition from other vegetative forms such as grasses, possibly aided by the availability of resources stored belowground (Sukumar, 2015).

A study was conducted in Mudumalai Tiger Reserve (MTR) with aimed to analyse the effect of repeated forest fires on tropical dry deciduous forests. Although it is well

documented that among the total forest of India, more than 40% of fires occurred in the tropical dry deciduous forest (Sundaram, 2005). They stratified the area based on the frequency of fire and compared it with the control site. In the study site plots were laid down and documented according to different strata (seedling, sapling & tree). The nutshell of the study is that dominance is increased and diversity is decreased with increasing fire intensity and also long interval fire promotes seedling density (Jayakumar, 2015).

Few studies found that Forest fire is not always harmful, it depends on their severity, duration, & intensity. Control fire is very beneficial for the forest ecosystem because it burns dead and decaying matter. Forest fire also removed dead and disease-affected trees, from the forest and thus sustained the forest ecosystem (Habeck and Mutch, 1973; Loope and Gruell, 1973; Barrows, 1974). There are additional benefits, by removing trees and forest floor, sunlight reaches to ground assisting in seed regeneration (Arno, 1976). Some plant species also need some temperature or control fire to break their dormancy and germinate well to stimulate plant growth such as species of *Panderosa* pine and *Tectona grandis* in tropical countries (Goldammer and Seibert, 1990, Seth, 1978). Therefore, control fire is beneficial for light-demanding trees, because it serves the ecological function of regeneration (Molofsky and Augspurger, 1992).

Although frequency and intensity of fire change the forest drastically. If the intensity of the fire is high & frequent fire occurs, then it will disrupt the natural cycle, destroys the native plant species, and promote the growth of invasive & fire-resistant species (Kodandapani et al. 2004). (Kittur et al, 2014).

Moderate Resolution Imaging Spectroradiometer (MODIS) is a part of the National Aeronautics and Space Administration's emerging Earth System Data Records (ESDRs). The data provided by this sensor facilitate the knowledge of seasonal and inter-annual variability of fire & their long-term trends (Csiszar et al. 2005; Korontzi et al. 2006; Giglio et al. 2006).

Satellite imagery is used for calculating the seasonal and spatial changes in vegetation. Responses of vegetation are characterized and tracked through these images. While evaluating and comparing the pre and post-fire trends of the affected site, the influence of environmental conditions is taken care of. Whereas climate influence on post-fire vegetation could be described through time-series data. The application of time series data provided by MODIS for studying post-fire vegetation response has been investigated much less. However, many studies use the Normalized Difference Vegetation Index (NDVI) for examining post-fire vegetation responses.

The seasonal and spatial changes in the response of the vegetation are characterized and tracked through satellite imagery and calculating the vegetation indices. The influence of local environmental conditions is taken care of by evaluating and comparing the post-fire trends of the burned areas or forest fire-affected areas with the unburned areas. On the other hand, the influence of climate on post-fire vegetation can be explained through the interpretation of time- series data. The application of time series data provided by MODIS for studying post-fire vegetation response has been investigated much less.

Forest fire generally is a normal phenomenon, also natural fires in forests are get affected by anthropogenic fires. These fires may demonstrate damaging or helpful depending on the period or forest category. The total geographical area covered in forest land is 21.67% in India (FSI, 2019). Tropical biomass burning caused by forest fires affects the environment because it releases a lot of trace gases and aerosol particles and affects the chemistry of the troposphere and climatic anomalies (Kannemadugu et al., 2015). Every year, valuable forest resources, including carbon locked in biomass, are lost due to forest fires (Juárez-Orozco et al., 2017; Reddy et al., 2018; Pande et al. 2021). One of the largest forest fires in Turkey occurred in the Marmaris, province of Mugla in July 1996. The effective way to reduce the damages due to the forest fire is to conserve and manage the measures. Various studies have been conducted for earlier estimating of forest fires and detection during the incident time. However, today, with the development of remote sensing technology, satellite imagery is used as the most important tool to control, prevent, and monitor zones for fire and geographic information systems to integrate remote sensing and land-based information. In recent decades, researchers have predicted fire risk zones including fire risk zoning and modelling using remote sensing and geospatial applications (Roy PS 2003). A GIS was established to monitor and predict the extent of the damage, and to enhance fire management efficiency.

Currently, a forest fire is a global problem in the overall country due to rising temperatures. When forest fires started large amounts of gasses and particles are realized into the atmosphere. In addition, these emissions cause a decrease in air quality and, consequently, health problems for people (Miranda et.al. 2009; Wiedinmyer et.al. 2006). Forest fires affect more than 50 million hectares of area yearly worldwide (Ryan, 2002; Stylianidis et al., 2020). There are two ways of forest fire, i.e., direct and indirect methods. Avoid the precaution during activity in forest areas. This is a direct way; sometimes, metrological factors are responsible for forest fires. This is the indirect way. The main parameters of forest fire are dryness and moisture, wind, precipitation, and humidity (Suliman et al., 2014). Deliberate fires can be ignited for many purposes such as collecting Sal seeds after the fire, extracting illegal timber, scaring away wild animals, improving grass growth, etc. (Bhandari et al.,

2012). The forest resources are depleting at an alarming rate due to climate change impacting key ecological processes like rainfall patterns, water availability, and the sustenance of pollinators. Climate change, i.e., temperature play important role in forest fire mapping.

In recent years, the application of satellite images and, specifically, spectral signatures of the terrain (e.g., vegetation) allows researchers to obtain information on the severity of fires. According to Veraverbeke and Tran (Tran, B et.al. 2018; Veraverbeke, S. et.al. 2010), the application of spectral indices allows one to evaluate the severity of fires. Spectral indices are calculated based on spectral bands from satellite images (Mallinis, G et.al. 2018; Veraverbeke, S et.al.2013). In addition, these indices have correlation levels with vegetation biophysical parameters, such as biomass amount, photosynthetic activity, productivity and water content (De Santis et.al. 2007, 2010). The correlations between the multitemporal spectral indices allow researchers to estimate the fire's burn severity and the recovery of vegetation (Chen et.al. 2011; Navarro et.al. 2017). There are various indices available to calculate the condition of the crop but out of which is most frequently used in fire assessment is the normalized difference vegetation index (NDVI). This index is conditioned by changes in the physiological state of plant covers, and their variations are used in Spatio-temporal studies of vegetation behaviour (Ayele, G.T et.al. 2018, Ariza, A. et.al. 2019). NDVI is the index which is used in many studies and it is very much useful in a forest fire. When the fire started, it damages the forest where there is a low amount of vegetation available or the soil moisture content is very low in this particular area that condition forest fire spread very easily, but a high amount of green vegetation, soil holding the water in high amount hence the moisture is high, fire spreading intensity is very low and forest damage rate is also decreased. By collecting the data from pre-fire and post-fire comparing these data get accurate results that how much area is damaged due to forest fire are studied by using this NDVI. This NDVI is computed by using many satellites like a sentinel, Landsat etc. the result will differ according to a resolution of a satellite. In formula NIR (Near infra-red) and RED, bands are must based on these two bands.

Satellite data, Global Positioning System (GPS), Geographical Information Systems (GIS), population, and other socioeconomic data were integrated to estimate and forecast LULC transition patterns with greater accuracy as well as to understand the different drivers of anthropogenic land-use change (Hathout, 2002). The GIS and remote sensing software is a powerful tool in this endeavour for quantifying the urban sprawl and other land changes and forecasting urban area expansion using spatial modelling (Pande et. 2018). Land-use and land -cover (LULC) are the basic portions of the Earth's surface and if any change has substantial effects on human society, climatology, biodiversity, and water cycles (Baldyga et al., 2008; Were et al., 2014;

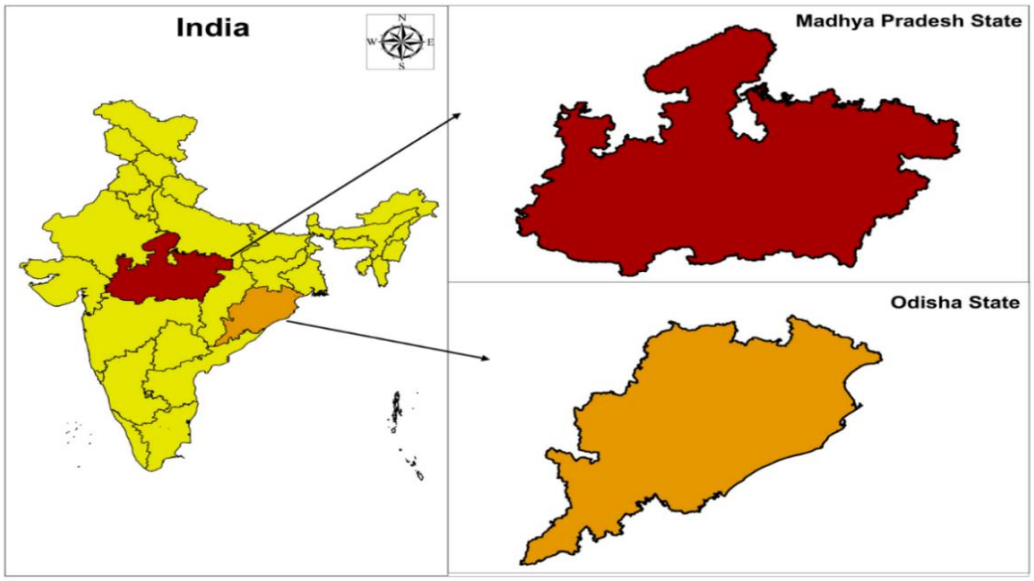
Tajbakhsh et al., 2020). Moreover, changes in LULC and their fragmentation for sustainability and global environmental stability are a big concern for earth scientists (Turner et al., 2007). The reason behind land cover fragmentation and ecosystem losses might be associated with agricultural practices and infrastructure build-up, over-uses of natural resources, forest fire and environmental pollution, etc. (Singh et al., 2018). To develop sustainable land use plans and devise future landscape variations for resource management policies, therefore, it is essential to study the spatiotemporal dynamics of LULC changes for protecting these valuable natural resources. In forest fire two season data of LULC are very important, the assessment of damage is computed very easily. The image interpretation technique is very important to classify the land into different categories like agriculture land, barren land, scrub land, waterbody, forest, built-up land etc. LULC classes are classified according to level i.e., Level I, Level II, and Level III. The broad classes are present in level I then these broad classes are subdivided into sub-classes in level II and sub-classes are again divided into minor classes in level III. These level III data are computed using remote sensing techniques by the processes of image interpretation. Hence remote sensing technique is very much useful to protect natural resources like land, water and the environment.

A study was conducted in Odisha Districts, based on Spatial analysis of Fire Characterization along with various gradients of Season, and revealed that Kandhamal, Raygada and Kalahandi Districts had a high incidence of Fire. These Districts covered almost 38% of Total Forest Fire events in Odisha. The Forest Type of these districts was Dry Deciduous Forest, Tropical mixed deciduous forest Tropical lowland forest etc. The study also resulted in approximately 70% of forest fire events occurring in a Highly tribal populated area. Elevation also played a significant role in forest fire events, 60% of fire events happened at an elevation of more than 500 m and approximately 48% of fire events happened on moderate slopes (Firoz Ahmed et al, 2018).

Suchitra Rout, et al (2014) studied the ethnomedicine of Bondo PVTGs in Malkhangiri Districts Odisha and identified 34 Plant species belonging to 33 genera and 25 families. These plants are used for the treatment of about 17 ailments, including headache and toothache. Mostly *Fabaceae, Caesalpiniaceae* and *Acantharean* were highly used for medicine preparation

2.2 Study Area

This study is done in two Tribal Dominated Central Indian States viz. Odisha and Madhya Pradesh (Map 1). These States have been selected based on being the top two states in forest fire instances, having rich forest cover, and a high concentration of tribal/forest dwellers dependent on the forest for their livelihoods.



Map 2.1: Selected Study States

2.3 Sampling Design

A purposive sampling method will be adopted to identify the study districts/ forest areas based on the following criteria

- Total Forest Cover (Dense, Moderate and Open Forest)
- Frequent incidence of forest fires in the past
- Dependence of tribal/PVTG population on the forest for their livelihood and other subsistence needs
- Forest with rich ecological diversity (preferably sanctuary or biosphere reserve)

Criteria for selecting forest divisions are as follows: -

1. The selected forest division and forest range area should have a high percentage of the tribal population.
2. The selected forest area (Division/ Range) should have a high frequency of forest fires within the last ten years, i.e., counting 2021 as zero years.
3. The area should have representative forest types of the study States.

Based on the above criteria a total of 15 forest areas will be identified in each of the State

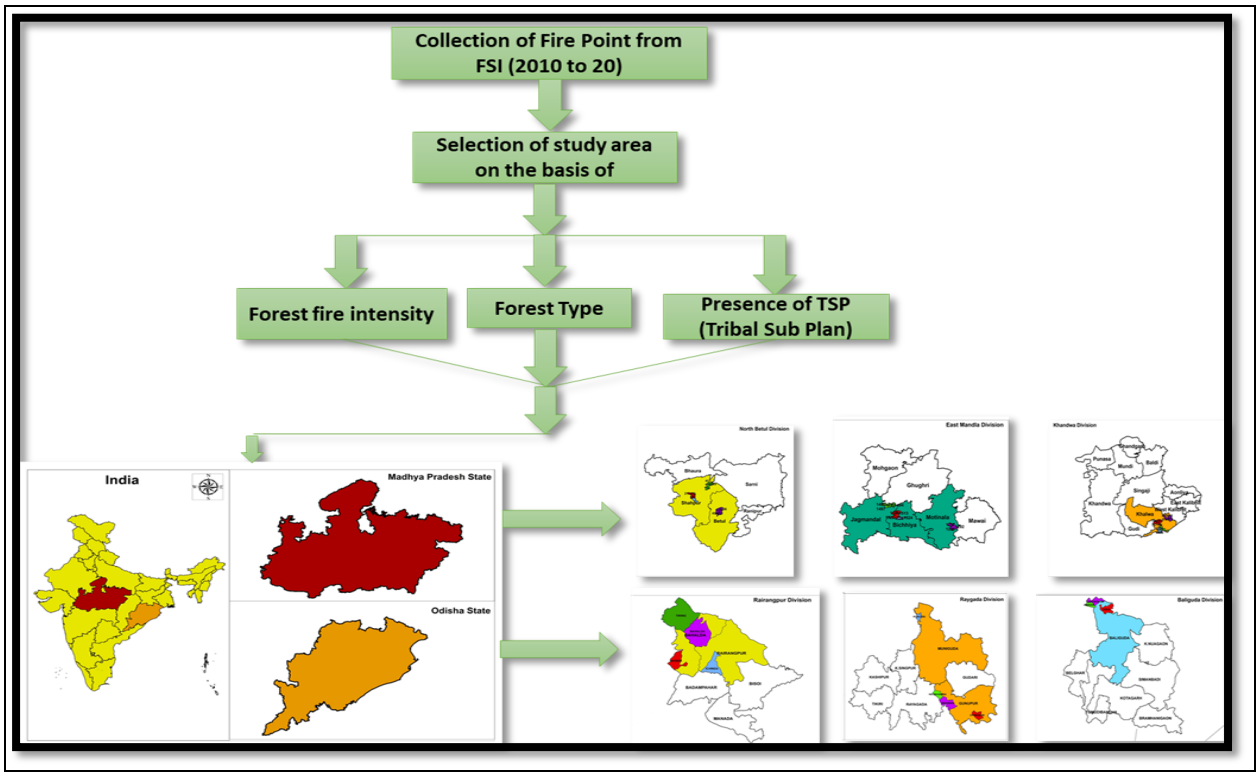
- 5 Forest Areas with high occurrence/incidences of forest fire
- 5 Forest Areas with reduced incidence of a forest fire over the last 5 years
- 5 Forest Areas with negligible incidences of forest fire

As per the above criteria selected three Districts of each study State (Madhya Pradesh and Odisha), where those districts are fulfilling the criteria for the Diagnostic Study of Fire. Accordingly selected these forest types, which is based on the rich biological

diversity and economic importance of particular forest types. These forest types are represented in large areas in both states (M.P. & Odisha). (see table 2.1 and Map 2)

Table 2.1 Sampled districts and villages from Odisha and Madhya Pradesh

States	District/ Division	Fire Vulnerability	Rural ST Pop %	PVTG /ST	Forest Type
Madhya Pradesh	Betul	High	50.41%	Gond, Korku	3B/C1c Southern tropical moist deciduous Teak/ slightly moist deciduous Teak 3B/C2 Southern tropical moist mixed deciduous forest
	Khandwa	High	41.95%	Kol, Korku, Saharia, Baiga	5A/C1b Southern Tropical Dry Deciduous Teak Forest 5A/C3 Southern Tropical dry mixed deciduous forest.
	East Mandala	High	63.85%	Gond, Baiga	3C/C2e Moist peninsular Sal Forest
Odisha	Rairangpur	Moderately Vulnera	58.7%	Santal, Kolha, Bhumji, Ho	3C/C2e (i) Moist peninsular high-level Sal 5B/C1b Dry plains sal forest
	Baliguda	High	54.5%	Kandha	5B/C1c Dry peninsular sal forest 3C/C3b East Himalayan moist mixed deciduous forest etc
	Rayagada	High	56%	Kandha, Soura (PVTGs)	5B/C1c Dry peninsular sal forest 5A/C2 Dry red sanders-bearing forest



Map 2: Sampling and Map of Selected Forest Divisions and Ranges

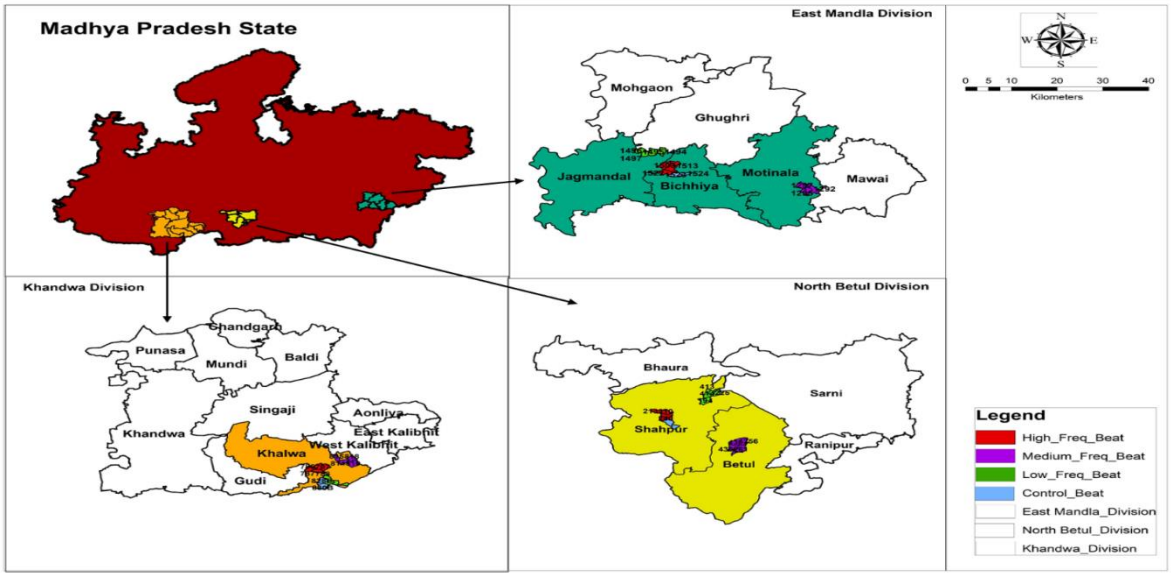
The above table gives broad details of the selected forest divisions based on the selection criteria, further, these Divisions are again categorized into Ranges and Compartment, where most of the fire events are documented.

To reach out the sampling criteria use of the Remote Sensing tool was done to select Forest Range and Compartment or beat in both states (M.P & Odisha) (Tables 2-2 and 2.3 in Annexure). The procedure followed for the selection of sample areas is as follows

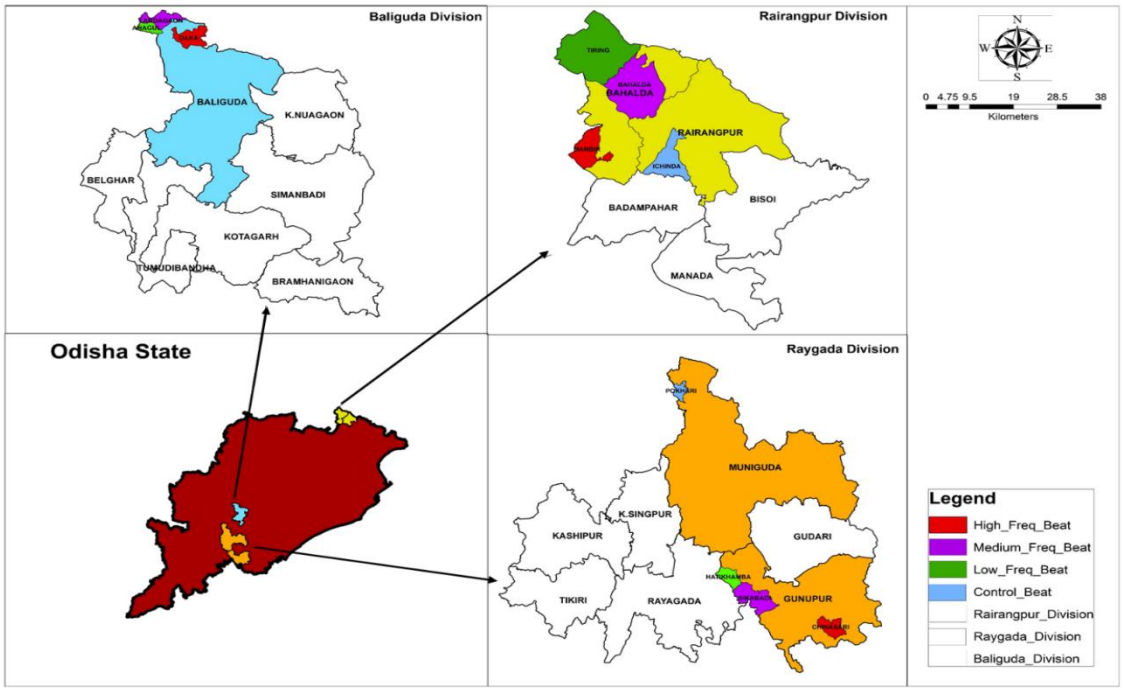
1. Collected the fire points 10 years' data (2010 to 2020) from FSI.
2. Selection of study area based on forest fire intensity, presence of tribal community and Forest type
3. Prepared the cluster of four compartments in the selected range and categorised it into four categories based on fire frequency. (a) High-frequency zone, (b) Medium frequency zone, (c) Low-frequency zone and, (d) Control Site for reference study.

A stratified sampling approach has been used for categorising the fire-affected areas in selected divisions of M.P and Odisha. The following fire intensity zones identified based on the number of times the fire reported in the compartments and they are namely, High-intensity fire [5-9 years of fire incidences], Moderate intensity fire [3-5 years of fire incidences], Low-intensity fire [1-3 years of fire incidences], and Control with fire incidences years 0 respectively. The data on fire are collected from the authentic data source i.e., the Forest Survey of India.

In the table (Tables 2-2 and 2.3 in Annexure) of Odisha column, no 4, in the Baliguda range, no area was found as proposed for control, because in the last 10 years, no area was found non-affected by fire.



Map 3: Location of sampled ranges and fire frequency, Madhya Pradesh



Map 4: Location of sampled ranges and fire frequency, Orissa

2.4 Parameters and Indicators

The parameters used for these studies are broadly classified into 3 categories, which are Remotely sensed data to know the frequency and extent of forest fire, Ecological parameters for biodiversity analysis and social parameters to know the causes, social structure and economical losses of forest-dependent communities, residing around the forest fringes, who are totally or partially dependent on Forest for their direct and indirect needs (see annexure II for details of Remote sensing parameters).

A) Ecological Parameters

i) Importance Value Index (IVI)

The Importance Value Index (IVI) was also calculated to measure how dominant a species is in the given strata. IVI is the sum of relative frequency (Rf%, the per cent of inventory points occupied by species A as a per cent of the occurrence if all species), relative density (Rd%, the number of individuals per area as a per cent of the number of individuals of all species) and relative dominance (Rc%, total basal area of species A as per cent of total basal area of all the species).

IVI = RF + RD + RBA or dominance

The importance index value ranges between 0 and 300. The high importance value indicates that Species is well represented in the stand because of a large number of species, compared with other species in the stand or smaller number of individuals of species but, the trees are large compared with others in the stand. It is not possible to draw exact inferences in the absence of a baseline

situation. However, we are referring compartment history of the Forest Working Plan and also discussing the species diversity with the local people.

ii) Plant Bio-Diversity (Shannon & Simpson Index)

The species diversity and divergent component assessment is the measure of the species richness (the number of species present) and species abundance (the number of individuals present) and the relative distribution of trees and regenerative seedlings/saplings in the region. Diversity indices were calculated based on the primary data collected from the tree enumeration form and regeneration form from the sample study sites.

Two types of diversity indices were computed for this, namely the Shannon index, an information statistic index which assumes all species are represented in a sample and that they are randomly sampled. The other index is Simpson's index, a dominance index which gives more weight to common or dominant species.

$$\textbf{Shannon Index (H)} = \Sigma\ pi\ ln\ pi$$
$$\textbf{Simpson Index (D)} = 1/\ (\Sigma\ pi2)$$

Where p is the proportion of individuals of one particular species found (n) divided by the total number of individuals found (N).

j) Regeneration Survey

Regeneration surveys are generally carried out to measure the new stocks of forest tree species. One of the measure objectives of the regeneration survey is to know, whether there is a sufficient number of species present or not, to support the future forest stands of any forest area/cover. The regeneration survey usually includes the tree species composition, stocking, and age class. If the area has above than 2500 established plants, it comes under profuse regeneration, 1500-2500/ha referred to as adequate. 500-1500/ha is referred to as moderate and below 500/ha regeneration comes under the poor regeneration category.

B) Socio-Economics Parameters

- Wide Stakeholder Consultations (consultations with forest department officials of respective study states, ground level forest staff, consultation with civil societies,
- Local community consultations
- House Hold Survey, Focused Group Discussion and Key Informant Interview will form the main tools for the study.

- Besides, the above methods case study method will also be used for the study.
- While the study will depend upon the primary sources of data, that is the field, secondary sources will also be tapped for capturing information.
- Ecological assessment tools, GIS mapping and SPSS will be used to quantify the data for a detailed analysis and preparation of the Action Plan of Forest Fire Management.

a. Age Classification of Forest Dwellers

Studying the age of villagers in nearby forest areas is important. By doing this we can find who are the earning members and how many people are dependent on the forest. Finding the age classification can give us the following results-

a. The persons of which age class would be going to the forest for collection of fuelwoods and for doing other forestry works and these are the probable persons who are involved in setting the area to fire. So, more meetings with them are required for reducing forest fires.
b. Based on this number, we can estimate the income per family.
c. Persons between 10 to 17 years are important as they are the future of the village, hence more emphasis is given to their teaching. they can be given more information about the conservation of forests.

b. Income from NTFPs

NTFPs are an important source of earning for the villagers especially tribals because this is an income source available nearby their village only and the NTFPs are generated every year by the nature. For any other employment, there has to be a budget and then a long sanction process to be followed and after that, the particular job can be created in a particular village. This development work may continue for a year or two. Whereas the NTFP availability is maintained for a long time and can be maintained for any length of time if proper measures are taken for their sustainable harvesting. Income from Tendu Patta is recurring every year. Though the rate for each Gaddi (a bunch of 50 tendu leaves) varies between Rs 1.50 each in Odisha to rs 3.0 each in Madhya Pradesh. So, though the income may vary from one state to another income is sustained. Income from NTFPs will give an idea about the dependency of tribals on the forest nearby.

a) Work Classification of Tribals

This study would give us information about the involvement of tribals in different works e.g., cultivation, Daily labour, forest produce collection etc. This would also give us the seasonal dependency of tribals on the forest.

b) Losses from Forest Fire

Losses from forest fire (including health/goods/environmental losses) Tribals residing in the vicinity of forest are affected by forest fire for their day-to-day needs. In this study, their actual loss was estimated to know the after-effects of forest fires. This loss was roughly estimated in monitory terms.

c) Fire Response/Perception of Villagers

The perception of villagers reveals their attitude toward the forest fire. The fringe villagers and their ancestors who have lived in the forest for a long time also share their perspectives on the temporal changes, causes, and consequences of forest fires over the years. Their wisdom also helps us to know the traditional practises to combat forest fires.

2.5 Tools and techniques of data collection

A. Primary Data Collection

1. **Plot Enumeration**

   For this purpose, sample plots are laid in all the categories of the forest as selected based on fire frequency i.e., areas of High, Medium and low frequency of fire and control areas as found through MODIS data. A minimum of 10 sample plots of 20m*20m size have been laid out for the study of growing stock and regeneration of tree species and within this plot small plots of 2m*2m size 5 number in each 20m*20m plot laid out for regeneration study (grasses and other herbs). Plots are taken 200 meters apart keeping in view the representative forests to be covered necessarily. In the field study, the regeneration status of NTFP species was taken with special care.

2. **Focused Group Discussion**

   A focus group discussion survey was done by the team, to gather social data regarding forest fires. FGD is a tool, we applied to cover qualitative research, where we float a question among people and their perceptions, observation, opinion and beliefs about forest fire were discussed and documented. The group of people generally involved 8-10 in numbers of all groups (male & female). They were free to talk about the problems, impact, solutions, suggestions, and co-ordination with the department person during the fire year.

3. **Personal Interview**

   Personal Interview has been conducted in the form of a structured schedule, drafted to know the individual's dependency on the forest, their social structure, economic conditions, sources of income, NTFP collection and perception of the forest fire.

4. **Case Study**

   In addition to the primary household survey, the case study method was adopted for the study of Vana Suraksha Samithi (VSS) and JFMCs. The method used to know about the good and bad practices of Forest Fire Management at the village level.

5. **KII (Key Informant Interview)**

   Key Informant interview has been conducted for the department person to forest range level. They help us to know the technical, social, and organizational aspects of forest fire management.

B. Secondary Data

Secondary data has been collected through various govt websites, published journals, reports, forest working plans, and many other platforms to gather information about forest fire studies in India, selected states and selected forest divisions. The data retrieved from various sources are authentic and verified.

2.6 Profile of Odisha and Madhya Pradesh Districts, Forest divisions

The tribal population of the country, as per the 2011 census, is 10.43 crore, constituting 8.6% of the total population. They live in various ecological and geo-climatic conditions ranging from plains and forests to hills. Scheduled Tribes are collectors of forest produce, hunter-gatherers, shifting cultivators, pastoralists and nomadic herders, and artisans. Traditional occupations of tribal groups may range from honey-collection to hunting small animals to engaging in metal-work and rope-making.

A. Profile of Odisha

The State has a geographical area of 155,707 km^2 and extends for 1030 km from north to south and 500 kilometres from east to west. Its coastline is 480 km long. The State of Odisha is located in the eastern part of our country along the Bay of Bengal. It is bounded by Andhra Pradesh in the South, West Bengal in the North, Jharkhand in the North West and Chhattisgarh in the West. The state is divided into 30 districts for administrative purposes. Odisha is home to some of the primitive tribal communities of our country and about one-third of the area is under forests.

a) Forestry and Tribal population of Odisha

The State has reported the extent of recorded forest area (RFA) as 61,204 sq km which is **39.31%** of its geographical area and has very rich faunal and floral diversity. Floral Diversity has the important trees of Teak, Sal, Bamboo forests, and lush green mangroves on the coast. According to the Forest Classification by Champion and Seth, Odisha has five major forest types, namely tropical semi-evergreen, tropical moist deciduous, tropical dry deciduous, subtropical broad-leaved hill forests, and littoral and swamp forests. The coastal areas have low forests and high population density.

As per the Census 2011, the state of Odisha has the third highest percentage of tribal population in the country which stands at 9590756. The state has the unique distinction of having 62 different tribal communities spread over 30 districts and 314 blocks. They constitute 22.85% of the total population of the state and contribute 9.17% to the total tribal population of the country.

The districts of Gajapati, Kandhamal, Keonjhar, Koraput, Malkangiri, Mayurbhanj, Nabarangpur, Rayagada and Sundergarh have more than 40% tribal population. The uniqueness of Odisha is that 62 ST groups are residing with their specific culture and living standards, which is the highest among all the states of the country.

There are 12 major tribes such as Kandha, Gond, Santal, Saura, Kolha, Munda, Paraja, Bhuyians, Kisan, Oraon, Koya and Gadaba. According to their origin and habitat, they are variously designated as Adimajati (primitive castes), Janajati (folk communities), Girijana (hill folk), and Vanajati (forest dwellers).

B. Madhya Pradesh

Madhya Pradesh has a total geographical area of 3, 08, 245 sq km, making it the second largest state in India. The state has the state boundaries of Uttar Pradesh in the north, Chhattisgarh in the east, Maharashtra in the south, and Gujrat and Rajasthan in the west. The climate of the state is subtropical. Alluvial, Medium & Deep Black, Mixed Red & Black are the soil. There are 11 different agro-climatic zones in the State.

According to the 2011 census, the total population of Madhya Pradesh is 7.27 crore, with 3.76 crore males and 3.51 crore females. There are 46 recognised scheduled tribes in Madhya Pradesh, India, three of which have been identified as 'Particularly Vulnerable Tribal Groups" (PTGs) (formerly known as "Special Primitive Tribal Groups). They are Bharia, Baiga, Sahariya. The population of Scheduled Tribes (ST) is 21.1% of the state population (15.31 million out of 72.62 million).

b) Forestry and Tribal population of Madhya-Pradesh

The forests of the state are rich in timber and non-timber forest products. NTFPs have been traditionally collected, processed, and sold by the tribal people and form an important source of cash income for them. Estimates indicate that nearly 100 million person days of employment are generated in the forestry sector, and the largest share (70%) of these accrues to the tribal residents of the forest areas.

As per the law, free timber trade is prohibited all over the country, but most of the employment generation in forestry takes place through the collection and sale of non-timber forest products (NTFPs). The five most important NTFPs are nationalized (Tendu Patta, Sal seed,) with the Madhya Pradesh State Minor Forest Produce Co-operative Federation having monopoly rights of collection. The federation undertakes the collection of nationalised NTFPs through primary cooperative societies. The most important NTFP from a livelihood generation point of view is *Tendu Patta,* Head loading of firewood in nearby towns is frequent and provides critical income to poor households.

2.7 Studied Districts and Forest Coverage: Odisha Divisions

2.7.1 Baliguda Division

Baliguda Division lies between 19°-34' N and 20°-40" N latitude and 83°-30' E and 84°-15' E, longitude. The total geographical area of the Division is 5627.45 sq km. The forest extends from the Daringbadi block in the east to Lankagarh and Jhiripani "C" blocks in the west and from Khamankhol, Barakhamba blocks in the north to Durgapanga, Srirampur, Lasseri and Dadangi block in the south. Most of the area forms part of the Mahanadi catchment, Vamsadhara catchment and Rushikulya sub-catchments.

The major forest types of Baliguda division are: - Moist Tropical Forests 3 C/C3b Moist mixed Deciduous Forests,3c/c2e Moist Peninsular Sal Forest.

2.7.2. Rairangpur Division

Rairangpur forest division headquarters is located at 22º27´N and 86º17´E. The average elevation of the division is 248 meters. Temperature ranges from 13ºC in January to 40ºC in May. The average rainfall is 622.18 mm. Hills in this division are rich in Iron ore.

Major forest types as per champion and Seth classification are: -3C/C2e Moist Peninsular high-level sal forest and 5B/C1 b Dry plains sal forest.

Main tree species found in this forest are- *Shorea robusta* (Sal). *Terminalia tomentosa* (Saja), *Adina cordifolia* (Haldu), *Lagerstroemia parviflora*, *Bridellia retusa*, *Hymenodictyon exelsum, Pterocarpus marsupium, Gmelina arborea, Salmalia malabarica.*

2.7.3 Raygada Division

This division lies between 18º14´ N to 19º58´ N and 82º25´ E to 84º02´ E. Total geographical area of the division is 7073 sq km, Rainfall in this area is mostly from the South-West monsoon. Average rainfall varies from 1030.2 to 1569.5 mm.

The major forest type in the division is: - 5B/ C1c Dry Peninsular Sal Forest. 3C/C2e Moist peninsular high-level Sal and 5B /C2 Northern dry mixed deciduous forest.

2.8 Studied Districts and Forest Coverage: Madhya-Pradesh

2.8.1 Khandwa

Khandwa Forest Area is situated within the Khandwa, Pandhana, Khalwa, Harsud, and Punasa tehsils of the Khandwa district. The area lies between $21^0$32'00" and $22^0$25'00" North latitudes and $76^0$00'30" and $77^0$13'30" East longitudes.

The climate of the division area is sub-tropical with three well-defined seasons. The rainy season is from mid-June to September. During this season, the area receives more than 80% of its rainfall due to the southwest monsoon. Some winter rains are also there due to the retreating monsoon. The average rainfall of the area varies from 824.2 mm to 984. During summer, the average maximum temperature is 41.90 °C and the average minimum temperature is 8.10 °C. The overall climatic conditions are not very suitable for the good growth of the plants.

Forests are mainly of the southern dry deciduous type, in which teak is the main type. Out of the total forest area, teak forest covers 73.77% of the area. In addition to the teak forest, the miscellaneous forest covers 8.43%. The main associates of teak are Dhawda, Lendia, Saja, Moyen, Palas, Tendu, Anjan, Salai, Bamboo, etc. Marodphalll, Sirali, Ber, Dudhi, etc. are the main species in the undergrowth.

2.8.2. North-Betul

The total area covered by this plan is 119176.32 ha, which extends over six ranges, i.e., Bhaura, Betul, Shahpur, Sarni & Ranipur ranges of the north Betul (T) Division and Gawasen range of the west Betul (T) Division. It includes the reserve, protected forests, and demarcated orange areas. The forests of the area are broadly classified into dry deciduous teak or mixed forest with or without bamboo. According to the revised classification of forest types in India by H.G. Champion and S.K. Seth, the forest of the plan area falls under subgroup 3-B (South Indian tropical moist deciduous forests). 5-A (Southern tropical dry deciduous forest), 4-F/R-5 (riparian fringing forests) and 5/E-2 (Boswellia forests).

The main species found in the plan area are Teak, Saja, Dhawda, Saja, Haldu, Tendu, Papra, Gunja, Bahera, Kahwa, Kusum, Achar, Aonla, Katai, Dhaman, Kari, Tinsa, Khair, Amaltas, Palas, etc. as tree species. Apart from the major tree species, an

enormous NTFP collection is being done in this forest area. The dependence of people living near forests on forests for fuel-wood, fodder, and small timber is too high.

2.8.3. East-Mandla

The total geographical area of the Working Plan is 3338.30 sq. km. The forest accounts for 36.62 per cent of the total land area. The working plan area has a subtropical climate with three well-defined seasons. The rainy season is from mid-June to September. The area receives about 1177.1 mm of rainfall due to the southwest monsoon during the season. The average rainfall of the plan area is 1413.2 mm. The average maximum temperature ranges from 35.10 to 43.90 during the summer. The overall climatic conditions are suitable for the good growth of plants.

The forest area mainly consists of teak, sal, and miscellaneous forest with a few patches of bamboo undergrowth.

2.9 Profile of sampled Villages

For the study of forest fire there is a total of 36 villages have been chosen (both from Odisha and Madhya Pradesh) in multi-stage sampling according to the availability of tribals, Forest distance and dependency on the forest. The selected villages are tribal-dominated and dependent on the nearby forests.

A. Sampled villages of Odisha (18 villages)

Odisha is dotted with many ancient tribal villages. Odisha has the largest number of villages in its territory. 47,477 (census 2011) villages are there in Odisha. By 2023 the numbers are likely estimated at 50,000, as the state government converted most hamlet villages into revenue villages. A total of 18 villages listed below are the sample from three divisions (Baliguda, Rayagada and Rairangpur) of Odisha state. Social data analysis and forest dependency were collected from these villages and relation with forest fire was documented. The demographic details of population, group classification and total households of villages are given in annexure III.

B. Sampled villages of Madhya Pradesh (18 villages)

Madhya Pradesh state has rich forest cover, a large number of National Parks and a tribal population. As per the census of 2011, there is a total of 51,527 villages in Madhya Pradesh state. In Madhya Pradesh total of 18 villages (from Betul, Khandwa and Mandla dist.) have been selected for the analysis of social data and forest dependency. The demographic details of population, group classification and total households of villages are given in annexure III.

2.10 Profile of the communities in the study area

"Scheduled Tribes" and other tribes are highly dependent on nature for their survival. The majority of Scheduled tribes live in forest fringe villages (FFV). Forest plays an important role in socio-cultural practices among the tribes.

There are 75 Particularly Vulnerable Tribal Groups (PVTGs) in India which are small in number, and socially and culturally different vulnerable. They live in remote habitations with low administrative and infrastructure facilities depending mainly on traditional occupations such as hunters and food gatherers. Few numbers are depending on cultivation in small land holdings depending on shifting cultivation. There are some PVTGs even on the verge of extinction, due to their aboriginal nature, they still roam in jungles for hunting and food gathering.

2.10.1 Profile of the STs/PVTGs in the Sampled districts of Odisha

As per the 2011 census, the proportion of the tribal population in Odisha is 22.85% which is much higher as compared to the national figure. In Odisha, there are 62 Scheduled Tribes, out of them five tribes have been found in our study divisions. In the Rairangpur division Santal, Kolha, Bhumij, and Ho (Scheduled Tribes) are found. Kandha Tribe only comes under the study in both Baliguda and Rayagada divisions. There are 13 Particular Vulnerable Tribal Groups(PVTGs) in Odisha. Out of them, only one PVTG Saora comes under study in the Rairangpur division.

a) Description of Tribal Communities

"Santal" - The Santals, one of the populous tribal community of India, are mainly found in the districts of Mayurbhanj,Keonjhar and Balasore of Odisha.The word 'Santal' is derived from two words; santa meaning calm and peaceful and ala meaning man.Among the Odisha tribes, the Santals are an advanced tribe.The primary occupation of the Santal is settled agriculture. According to 2011 census, the total population of Santal is 894764 in Odisha.

"Kolha" - the name Kolha is derived from the Monad word Kop, which means 'they are their own. Kolha tribe is mainly found in the district of Mayurbhanj, Keonjhar and Balasore. According to the 2011 census, the population of Kolha tribe is 625009 in the state. Their primary occupation is cultivation and wage labour.

"Bhumij"- the term "Bhumij" denotes one who is born from the soil. They are believed to be a branch of the Munda Tribe. Bhunij Tribe is found mainly in the Mayurbhanj district of Odisha. According to the 2011 census, the population of the Bhumij tribe is 283909 in Odisha.

"Ho" - the 'Ho' is one of the major tribes in Odisha belonging to the Proto-Austroloid group. The name 'Ho' is derived from the word 'horo' which, in their language means man. Hos have mainly inhabited Keonjhar and Mayurbhanj districts of Odisha. According to the 2011 census, the population of Ho is 80608 in Odisha.

“Kandha” - In Odisha, Kandha is numerically the most populous tribe and the major tribe of the state. The word Kandha is derived from the Telugu word Konda which means a small hill as well as the hill men. Based on socio-cultural characteristics, The Kandha tribe is divided into mainly three sub-sections such as; Desia Kandha, Dongria Kandha and Kutia Kandha. Kutia Kandha and Dongria kandha have been identified as Particular Vulnerable Tribal Groups(PVTGs). Kandha Tribe is mostly found in Kandhamal and Rayagada districts. According to the 2011 census, the total population is 1627486 in the state.

“Saora (PVTG)” - the “Saora” are a great ancient tribe. They are not only numerical important but also a historically and culturally significant tribal community of Odisha. The term Saora appears to have two connotations, one derived from the Sagories, the Scythian word for axe, and the other from Saba Roye, the Sanskrit term for carrying a dead body. Both of them fit well with their habit of always carrying an axe over their shoulder and their primitive occupation of hunting and living on the spoils of the chase. They inhabit a contiguous mountainous territory stretched across the Rayagada and Gajapati districts of Southern Odisha. According to the 2011 census, the total population of Saora is 709349 in Odisha.

2.10.2 Profile of the STs/PVTGs in the Sampled districts of Madhya Pradesh

Madhya Pradesh holds the first rank among all the States/Union Territories in terms of Special Tribal Population, and 12th rank in respect of the proportion of ST population to the total population. According to the 2011 census, the population of Scheduled Tribes (ST) is 21.1% in Madhya Pradesh. There are 46 recognized Scheduled Tribes in Madhya Pradesh, out of them 4 tribes reside in our study divisions. In the North Betul division Gond, Korku, Tribes, Gond, Korku, Barela, and Bhilala are found in the Khandwa division and Gond are found in East Mandla under the study. There are three PVTGs in Madhya Pradesh and out of them only one PVTG Baiga comes under study in East Mandla.

b) Description of Tribal Communities

“Gond” - the Gond are a Dravidian ethnolinguistic group. They are one of the largest groups in India. They are spread over the states of Madhya Pradesh, Maharashtra, Chhattisgarh, Uttar Pradesh, Telangana, Andhra Pradesh, Bihar and Odisha. The Gond have formed many kingdoms of historical significance. According to the 2011 census, the total population of Gond is 5093124 in Madhya Pradesh.

“Korku” - Korku is the main tribe of Madhya Pradesh. The meaning of the word “Korku” is “Group of men”. The Korku tribe is considered to be a branch of the Munda or Kolorian tribe. The major population of this tribe lives in different districts of Madhya Pradesh. The Korku tribe use to live in hilly areas and depend on agriculture.

According to the 2011 census, the total population of Korku is 840027 in Madhya Pradesh.

"Barela" - The Barela are a part of the Bhil group. They are a scheduled tribe that lives in the state of Madhya Pradesh in Khargone and other places of that state. They speak Rathi among themselves. The Barela work mainly in agriculture and labouring. According to the 2011 census, the total population of Barela is 1182000 in Madhya Pradesh.

"Bhilala" - Bhilala tribe is a small caste largely found in the central region of India. Bhilala tribe is considered a mixed caste that originated from the alliances of immigrant Rajputs with the Bhil tribe of the hills of central India. The Bhilala Tribe is belonging to the Indo-Aryan language family. The Bhilala are landholders and live like mukhiyas, darbar or Thakur. According to the 2011 census, the total population of Bhilala is 150000 in Madhya Pradesh.

"Baiga (PVTG)" - The Baiga tribe is the PVTG tribe of Madhya Pradesh. The Baiga tribe is the sub-group of Munda & Kol. Developed people of the Baiga tribe got a special title and are known as "Bizwar or Jamindar". Baiga people use to collect forest products from the forest and sell it in the market to earn their livelihood. They are a very good archer and use to hunt animals and also do fishing. According to the 2011 census, the total population of Baiga is 414526 in Madhya Pradesh.

2.11 Livelihood Profile of sampled villages of Odisha and Madhya Pradesh

Various study experience shows that socio-economic factors contribute significantly to disparities in forest fire among the Scheduled Tribe / PVTGs. Keeping this in view, the research team tried to find out the livelihood conditions of the forest dwellers through FGD and personal interviews. Besides, during interaction with the forest dwellers, their perceptions and views were recorded. The team also attempted to study the perception and views of different stake holders like The Scheduled Tribes / PVTGs, Other traditional Forest Dwellers, JFMC, VSS members, and Non-VSS members through FGDs and individual interactions.

2.11.1 Age classification of Forest Dwellers

The evaluation study has attempted to find the livelihood background of forest dwellers. For this purpose, each 10 forest dwellers from each sample village of the selected divisions of Odisha and Madhya Pradesh were interviewed. A total of 360 participants (Odisha – 180, Madhya Pradesh – 180) were covered in the study.

The field survey was conducted to evaluate the forest fire in both states Odisha and Madhya. Is a tribal house, a family is dependent on the forest/Nature for day-to-day life? Therefore, most of the members of the family usually visit the forest to full fill their needs. The age group is classified as "Under 18 years", which is considered as "under

age". Age group "Between 19-30 years", which is classified as "Well productive age group". "Between 31-60 years" as the "least productive age group". Besides this, the age group "above 60" is a senior citizen forest dweller category.

From the table (annexure VI) it is visible that Odisha has 81.7% of Forest dwellers aged between 19-30 years. Similarly, 11.1% of forest dwellers belong to the age group of 31-60 years. i.e is classified as a less productive age group. On the other hand, in Madhya Pradesh age group of 19-30 years is 52.2% and the age group of 31-60 years is 40.6% in the case of forest dwellers. Form the study it is found that from total samples the productive (19-30 years) age group of forest dwellers is 66.9%. Similarly, the percentage of the least productive (31-60 years) age group of forest dwellers is 25.8% and in the case of the senior citizen, forest dwellers account for only 1.7% of the study sample. The underage forest dwellers are found in 5.6% of the study villages.

2.11.2 Caste and Tribal Classification

The study villages are selected near the forest areas. Though the survey tries to focus mainly on the tribal people FRA act 2006 includes all the other traditional forest dwellers. The caste of sampled forest dwellers reveals that the majority of forest dwellers i.e 70.6% (127 out of 180) belong to the ST population in Odisha and 82.2% (148 out of 180) belong to the ST population in Madhya Pradesh. In the survey 76.4% population belongs to tribal forest dwellers. Similarly, 17.8% and 4.2% of forest dwellers are classified as General and OBC of a total of 360 samples.

2.11.3 Tribal Classification

Out of 180 sampled Forest dwellers of Odisha, 31.1%(56) are belongs to Kandha Tribe, 12.8%(23) are belongs to Santal Tribe, 11.7% (21) are Kolhaa Tribe, 11.7%(21) are Paraja Tribe, 3.3%(6) are Ho Tribe, 1.1%(2) belongs to Munda Tribe and 0.6%(1) belongs to Bhumij Tribe in Odisha. In the survey besides the Scheduled Tribes, PVTGs are found in very few percentages. Dongria Kandha (PVTG) stands for 11.7%(21) and Saora (PVTG) stand for 6.7%(12) in Odisha.

On the other hand, in Madhya Pradesh out of 180 sampled Forest dwellers, 46.1%(83) are belongs to Gond Tribe, 27.8%(50) are belongs to Korku Tribe, 7.2% (13) are Bhilala Tribe, 1.1%(2) are Panika Tribe, 0.6%(1) belongs to Barela Tribe, 0.6%(1) are Gual Tribe, 0.6%(1) are Tantia Tribe and 0.6%(1) belongs to Bhil Tribe in Madhya Pradesh. In the case of PVTG Baiga (PVTG) stands for 1.1%(2) in Madhya Pradesh.

2.11.4 Family types and economic classification

The table (annexure VI) above reveals the individuals belonging to the type of family in the selected divisions of the study states. Different tribals have their different taboos with their family types and sizes in India. For example, in the "GOND" tribe most of the family usually lives in a "joint family". In Odisha, a "Soara" house hold used to prefer

to live as a “Nuclear family” after marriage. The study has classified the forest dwellers' families into joint, nuclear and extended families. The changing social fabric has affected the traditional joint family system in India which has now given way to the nuclear family system. Overall It is clear that out of 180 interviewed forest dwellers the highest proportion of people who lived in a Nuclear family and this is 51.7%(93) while about 38.9%(70) of people lived in a Joint family and only 9.4%(17) families are lived in Extended family in Odisha. On the other hand, in Madhya Pradesh, the scenario is a little different. Most of the families are lived in Joint families. Out of 180 interviewed forest dwellers, 50.0% (90) lived in Joint families and 42.2% (76) people lived in Nuclear families when about only 7.8%(14) people lived in Extended families in Madhya Pradesh.

Chapter III

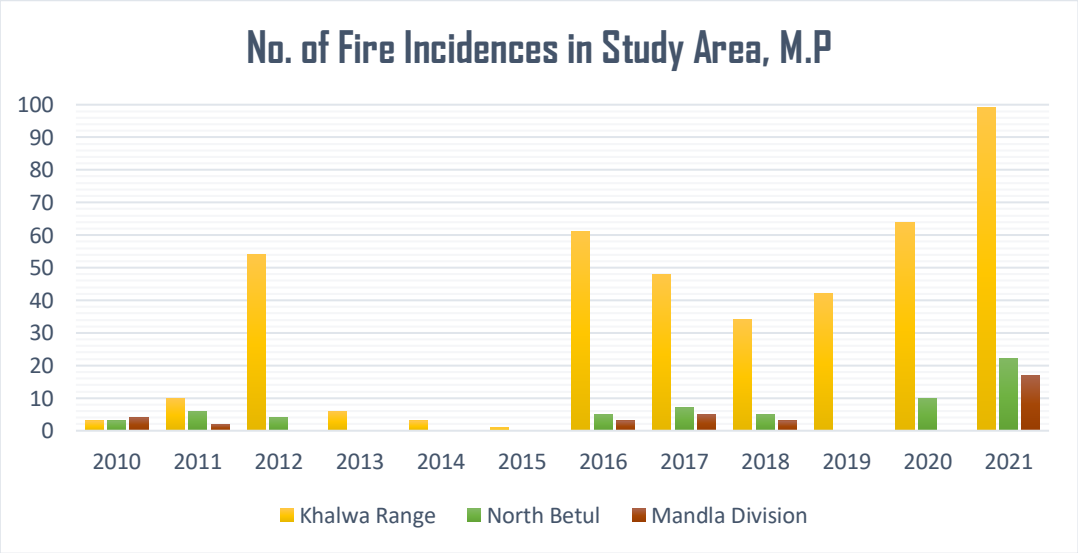
A Decade Patterns and trends of forest Fire in Two States

3.1 History of fire incidences

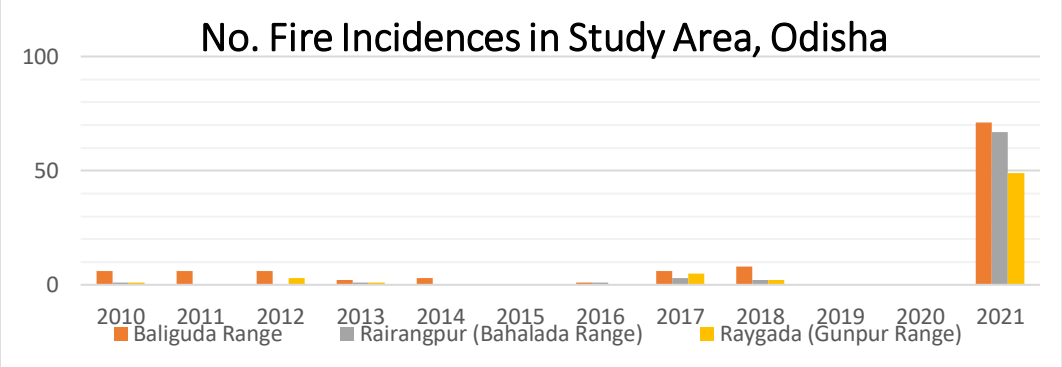
Forests had been facing fire for a long for various reasons. The devastating effect of this has become alarming in the present years because of the environmental issues the world is facing. Previously forest fires were not even reported by the department of forests. But now as a result of various institutions and satellites coming into action, there is more reporting of fire incidences and accordingly, more emphasis is being given to the protection against it. One of the objectives of the study is to record the patterns and trends of forest fires (in the last 5-10 years), the extent of forest fire areas and estimated losses in sample forest areas (Study area).

3.2 Fire incidences in the divisions of the project area.

The fire incidences in the six forest divisions are studied through the GIS and the result of that is tabulated for reference.



Graph1: Fire Incidences in Studied Ranges, Madhya Pradesh



Graph 2: Fire incidences in studied Ranges, Odisha

As seen in the above graphic the fire incidence in MP and Odisha has increased in the past 10 years. Another observation is that fire incidence in Dry deciduous forest was seen more now it is found to be extended yo Sal (Shorea robusta) Forest areas which are moist.

3.3 Remote Sensing and GIS analysis of Fire incidences in the divisions of the project area

The total geographical area covered in forest land is 21.67% in India (FSI, 2019). Tropical biomass burning caused by forest fires affects the environment because it releases a lot of trace gases and aerosol particles and affects the chemistry of the troposphere and climatic anomalies (Kannemadugu et al., 2015). Every year, valuable forest resources, including carbon locked in biomass, are lost due to forest fires (Juárez-Orozco et al., 2017; Reddy et al., 2018; Pande et al. 2021). Various studies have been conducted for earlier estimation of forest fires and detection during the incident time.

There are two ways of forest fire, i.e., direct and indirect methods. Avoid the precaution during activity in forest areas. This is a direct way; sometimes, metrological factors are responsible for forest fires. This is the indirect way. The main parameters of forest fire are dryness and moisture, wind, precipitation, and humidity (Suliman et al., 2014). Deliberate fires can be ignited for many purposes such as collecting Sal seeds after the fire, extracting illegal timber, scaring away wild animals, improving grass growth, etc. (Bhandari et al., 2012). The forest resources are depleting at an alarming rate due to climate change impacting key ecological processes like rainfall patterns, water availability, and the sustenance of pollinators. Climate change, i.e., temperature play important role in forest fire mapping.

However, today, with the development of remote sensing technology, satellite imagery is used as the most important tool to control, prevent, and monitor zones for fire and geographic information systems to integrate remote sensing and land-based information. In recent decades, researchers have predicted fire risk zones including fire risk zoning and modelling using remote sensing and geospatial applications (Roy PS 2003). A GIS was established to monitor and predict the extent of the damage, and to enhance fire management efficiency.

In recent years, the application of satellite images and, specifically, spectral signatures of the terrain (e.g., vegetation) allows researchers to obtain information on the severity of fires. According to Veraverbeke and Tran (Tran, B et.al. 2018; Veraverbeke, S. et.al. 2010), the application of spectral indices allows one to evaluate the severity of fires. Spectral indices are calculated based on spectral bands from satellite images (Mallinis, G et.al. 2018; Veraverbeke, S et.al.2013). In addition, these indices have correlation levels with vegetation biophysical parameters, such as

biomass amount, photosynthetic activity, productivity and water content (De Santis et.al. 2007, 2010). The correlations between the multi-temporal spectral indices allow researchers to estimate the fire's burn severity and the recovery of vegetation (Chen et.al. 2011; Navarro et.al. 2017).

There are various indices available to calculate the condition of the crop but out of which is most frequently used in fire assessment is the normalized difference vegetation index (NDVI). This index is conditioned by changes in the physiological state of plant covers, and their variations are used in Spatio-temporal studies of vegetation behaviour (Ayele, G.T et.al. 2018, Ariza, A. et.al. 2019). NDVI is the index which is used in many studies and it is very much useful in a forest fire. The fire causes damage to the forest where there is a low amount of vegetation available or the soil moisture content is very low. In such particular areas forest fires spread very easily, but in the case of a high amount of green vegetation, soil holds the water in high amounts hence the moisture is high, fire spreading intensity is very low and forest damage rate also decreases. By collecting the data from pre-fire and post-fire, and comparing these data we get accurate results. How much of the area is damaged due to forest fire is studied by using this NDVI. This NDVI is computed by using many satellites like a sentinel, Landsat etc. The result differs according to the resolution of the satellite. In the NDVI formula, NIR (Near-infrared) and RED bands are a must.

Satellite data, Global Positioning System (GPS), Geographical Information Systems (GIS), population, and other socio-economic data were integrated to estimate and forecast LULC transition patterns with greater accuracy as well as to understand the different drivers of anthropogenic land-use change (Hathout, 2002). The GIS and remote sensing software is a powerful tool in this endeavour for quantifying the urban sprawl and other land changes and forecasting urban area expansion using spatial modelling (Pande et. 2018). Land use and land -cover (LULC) are the basic portions of the Earth's surface and any change in this has substantial effects on human society, climatology, biodiversity, and water cycles (Baldyga et al., 2008; Were et al., 2014; Tajbakhsh et al., 2020). Moreover, changes in LULC and their fragmentation for sustainability and global environmental stability are a big concern for earth scientists (Turner et al., 2007). The reason behind land cover fragmentation and ecosystem losses might be associated with agricultural practices and infrastructure build-up, over-uses of natural resources, forest fire and environmental pollution, etc. (Singh et al., 2018).

To develop sustainable land use plans and devise future landscape variations for resource management policies, therefore, it is essential to study the spatiotemporal dynamics of LULC changes for protecting these valuable natural resources. In forest fire two season data of LULC are very important, the assessment of damage is computed very easily. The image interpretation technique is very important to classify

the land into different categories like agricultural land, barren land, scrubland, waterbody, forest, built-up land etc. LULC classes are classified according to level i.e. Level I, Level II, and Level III. The broad classes are present in level I then these broad classes are subdivided into subclasses in level II and subclasses are again divided into minor classes in level III. These level III data are computed using remote sensing techniques by the processes of image interpretation. Hence remote sensing technique is very much useful to protect natural resources like land, water and the environment.

The states of Madhya Pradesh and Odisha are the states in which the study has been conducted. Fire map points/ fire points were downloaded from the FSI free portal, and have been the basis for the selection of the study division/sites. These points collected/procured are stored in an excel sheet and the same has been converted into a shape file (GIS point data). These MODIS satellites (Moderate-resolution imaging spectra-radiometer) fire data have resolutions of 250m, 500m, and 1000m.

3.1 Data Used and Methodology

Sr. No.	Approaches	Satellite data	Source	Pre Fire Season	Post-fire Season	Bands	Findings
1.	NDVI	Sentinel 2	USGS (Open Portal)	20.02.2020 to 10.03.2020	10.05.2020 to 25.05.2020	NIR and RED	It is the vegetation index which was used in the study for the identification of the condition of vegetation.
				20.02.2014 to 10.03.2014	10.05.2014 to 25.05.2014		
2.	LULC	Landsat 8	USGS (Open Portal)	20.02.2020 to 10.03.2020	10.05.2020 to 25.05.2020	7 visible and near-infrared (VNIR) bands	Assessments of damage are calculated. Barren land is increased in post-fire season and scrubland is decreased.
				20.02.2014 to 10.03.2014	10.05.2014 to 25.05.2014		
3.	LST	Landsat 8	USGS (Open Portal)	28.02.2014 to 03.03.2014		Band 10 and 11	The Highest temperature is 33°C hence there will be a highest possibility of a forest fire.
				28.02.2020 to 03.03.2020			

NDVI:

The Normalized Difference Vegetation Index (NDVI) is an approach to mapping the vegetation cover and density that has been calculated using satellite remotely sensed data. The index demonstrates the density of vegetation and pixel-based data mostly in the visible range of 0.4 to 0.7µm and the NIR (Near Infra-Red) range of 0.7

to 1.1 µm. Healthy vegetation absorbs the sun's light in the red spectrum (0.63-0.69µm). The higher values of the index indicate a healthy and dense vegetation cover. In the present study, both pre and post-fire season NDVI have been calculated for identifying the condition of the forest crop before and after the fire. Based on NDVI conditions, crop damage has been tentatively computed. The index ranges from -1 to +1 and is calculated by

$$NDVI = \frac{NIR - R}{NIR + R}$$

(Where NIR is the Near Infra-red band; R is the Red band)

Remote sensing data of the study area have been downloaded from the open source i.e. USGS. Sentinel-2 data have been used for the calculation of the NDVI due to its high spatial and spectral resolution i.e. spectral resolution of 12 bands, the spatial resolution of bands ranging from 10 m to 60 m, i.e. bands 2,3,4, and 8 bands having 10 m resolution, bands 5,6,7 and 9 having 20m and 1,10,11 and 12 having 60m. With the help of digital image processing software (ERDAS) and by mathematical formula it can easily be computed the NDVI values of pre and post-fire season of any identified year.

3.5 Odisha State Forest: GIS data and analysis

In Baliguda (Orissa), the years 2014 and 2020 have been selected for the pre-set studies based on fire points downloaded from the FSI website. 2014 was a low fire frequency year, while 2020 was a high fire frequency year.

Now for both of the above years, the forest division was further divided into three categories, e.g., high, medium, and low fire frequency areas. For each such defined area, NDVI was computed by downloading the satellite images from the USGS site (Fig 1,2, and 3).

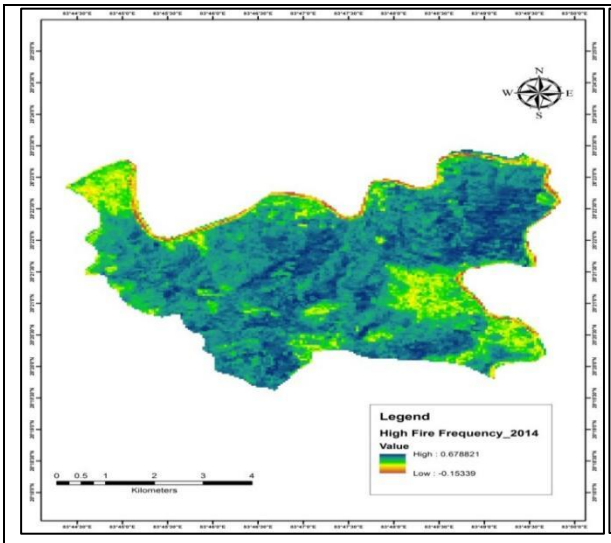


Fig 1 NDVI of Baliguda in the high frequency of pre-fire 2014

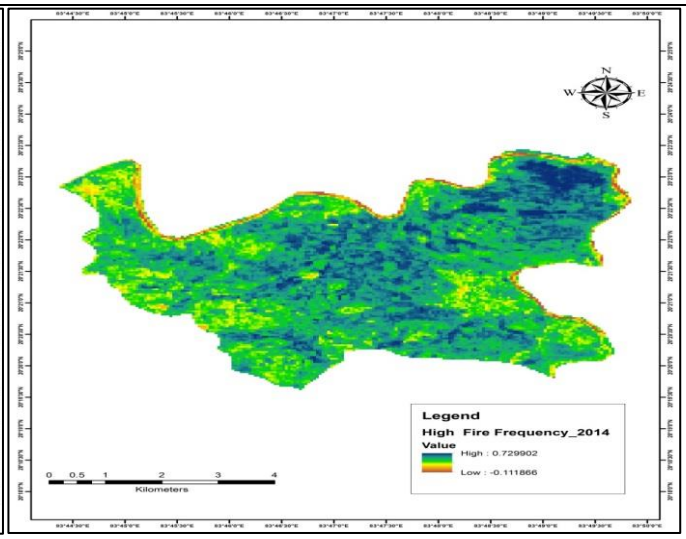
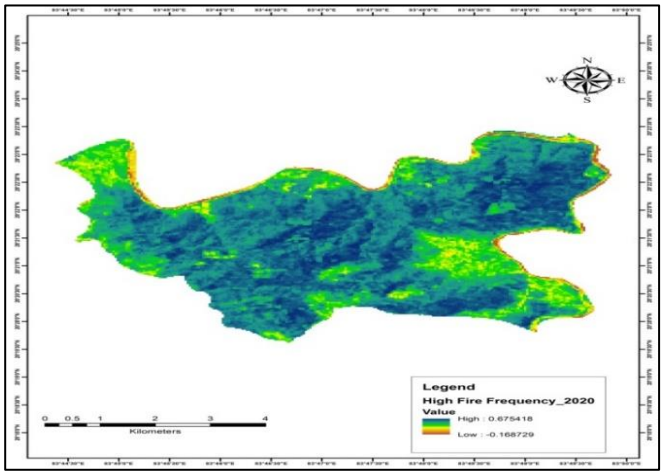


Fig.1 NDVI of Baliguda in the high frequency of post-fire 2014



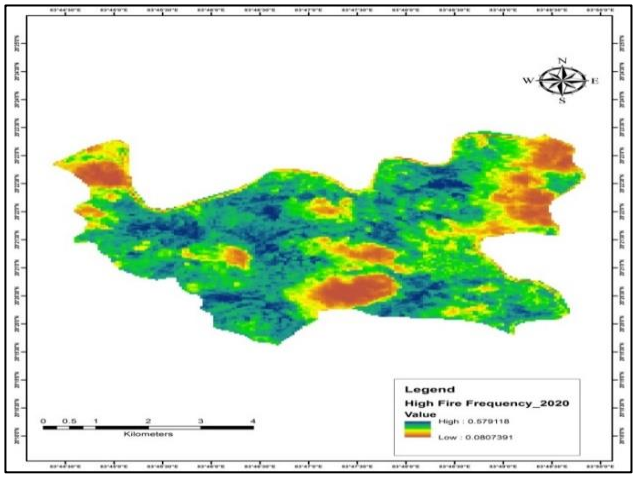


Fig.2 NDVI of Baliguda in high frequency of pre-fire 2020 Fig.2 NDVI of Baliguda in high frequency of post-fire 2020

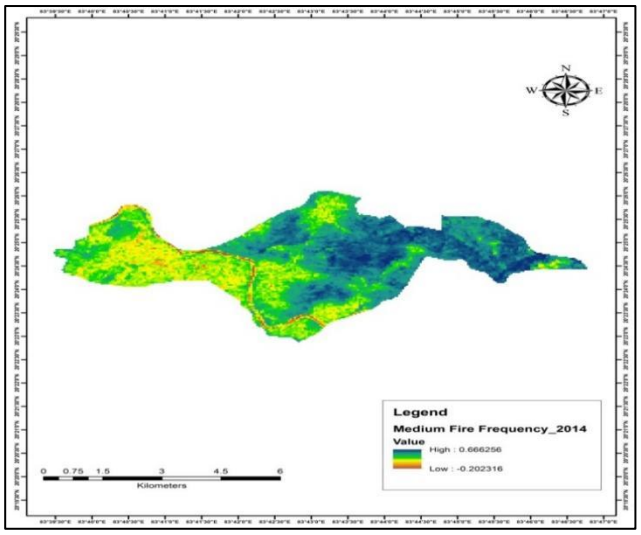


Fig 3 NDVI of Baliguda in Medium frequency of pre-fire 2014

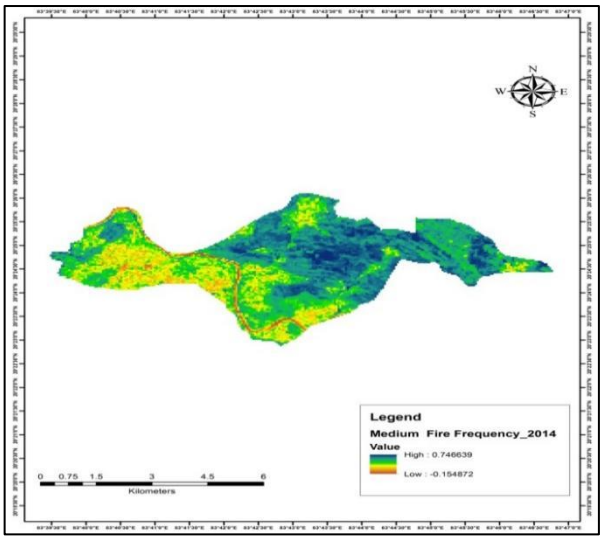


Fig 3 NDVI of Baliguda in Medium frequency of post-fire 2014

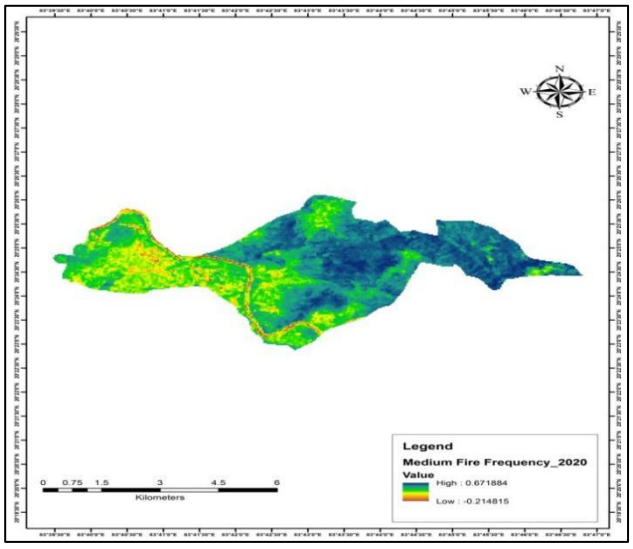


Fig.4 NDVI of Baliguda in medium frequency of pre-fire 2020

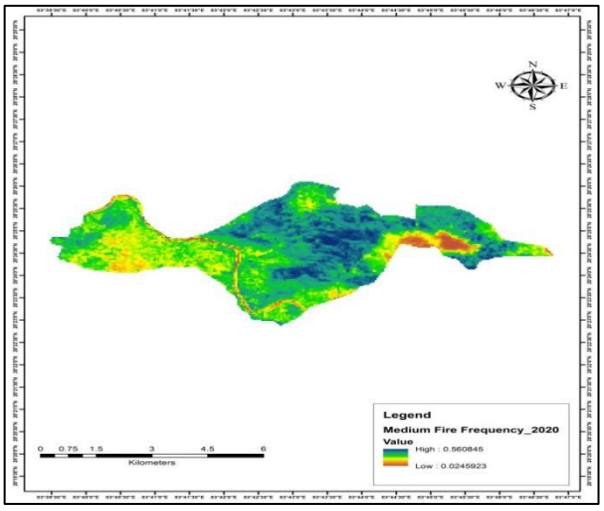


Fig.4 NDVI of Baliguda in medium frequency of post-fire 2020

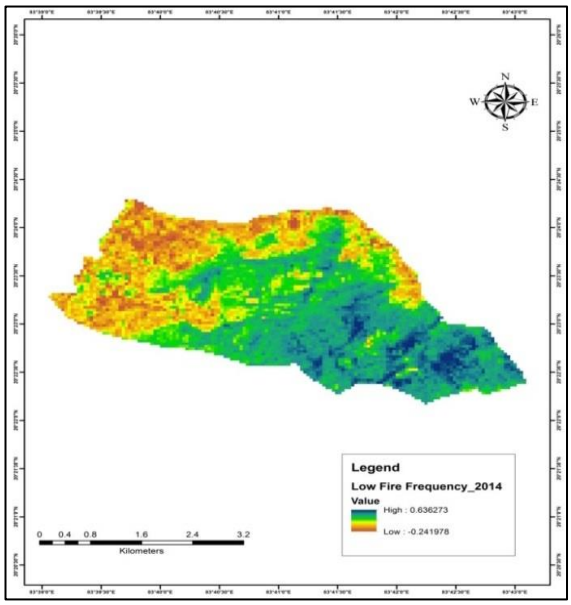


Fig. 5 NDVI of Baliguda in Low frequency of pre-fire 2014

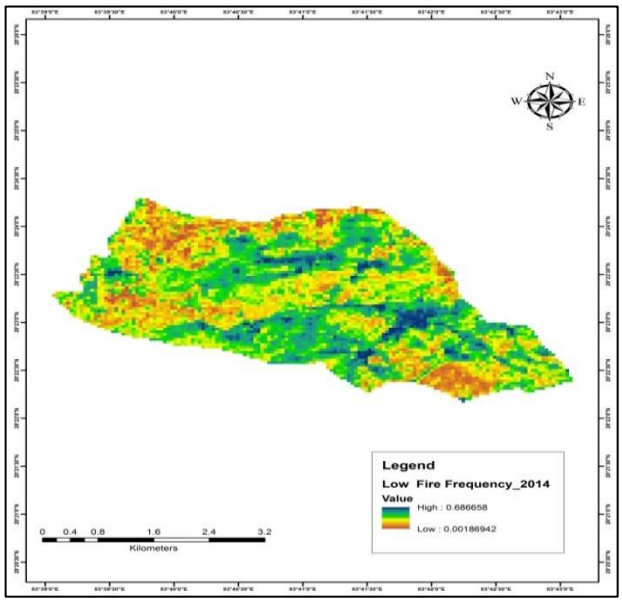


Fig. 5 NDVI of Baliguda in Low frequency of post-fire 2014

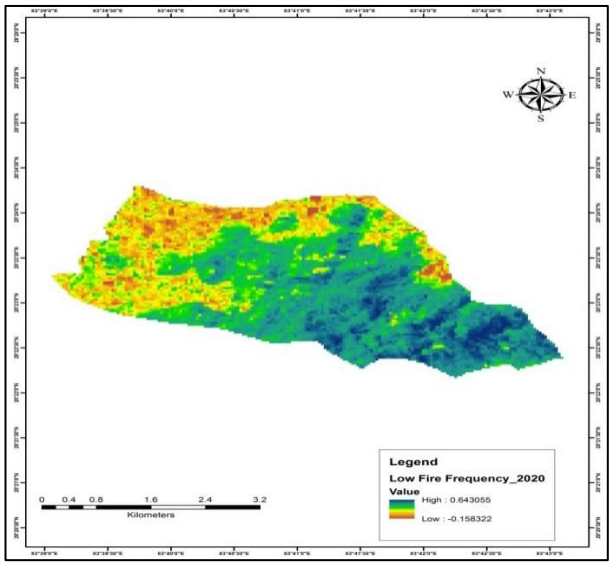


Fig.6 NDVI of Baliguda in low frequency of pre-fire 2020

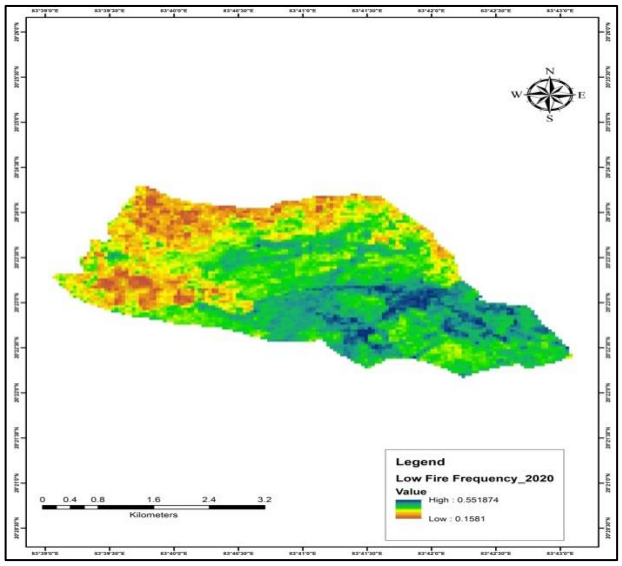


Fig.6 NDVI of Baliguda in low frequency of post-fire 2020

Map: 5 NDVI maps of Baliguda Forest Divisions (pre and post fire)

In Rairangpur Division the three beats are categorized into three fire frequency categories, i.e. High, Medium, and Low fire frequency areas, based on fire point availability in the concerned area.

In pre-fire conditions, the NDVI values were very high as compared to post-fire. Vegetation cover decreased in the post-fire season because it was damaged due to a forest fire. This is shown in the following figures: 7,8,9,10,11, and 12.

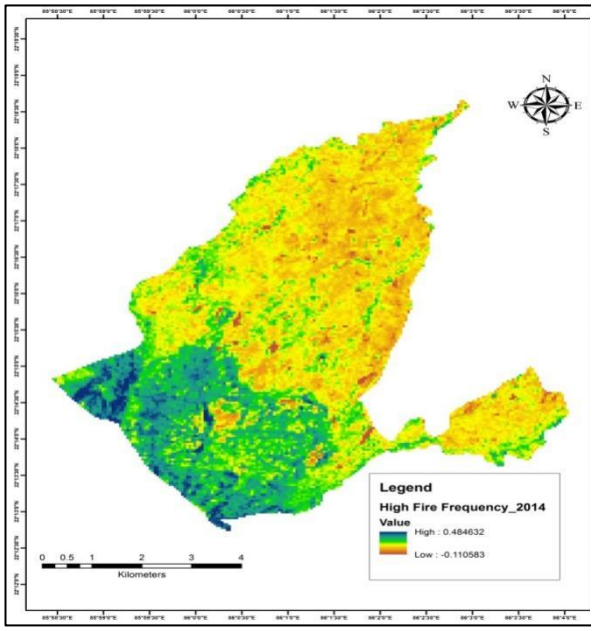


Fig.7 NDVI of Rairangpur in high fire frequency of pre-fire 2014

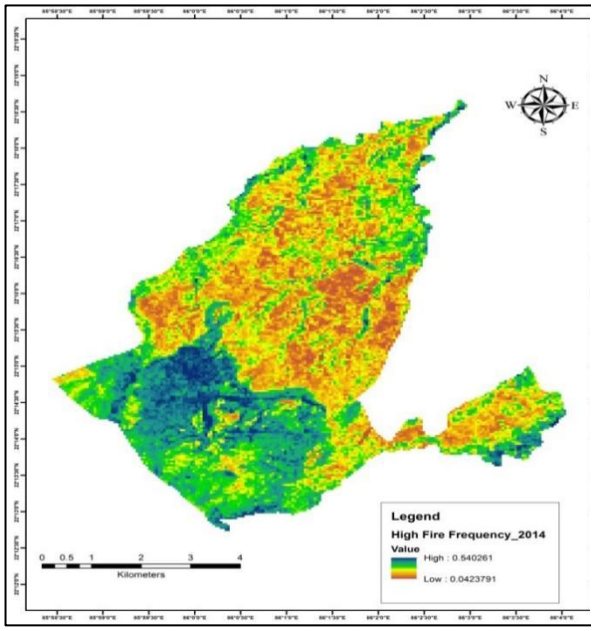


Fig.7 NDVI of Rairangpur in high frequency of post-fire 2014

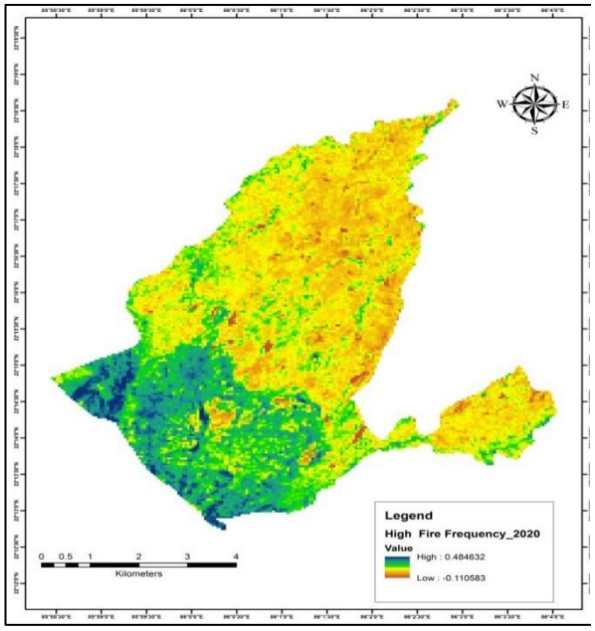


Fig.8 NDVI of Rairangpur in high frequency of pre-fire 2020

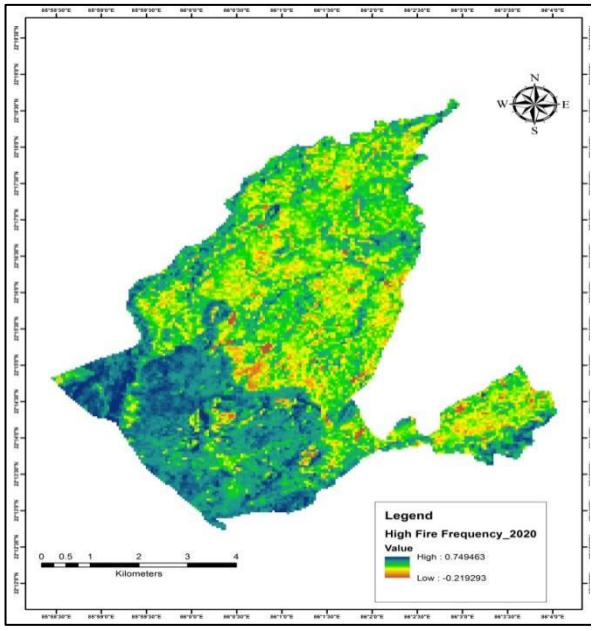


Fig.8 NDVI of Rairangpur in high frequency of post-fire 2020

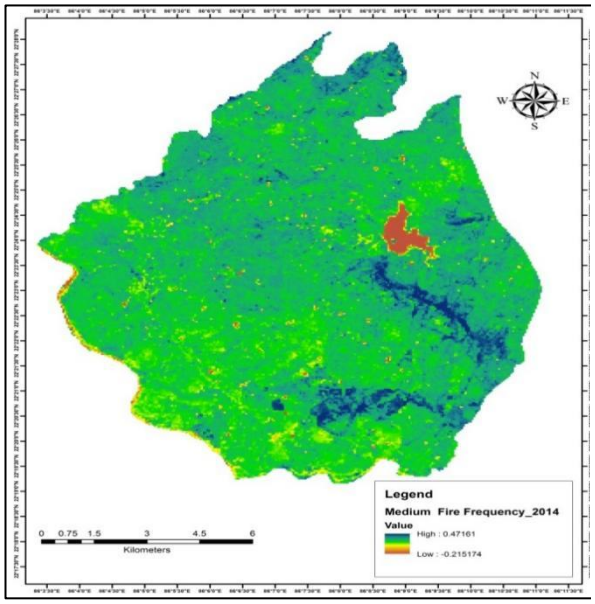


Fig.9 NDVI of Rairangpur in medium fire frequency of pre-fire 2014

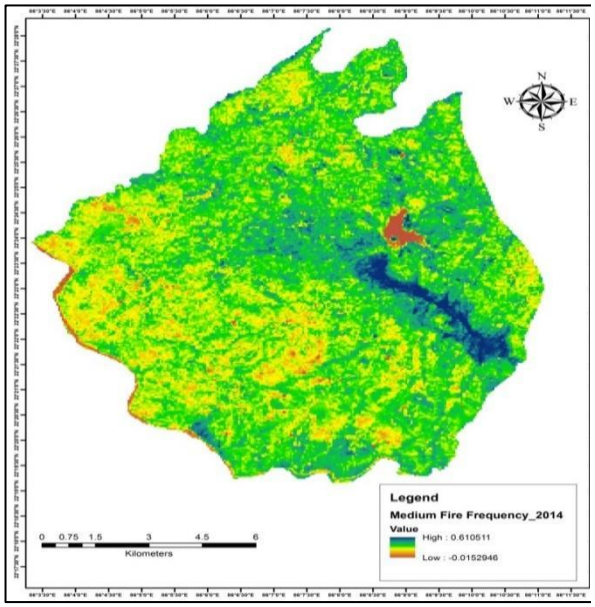


Fig.9 NDVI of Rairangpur in medium frequency of post-fire 2014

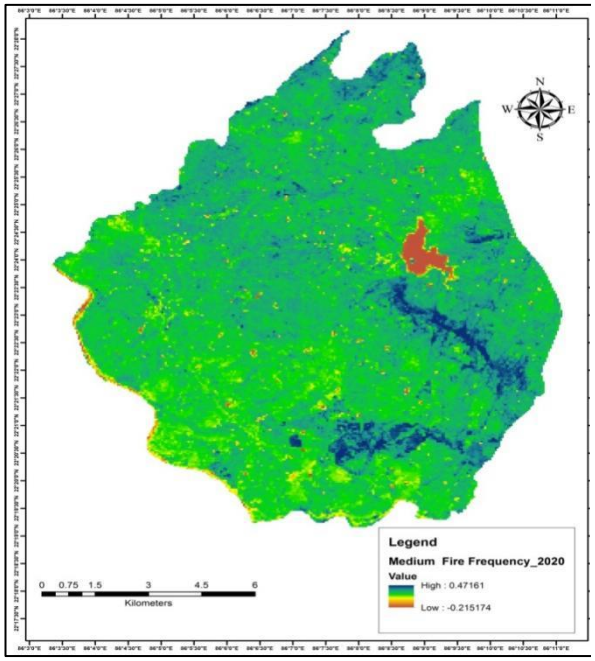


Fig.10 NDVI of Rairangpur in medium frequency of pre-fire 2020

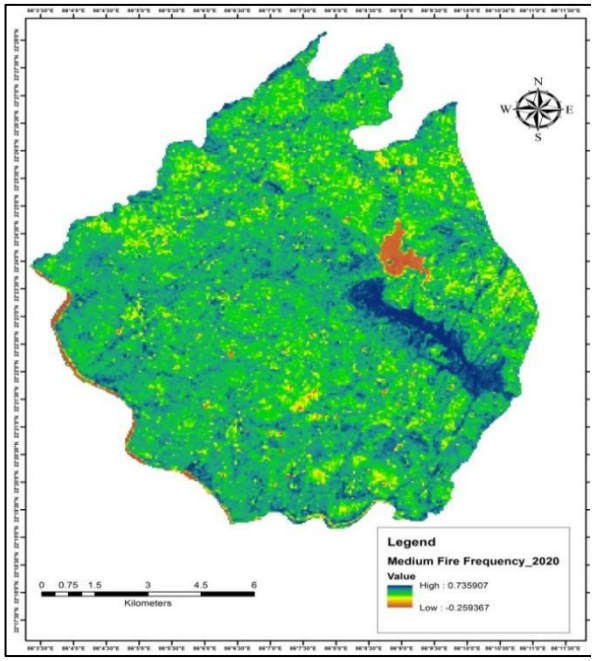


Fig.10 NDVI of Rairangpur in medium frequency of post-fire 2014

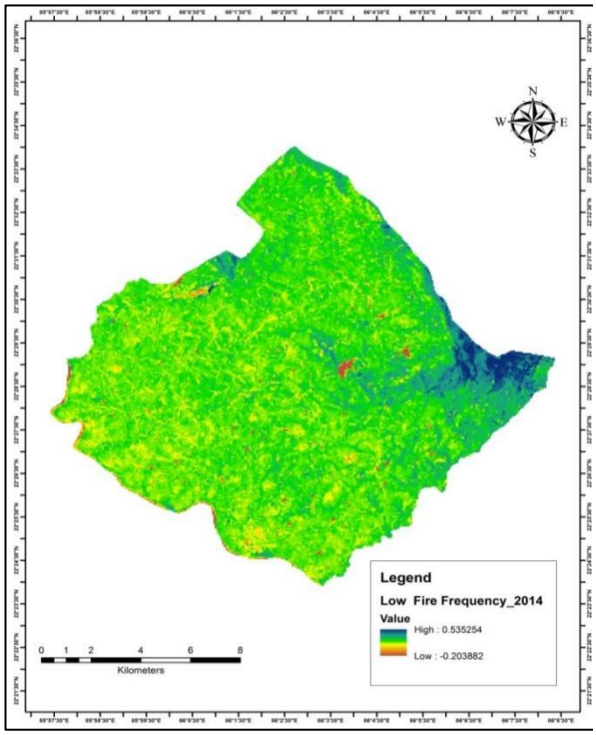


Fig.11 NDVI of Rairangpur in low frequency of pre-fire 2014

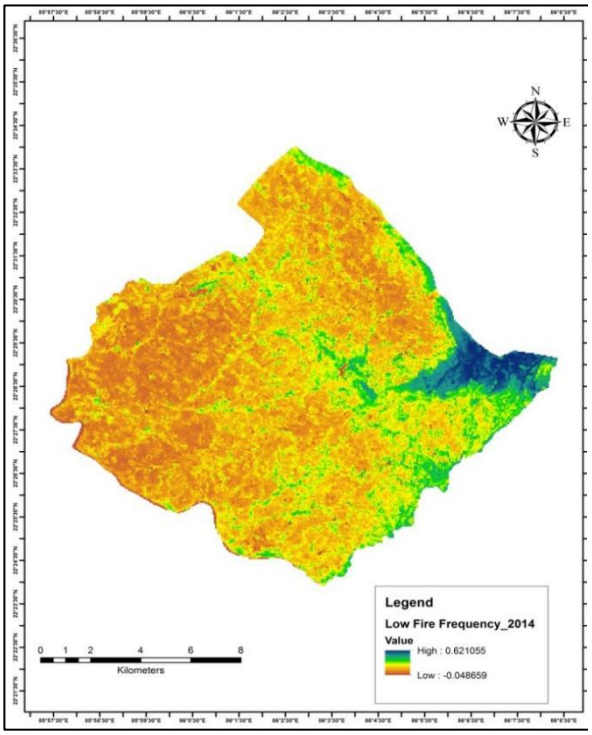


Fig.11 NDVI of Rairangpur in low frequency of post-fire 2014

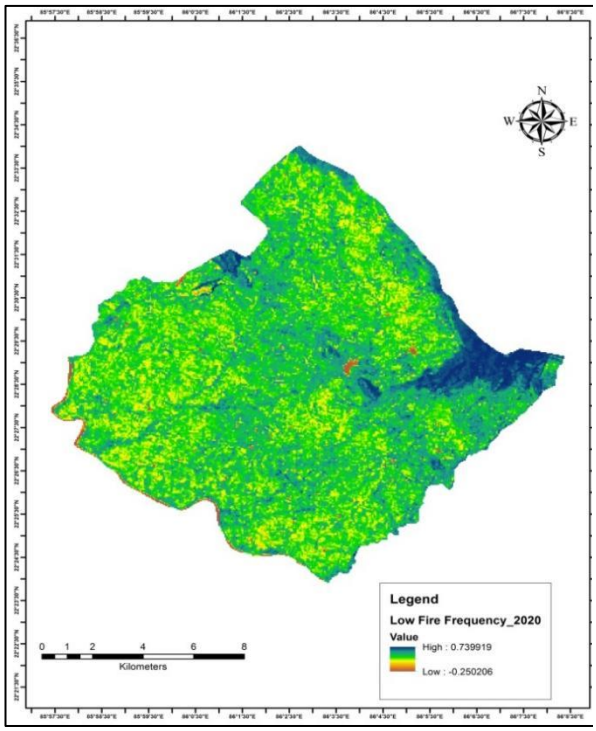


Fig.12 NDVI of Rairangpur in low frequency of pre-fire 2020

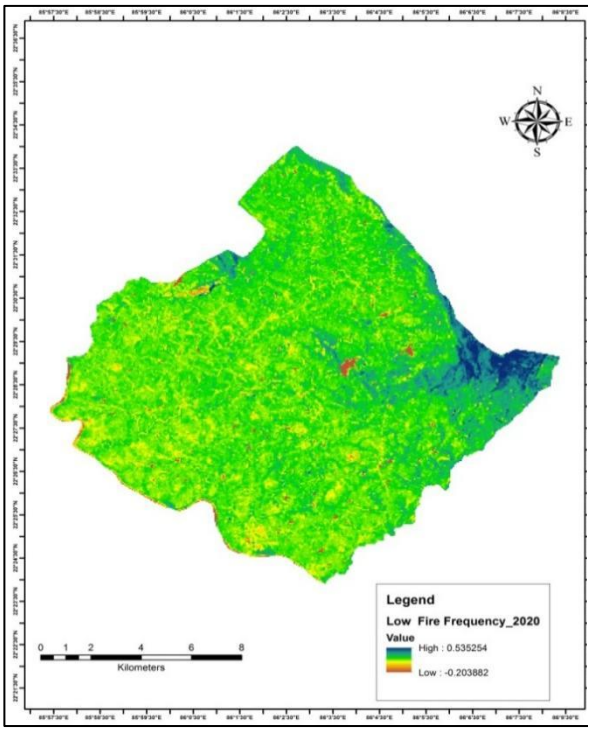


Fig.12 NDVI of Rairangpur in low frequency of post-fire 2020

Map 6: NDVI maps of Rairangpura Forest Division (Pre and post fire)

In the Rayagada forest division, NDVI maps are given below in pre and post-fire seasons 2014 and 2020.

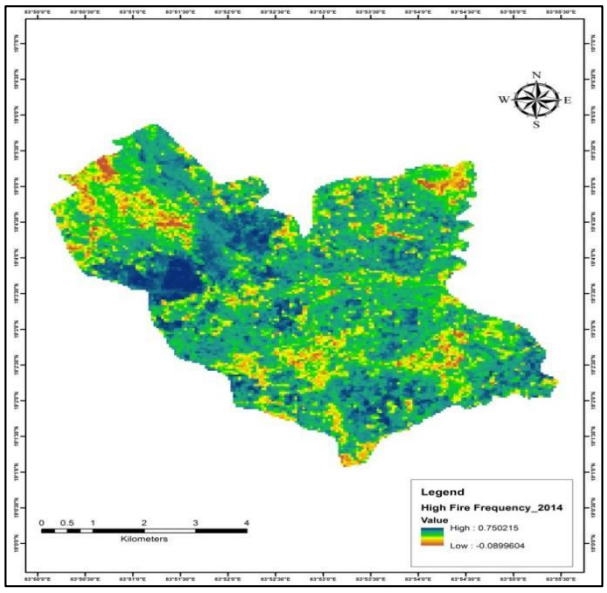


Fig.13 NDVI of Raygada in high frequency of pre-fire 2014

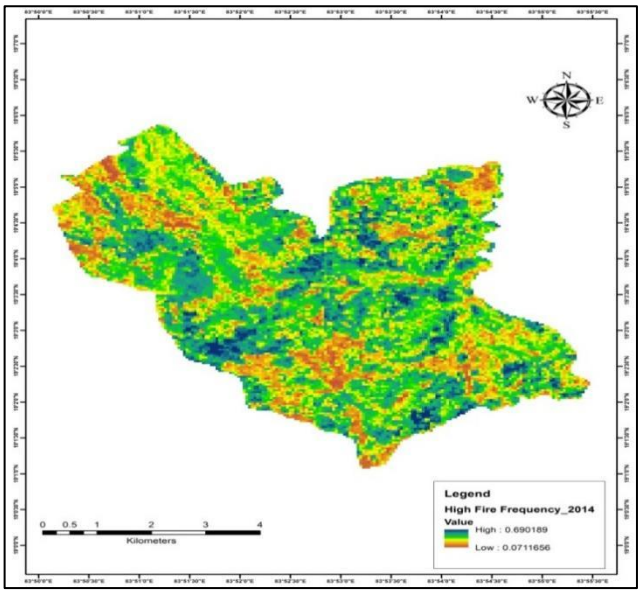


Fig.13 NDVI of Raygada in high frequency of post-fire 2014

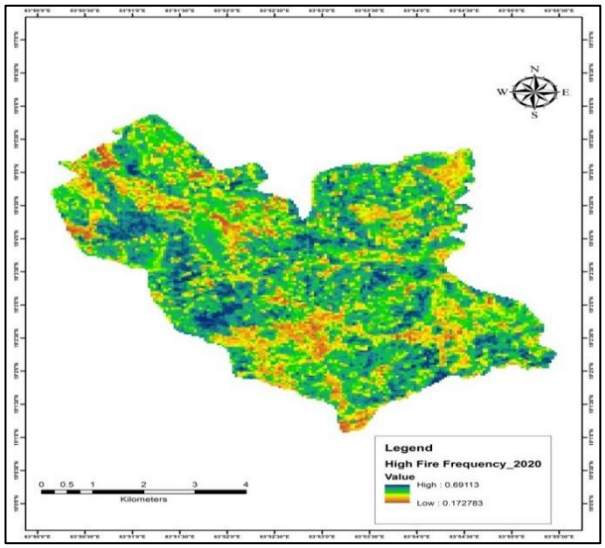


Fig.14 NDVI of Raygada in high frequency of pre-fire 2020

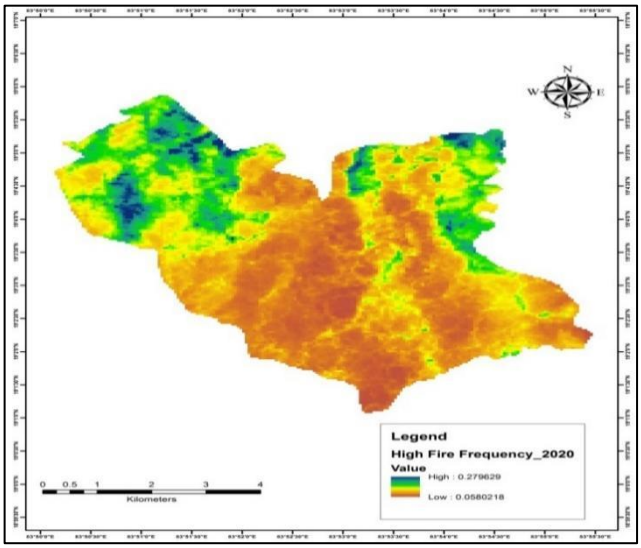


Fig.14 NDVI of Raygada in high frequency of post-fire 2020

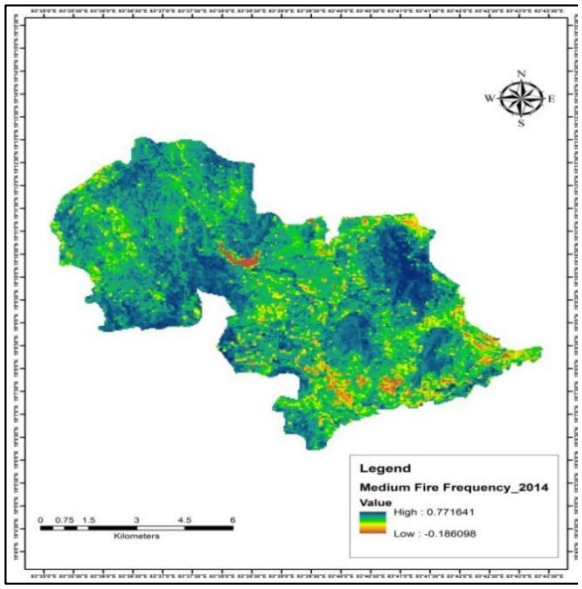


Fig.15 NDVI of Raygada in medium frequency of pre fire 2014

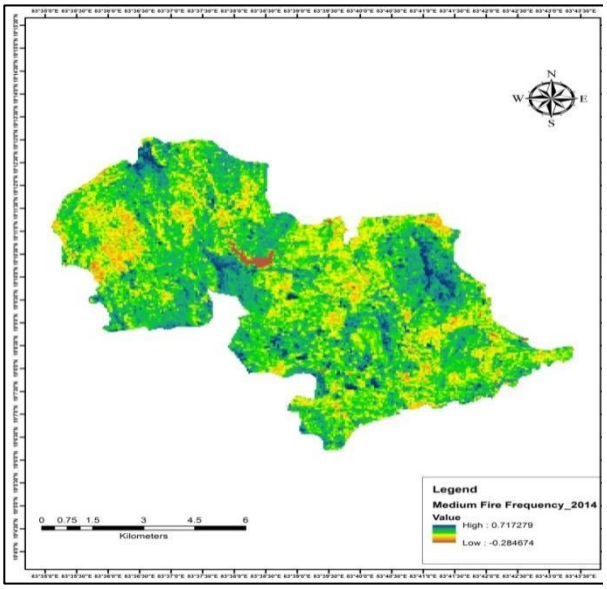


Fig.15 NDVI of Raygada in medium frequency of post fire 2014

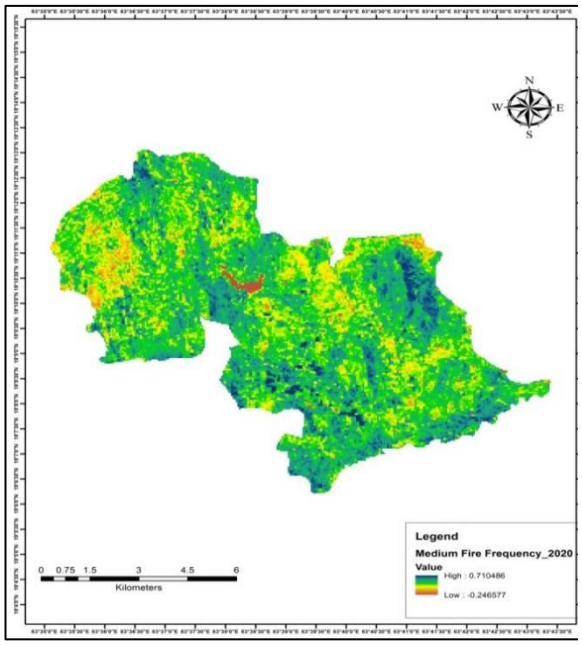


Fig.16 NDVI of Raygada in medium frequency of pre fire 2020

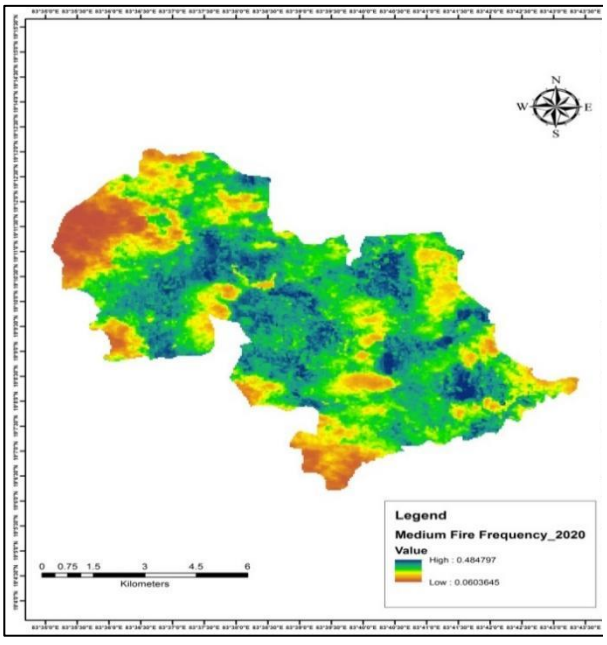


Fig.16 NDVI of Raygada in medium frequency of post fire 2020

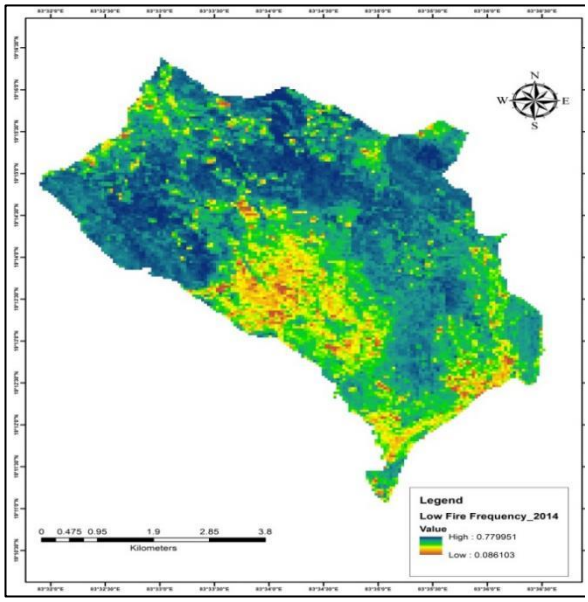


Fig.17 NDVI of Raygada in low frequency of pre fire 2014

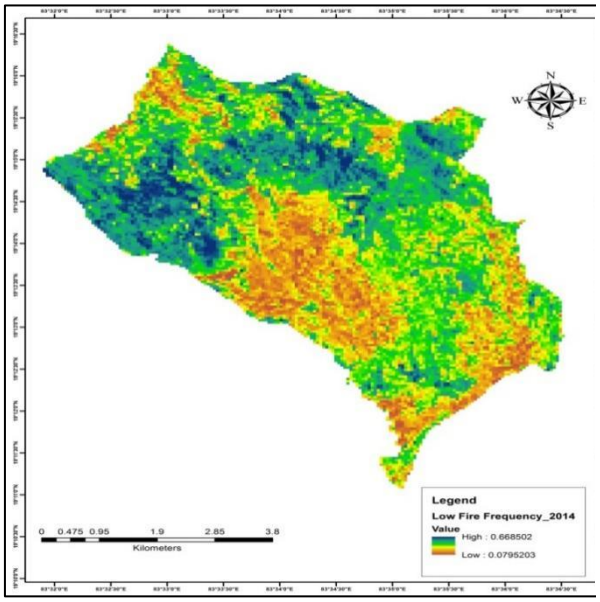


Fig.17 NDVI of Raygada in low frequency of post fire 2014

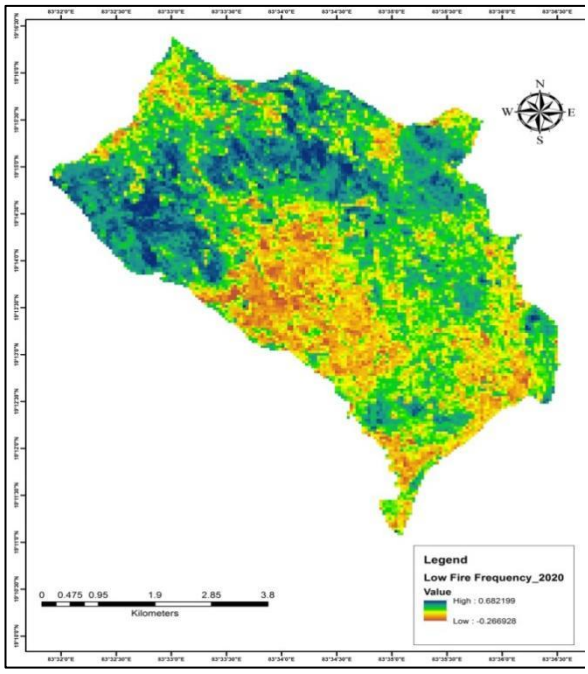


Fig.18 NDVI of Raygada in low frequency of pre fire 2020

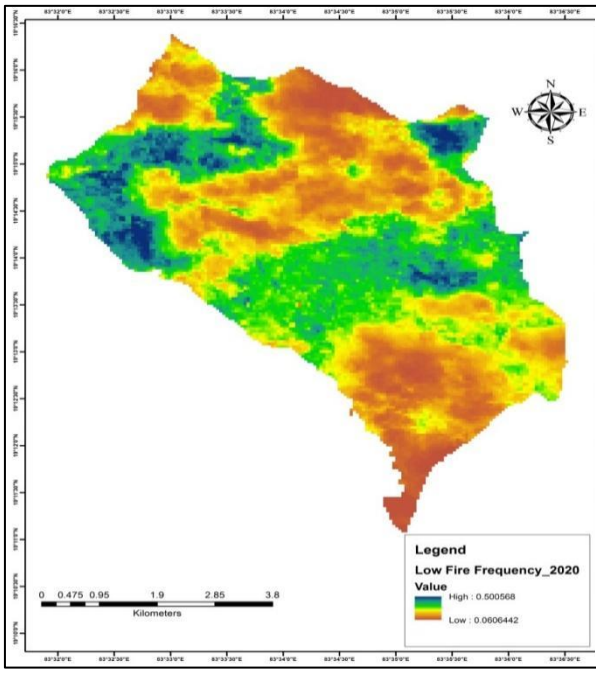


Fig.18 NDVI of Raygada in low frequency of post fire 2014

Map 7: NDVI maps of Rayagada Forest Divisions (Pre and Post fire)

3.6 Madhya Pradesh Forests: Data and analysis

We selected Betul (North), Mandla (East), and Khandwa divisions for this study. Three clusters have been defined based on fire frequency, i.e., low, medium, and high fire frequency. Each cluster is composed of four compartments. Thus, there were three clusters in each division for the detailed study of fire impacts. For the remote sensing application in the present study, Sentinel-2 data was used due to its better spatial and spectral resolution. The NDVI calculation and estimation were done using ERDAS

image processing software because the output is also clear and accurate. The NDVI figures are given below.

In the Khandwa Forest division, NDVI maps are given below in pre and post-fire seasons 2014 and 2020.

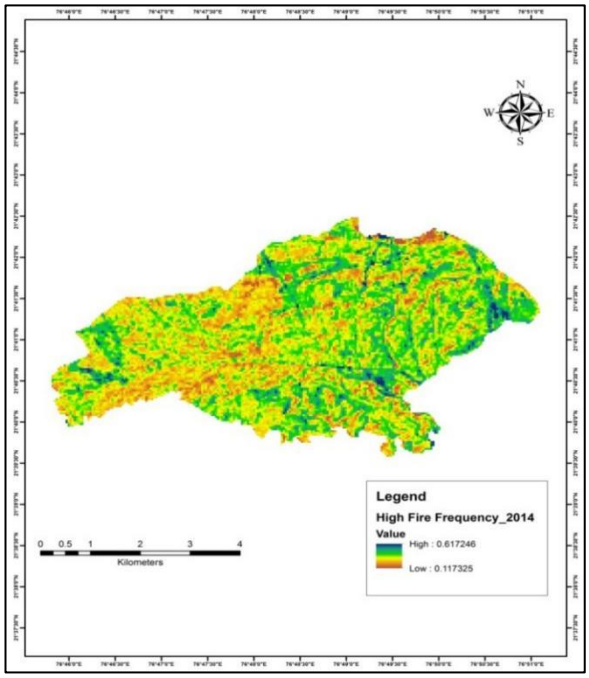


Fig.19 NDVI of Khandwa in high frequency of pre fire 2014

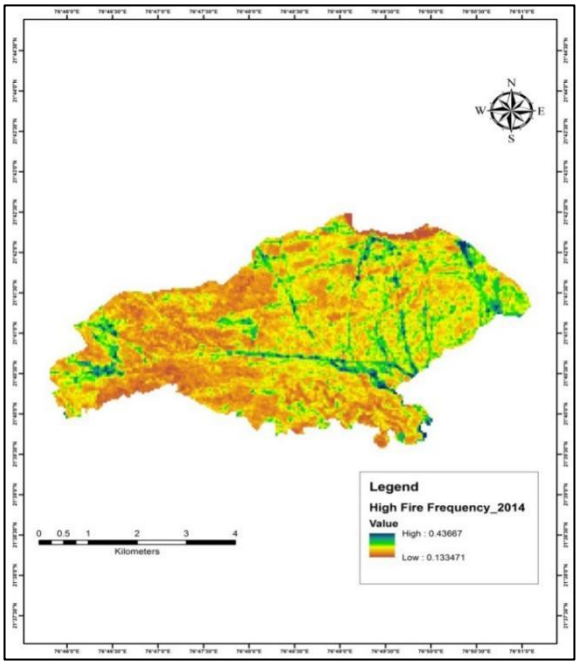


Fig.19 NDVI of Khandwa in high frequency of pre fire 2014

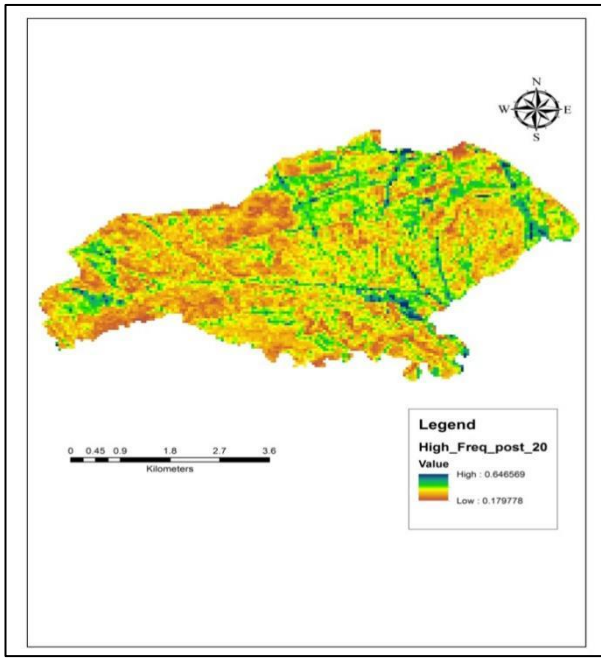


Fig.20 NDVI of Khandwa in high frequency of pre fire 2020

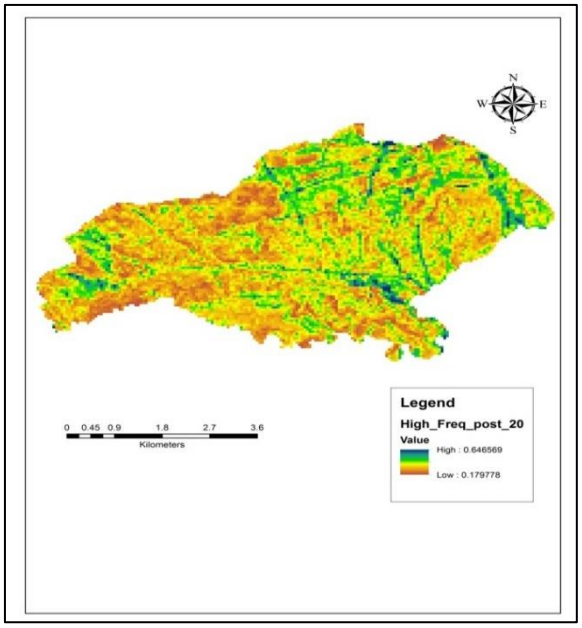


Fig.20 NDVI of Khandwa in high frequency of pre fire 2020

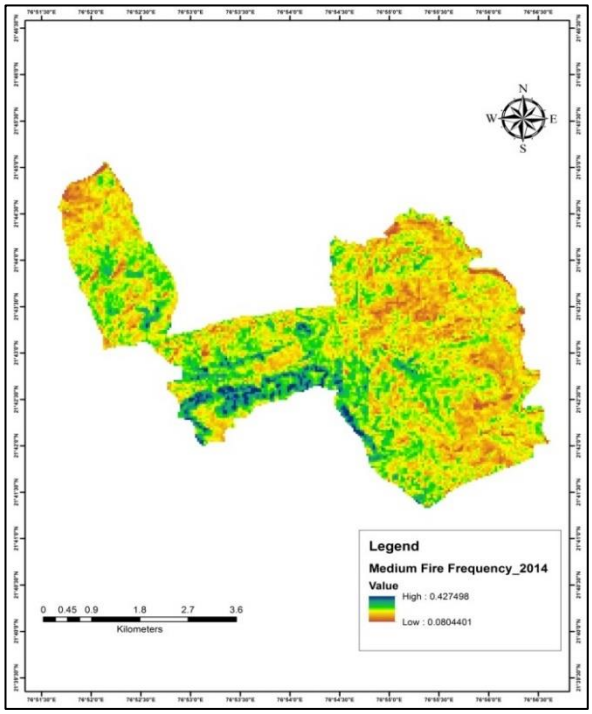


Fig.21 NDVI of Khandwa in medium frequency of pre fire 2014

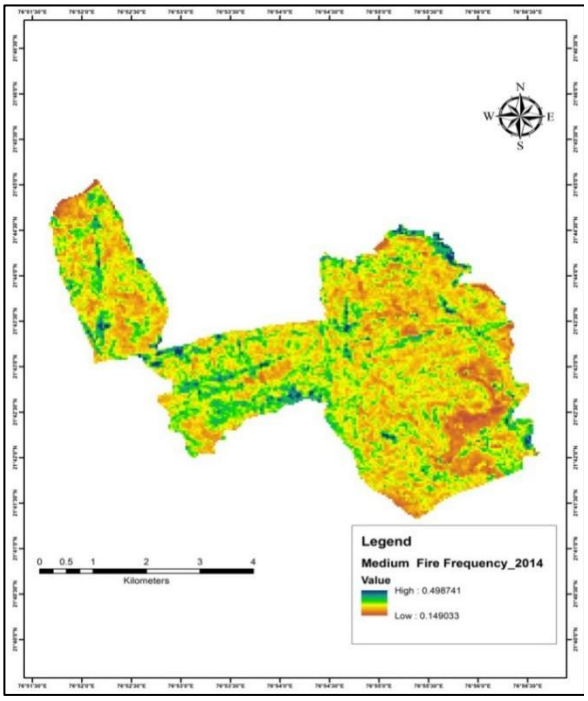


Fig.21 NDVI of Khandwa in medium frequency of pre fire 2014

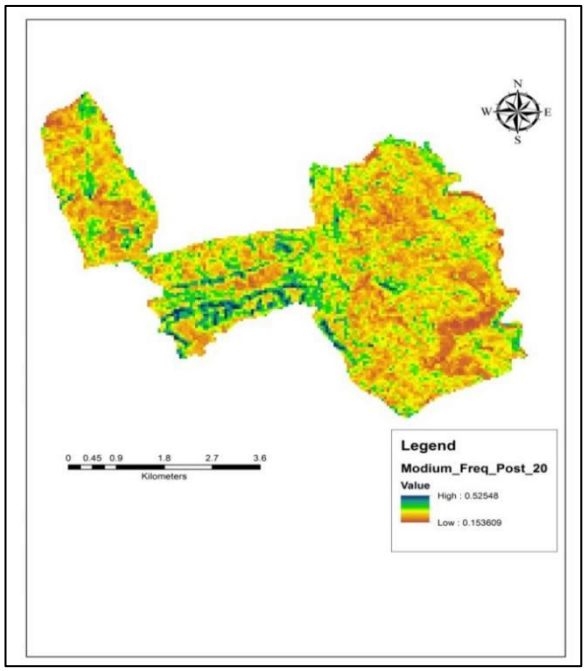


Fig.22 NDVI of Khandwa in medium frequency of pre fire 2020

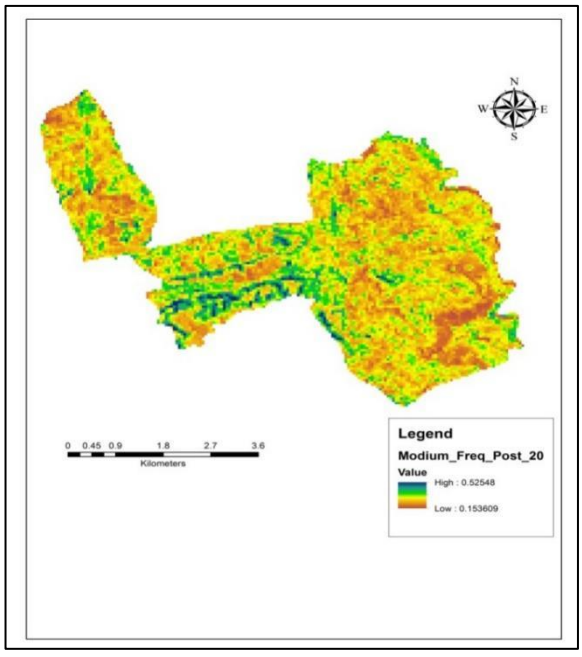


Fig.22 NDVI of Khandwa in medium frequency of post fire 2020

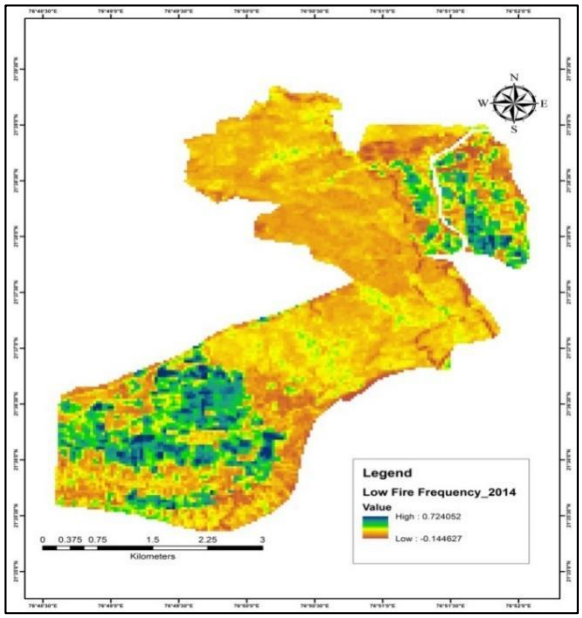


Fig.23 NDVI of Khandwa in low frequency of pre fire 2014

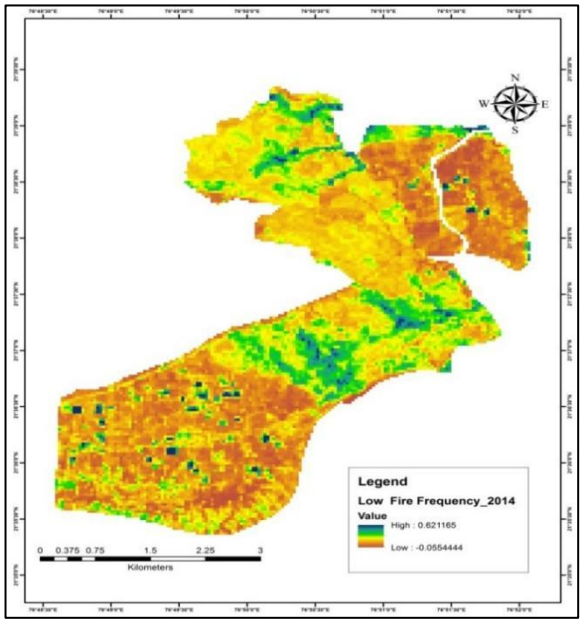


Fig.23 NDVI of Khandwa in low frequency of post fire 2014

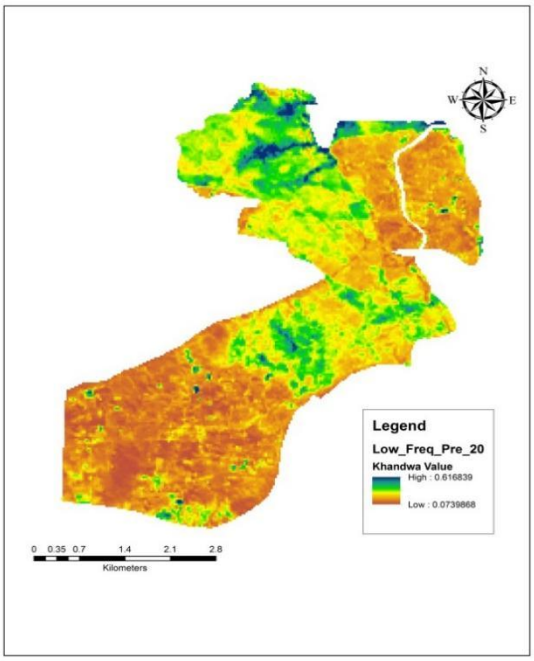


Fig.24 NDVI of Khandwa in low frequency of pre fire 2020

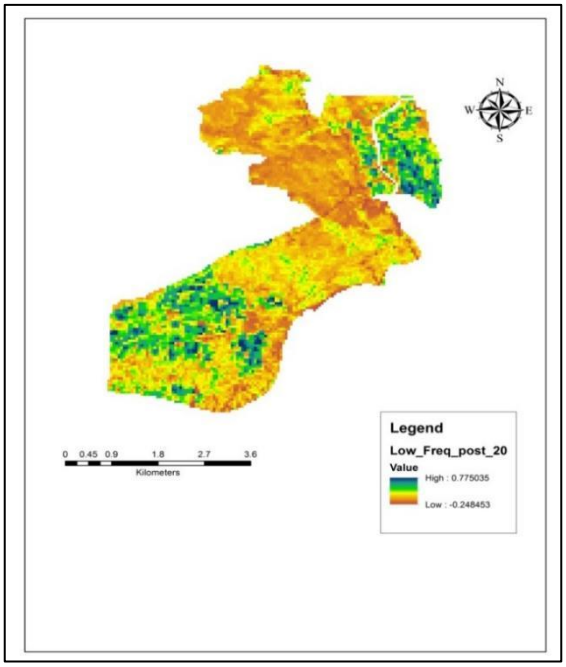


Fig.24 NDVI of Khandwa in low frequency of post fire 2020

Map 8: NDVI Maps of Khandwa Forest Division (Pre and Post Fire)

Mandla Forest Division NDVI maps are given below in pre and post-fire seasons 2014 and 2020.

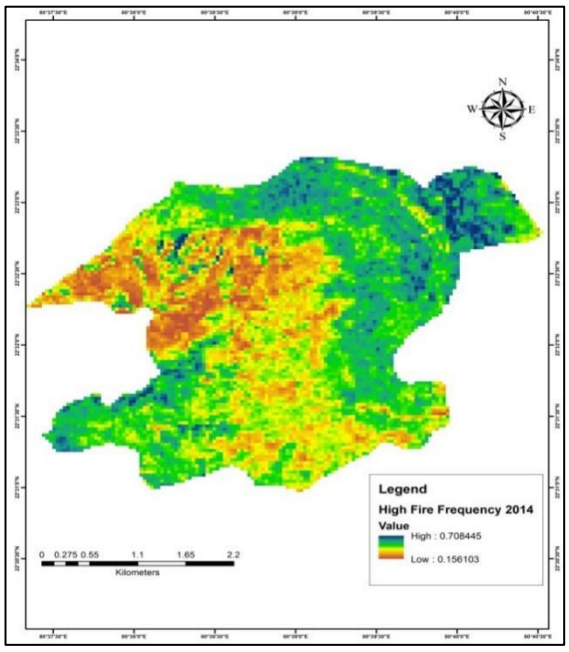


Fig.25 NDVI of Mandala in high frequency of pre fire 2014

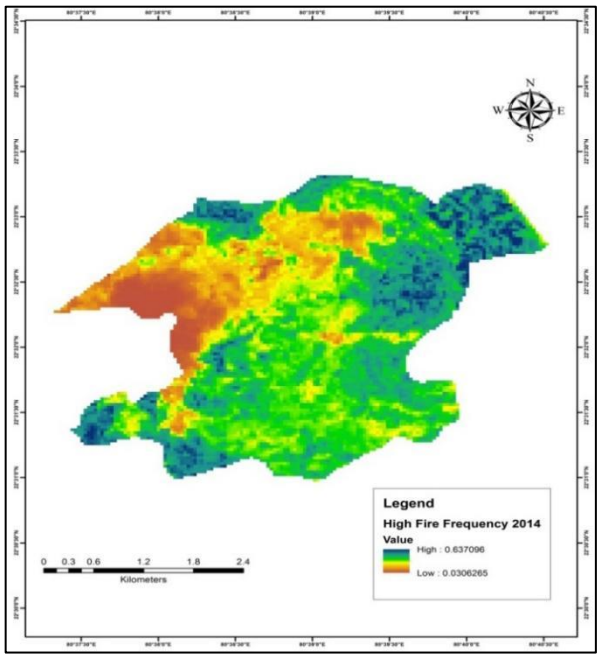


Fig.25 NDVI of Mandala in high frequency of post fire 2014

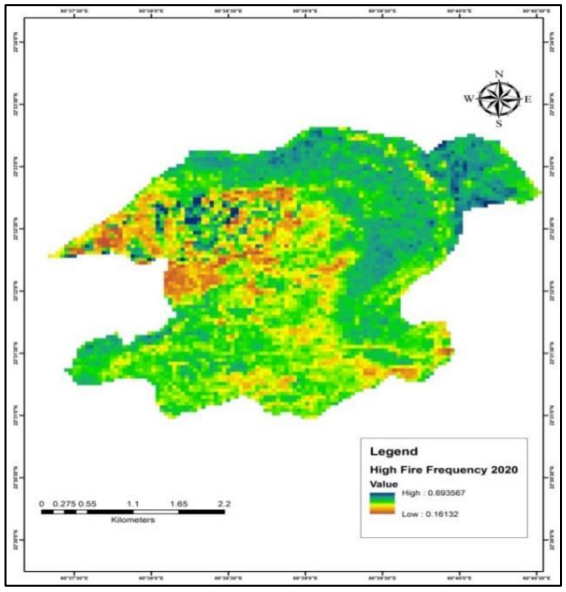


Fig.26 NDVI of Mandala in high frequency of pre fire 2020

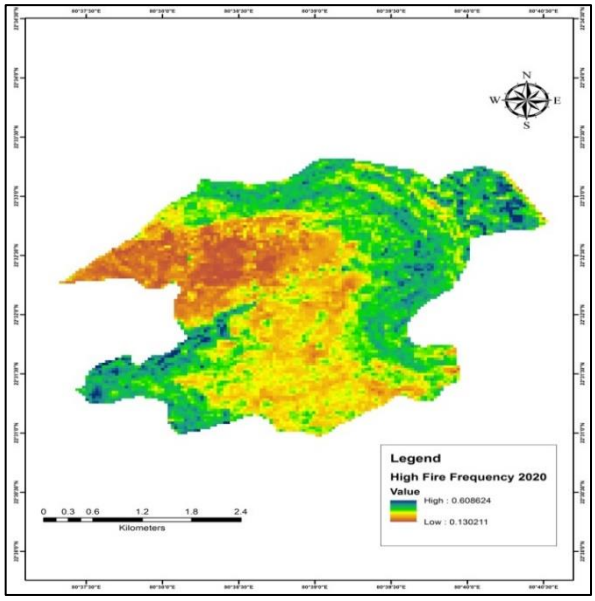


Fig.26 NDVI of Mandala in high frequency of post fire 2020

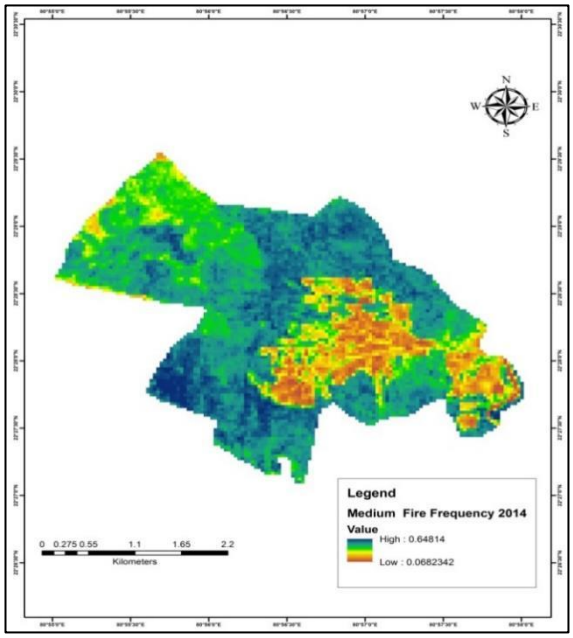


Fig.27 NDVI of Mandala in medium frequency of pre fire 2014

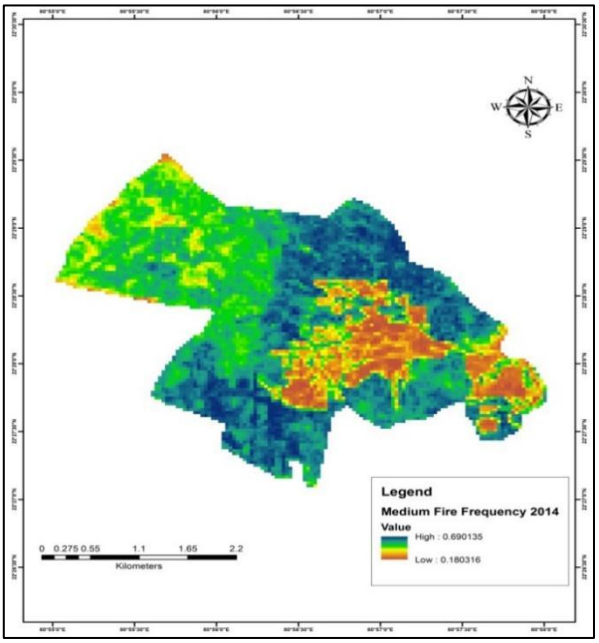


Fig.27 NDVI of Mandala in medium frequency of post fire 2014

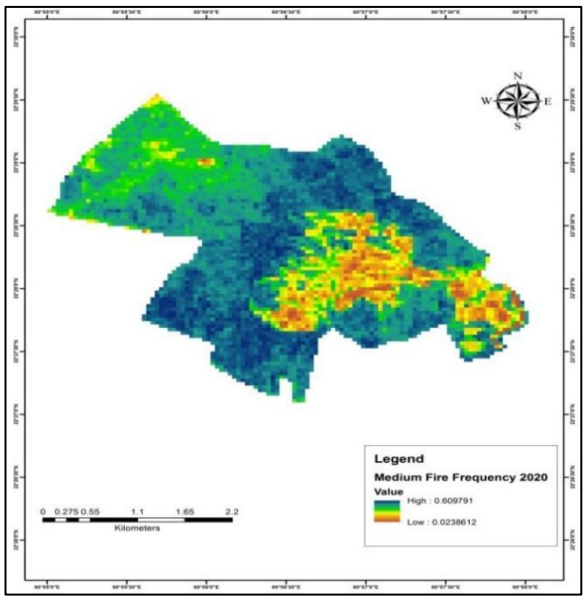


Fig.28 NDVI of Mandala in medium frequency of pre fire 2020

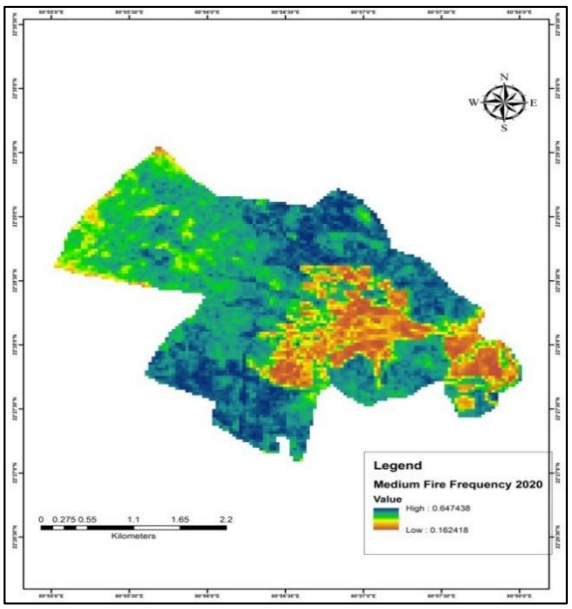


Fig.28 NDVI of Mandala in medium frequency of post fire 2020

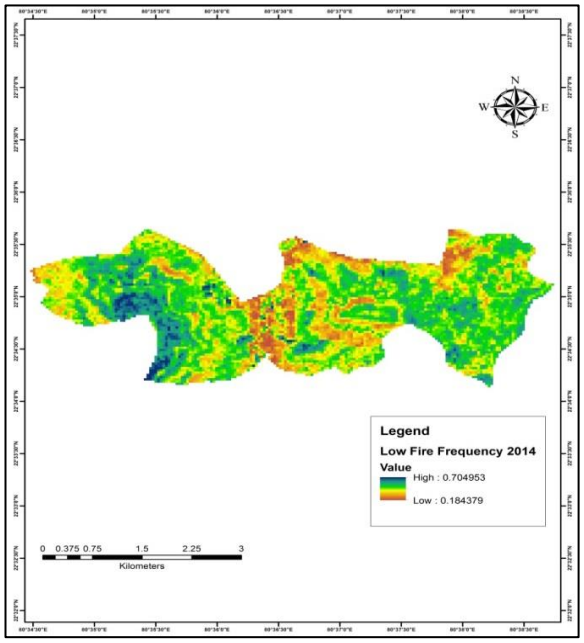


Fig.29 NDVI of Mandala in low frequency of pre fire 2014

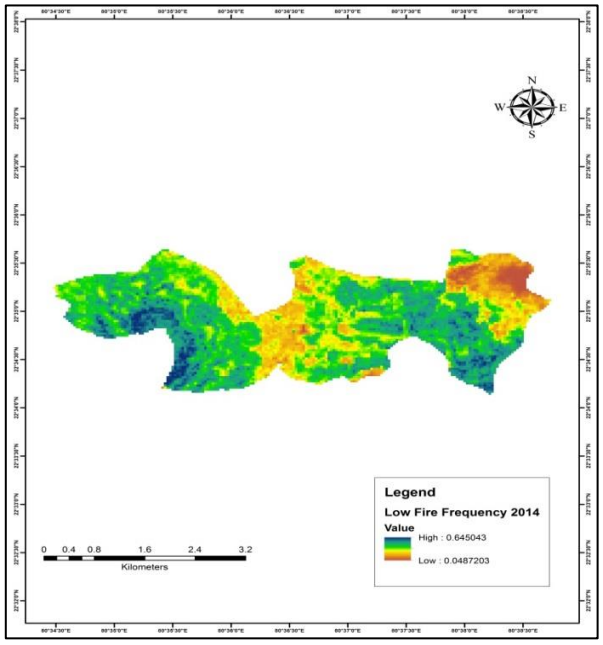


Fig.29 NDVI of Mandala in low frequency of post fire 2014

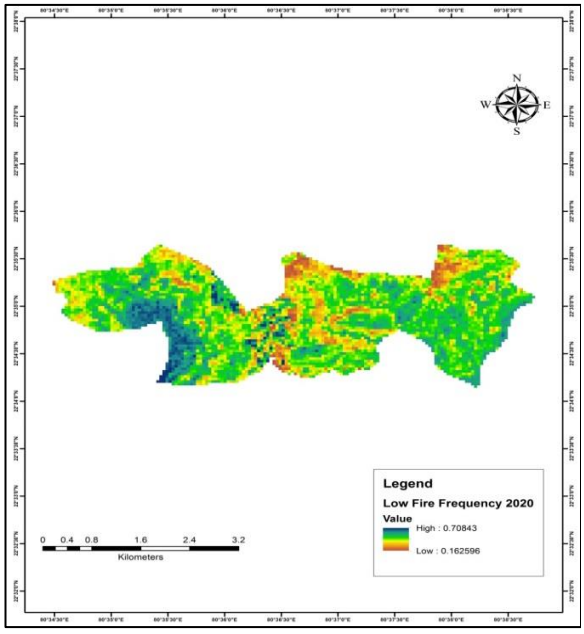


Fig.30 NDVI of Mandala in low frequency of pre fire 2020

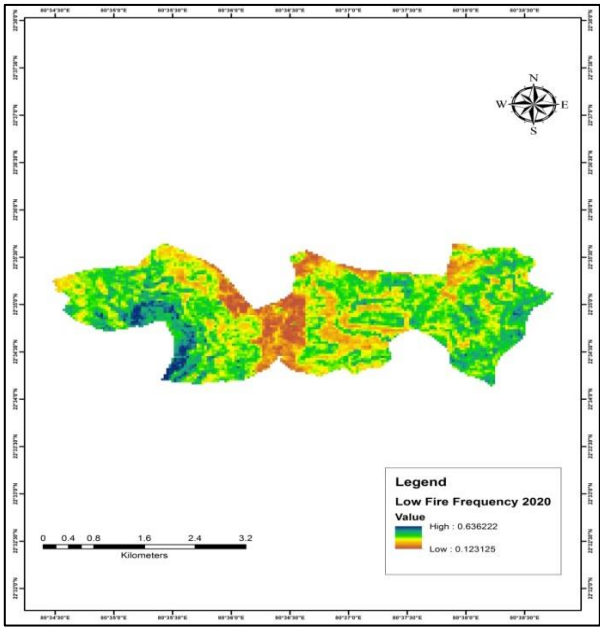


Fig.30 NDVI of Mandala in low frequency of post fire 2020

Map 9: NDVI maps of E Mandala Forest Divisions (Pre and Post fire)

Betul Forest Division NDVI maps are given below in pre and post-fire seasons 2014 and 2020.

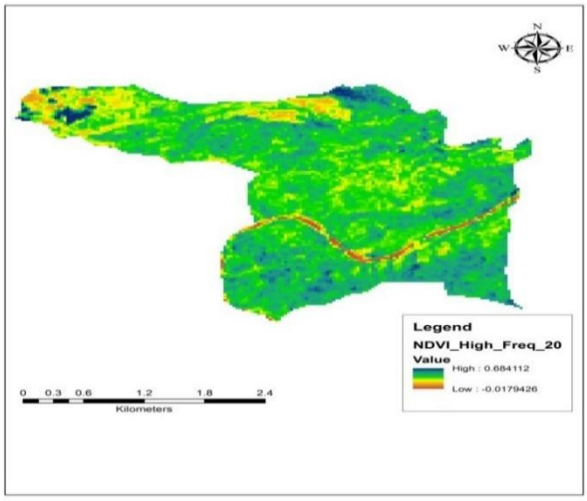


Fig.31 NDVI of Betul in high frequency of pre fire 2020

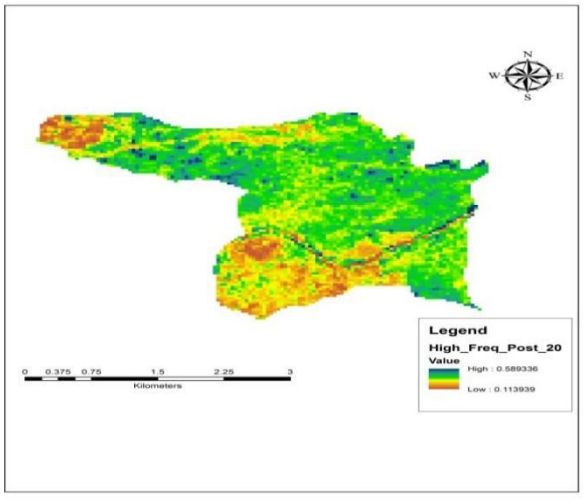


Fig.31 NDVI of Betul in high frequency of post fire 2020

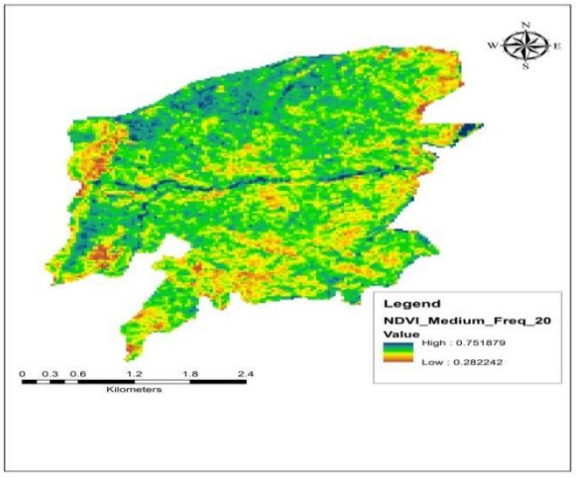


Fig.32 NDVI of Betul in medium frequency of pre fire 2020

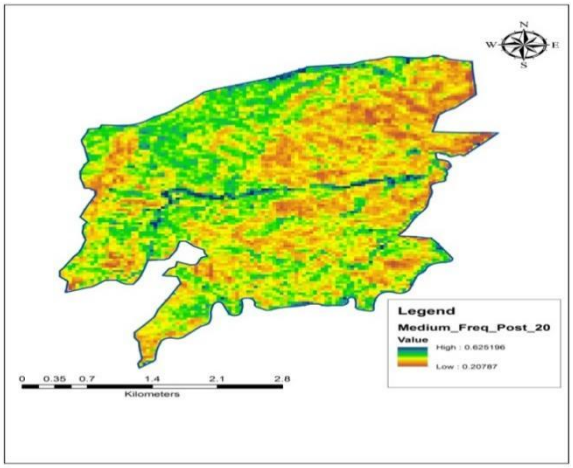


Fig.32 NDVI of Betul in medium frequency of post fire 2020

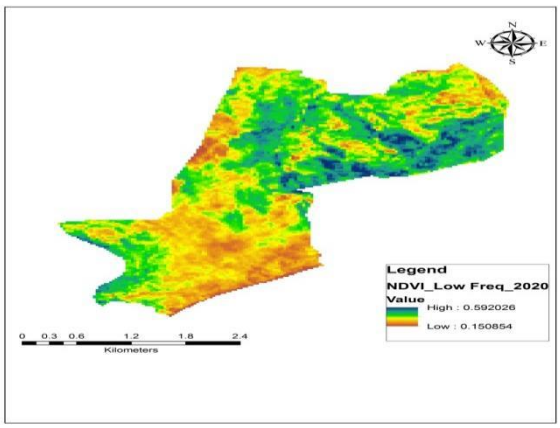


Fig.33 NDVI of Betul in low frequency of pre fire 2020

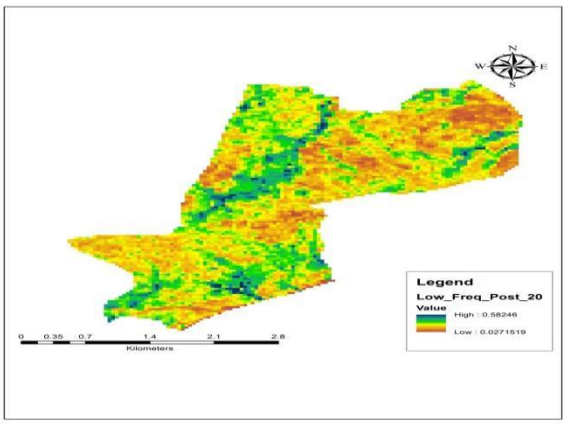


Fig.33 NDVI of Betul in low frequency of post fire 2020

Map 9: NDVI maps of North Betul Forest Division

3.7 Land Use Land Cover (LULC) change detection:

The rapid expansion of anthropogenic land use changes is one important feature that was observed in this study while using remote sensing data. Nowadays, GEE (Google Earth Engine) is a widely used technique in land use and land cover change detection analysis. It gives higher accuracy and lower interpretation (human) errors, etc. A machine learning algorithm is being contributed with a geographic objective for that. Land use/ Land cover map of the study area have been completed for the years 2014 and 2020 using remotely sensed data (TM, LANDSAT-8) imagery. The accuracy assessment of pre and post-fire data of the selected area was achieved. The areas of figures for two seasons in two years are given in the following tables. From the tables of each division, it can be seen that Barren land increased in the post-fire season while scrubland of the given division decreased. The change detection in different land use and land cover categories in Odisha and M.P. sampled clusters has been summarised and presented below:

a) Baliguda Division:

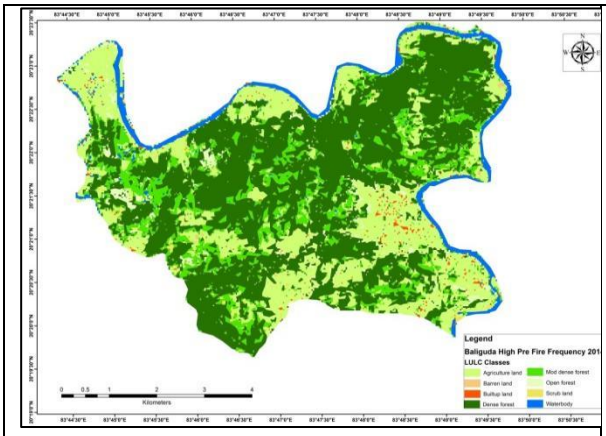


Fig 34 LULC of Baliguda High Pre-Fire Frequency 2014

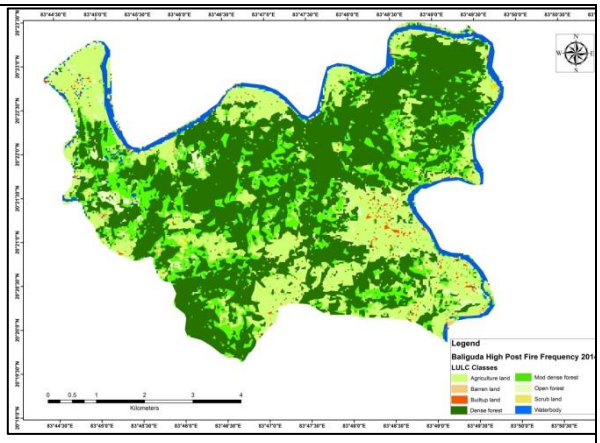


Fig 34. LULC of Baliguda High Post Fire Frequency 2014

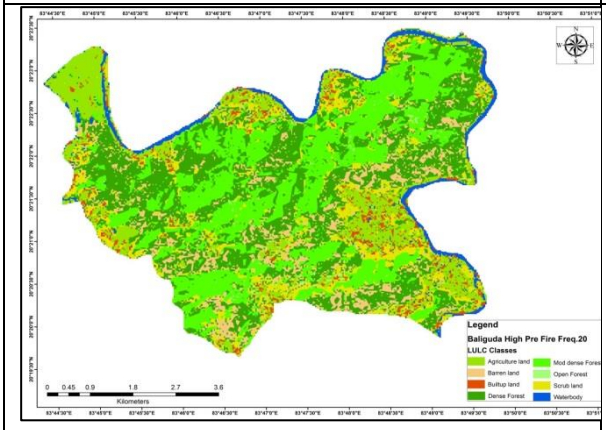


Fig 34. LULC of Baliguda High Pre-Fire Frequency 2020

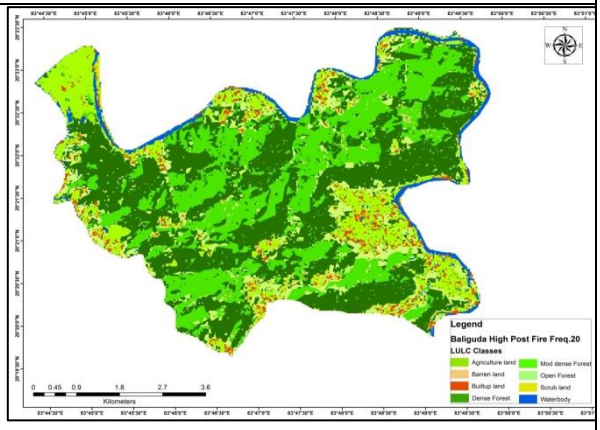


Fig 34. LULC of Baliguda High Post Fire Frequency 2020

Map 10 : Baliguda Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), High Fire Category

The table below shows changes detected in land use due to high forest fire frequency in the Bilguda range

Table 3.2 Change detection of Baliguda High fire frequency area Pre and Post Fire 2014 & 2020

Sr.	LULC_ Classes	Year 2014		Year 2020	
		Post Fire Area (Ha)	Pre Fire Area (Ha)	Post Fire Area (Ha)	Pre Fire Area (Ha)
1	Agriculture land	1054.437	1054.437	934.437	938.437
2	Waterbody	193.011	193.168	197.146	198.168
3	Builtup land	27.798	27.798	127.798	127.798
4	Dense forest	1942.849	1942.94	1939.849	1940.94
5	Barren land	32.342	8.163	34.342	18.163
6	Mod dense forest	608.469	608.5	608.469	610.5
7	Open forest	115.137	115	117	118
8	Scrub land	8.163	32.2	23.165	30.2
	Total	**3982.206**			

Table 3.3 Accuracy Assessment table

Sr.	LULC _Classes	Reference total	Classified total	Number corrects	Producer accuracy	User accuracy
1	Agriculture land	50	51	48	87%	83.89%
2	Waterbody	30	29	26	78%	76.69%
3	Builtup land	25	26	24	72%	68.86%
4	Dense forest	50	52	46	68%	58.69%
5	Barren land	10	12	9	66%	74.45%
6	Mod dense forest	8	9	7	81%	89.89%
7	Open forest	6	7	5	70%	90.86%
8	Scrub land	4	6	3	69%	87.88%

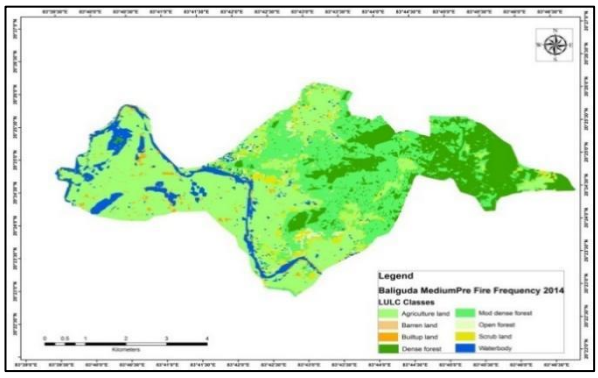


Fig.35 LULC of Baliguda Medium Pre Fire Frequency 2014

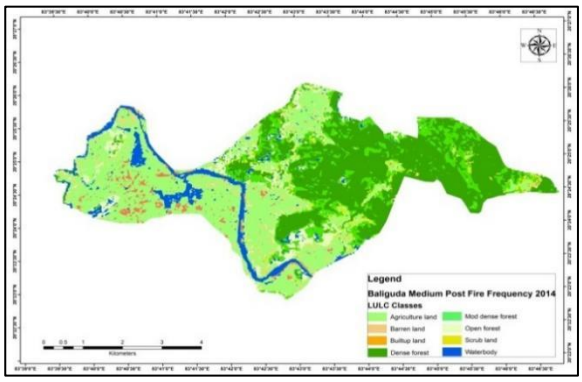


Fig.35 LULC of Baliguda Medium Post Fire Frequency 2014

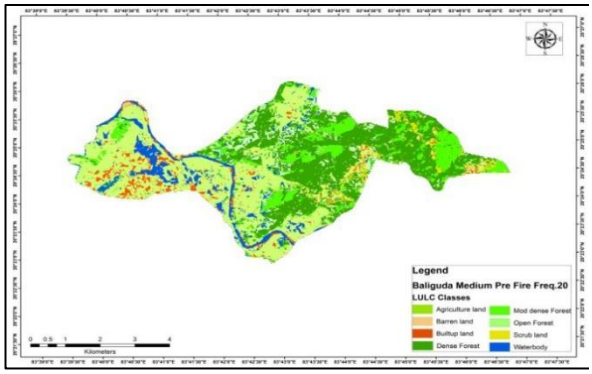


Fig.35 LULC of Baliguda Medium Pre Fire Frequency 2020

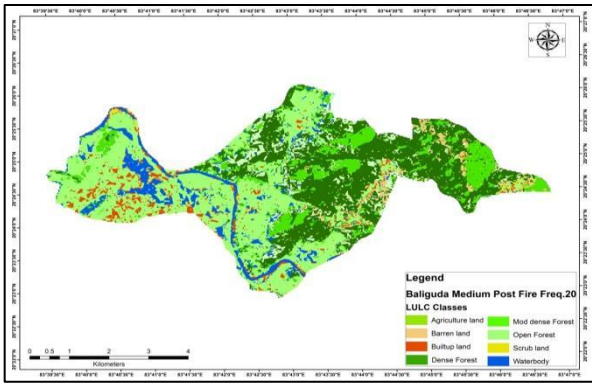


Fig.35 LULC of Baliguda Medium Post Fire Frequency 2014

Map 10 : Baliguda Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Medium Fire Category

The table below shows changes detected in land use due to medium forest fire frequency in the Bilguda range

Table 3.3 Change detection in Baliguda Medium fire frequency area Pre and Post Fire 2014 and 2020

Sr. No	LULC_Classes	Year 2014		Year 2020	
		Pre Area (Hectare)	Post Area (Hector)	Pre Area (Hector)	Post Area (Hector)
1	Agriculture land	1232.963	1232.963	1299.563	1169.996
2	Waterbody	226.216	220.636	235.216	231.636
3	Builtup land	69.858	69.858	89.858	89.858
4	Dense forest	589.015	589	780.258	769.989
5	Barren land	35.365	98.68	25.614	78.68
6	Mod dense forest	900.664	900.561	623.575	620.563
7	Open forest	243.001	242.668	243	242.43
8	Scrub land	151.735	94.451	151.732	108.451
	Total	3448.817			

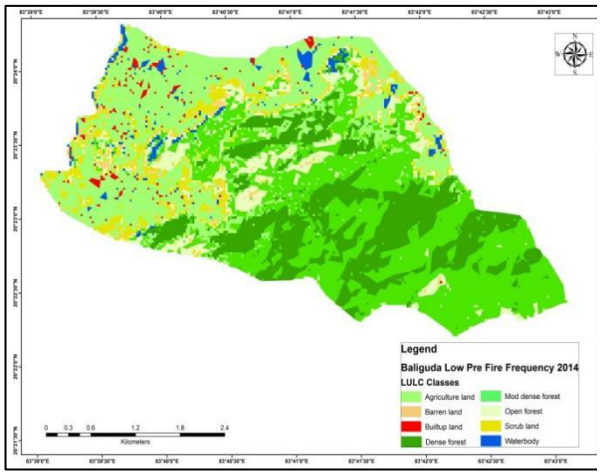


Fig.36 LULC of Baliguda Low Pre Fire Frequency 2014

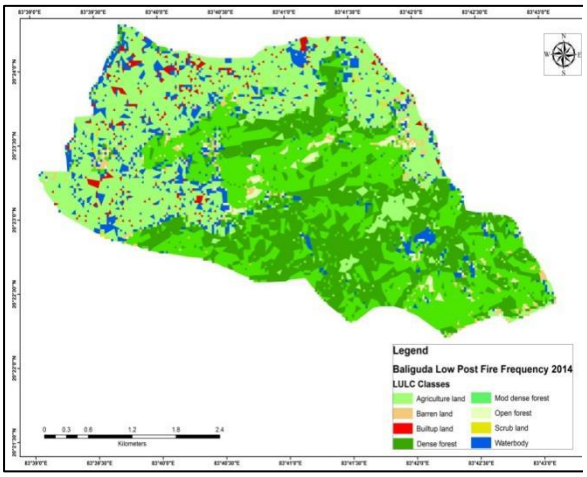


Fig.36 LULC of Baliguda Low Post Fire Frequency 2014

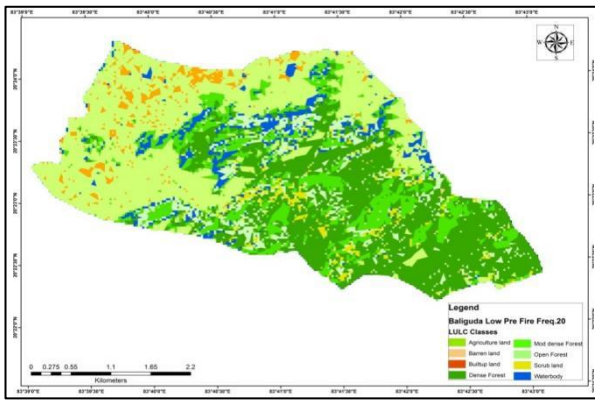


Fig.37 LULC of Baliguda Low Pre Fire Frequency 2020

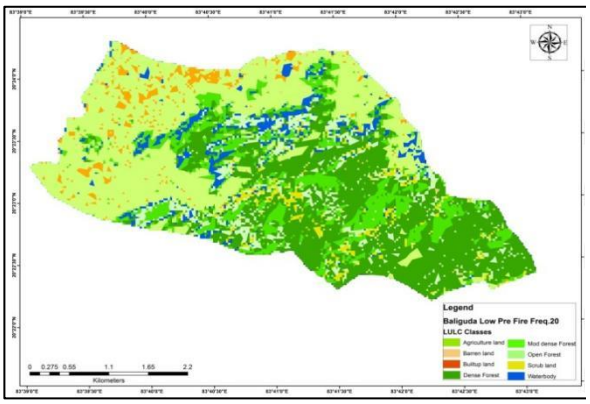


Fig.37 LULC of Baliguda Low Post Fire Frequency 2014

Map 11 : Baliguda Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Low Fire Category

The table below shows changes detected in land use due to low forest fire frequency in Bilguda range

Table 3.4 Change detection in Baliguda Low fire frequency area Pre and Post Fire 2014 and 2020

Sr. No	LULC Classes	Year 2014		Year 2020	
		Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	439.282	439.282	489.282	459.262
2	Waterbody	29.511	29.511	49.511	29.511
3	Built-up land	17.573	17.573	37.573	37.573

4	Dense forest	308.355	308.339	308.355	308.339
5	Barren land	31.926	69.7	46.026	79.7
6	Mod dense forest	517.507	517.041	423.407	420.041
7	Open forest	130.129	128.999	130.129	128.999
8	Scrub land	86.160	49.998	76.16	59.998
	Total	1560.443			

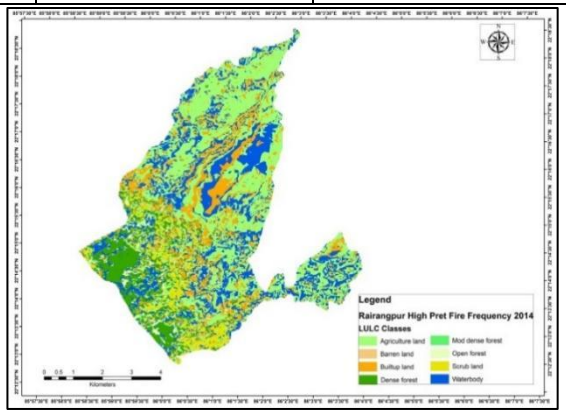


Fig.38 LULC of Rairangpur High Pre Fire Frequency 2014

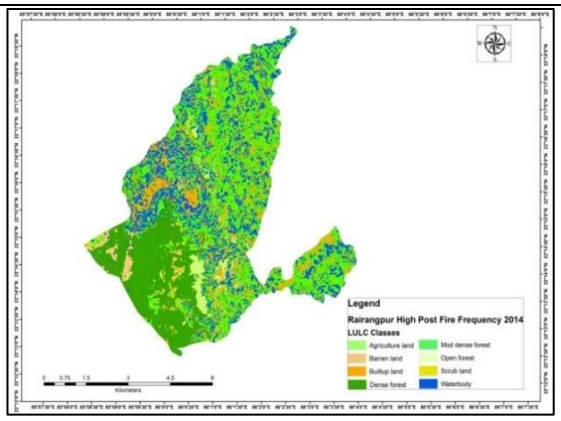


Fig.38 LULC of Rairangpur High Post Fire Frequency 2014

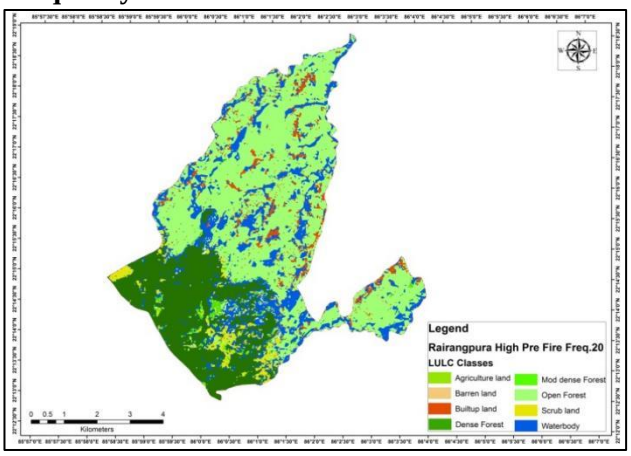


Fig.39 LULC of Rairangpur High Pre Fire Frequency 2020

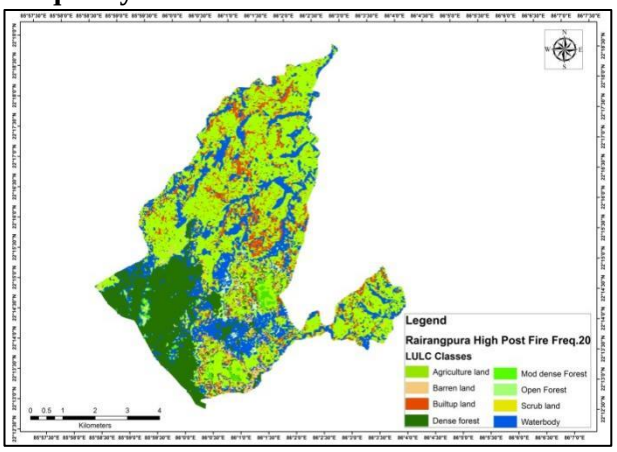


Fig.39 LULC of Rairangpur High Post Fire Frequency 2020

Map 12: Rairangpura Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), High Fire Category

The table below shows changes detected in land use due to high forest fire frequency in the Rairangpur range

Table 3.5 Change detection in Rairangpur High fire frequency area Pre & Post Fire 2014 and 2020

Sr. No	LULC Classes	Year 2014		Year 2020	
		Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	439.282	439.282	489.282	459.262
2	Waterbody	29.511	29.511	49.511	29.511
3	Built-up land	17.573	17.573	37.573	37.573
4	Dense forest	308.355	308.339	308.355	308.339
5	Barren land	31.926	69.7	46.026	79.7
6	Mod dense forest	517.507	517.041	423.407	420.041
7	Open forest	130.129	128.999	130.129	128.999
8	Scrub land	86.160	49.998	76.16	59.998
	Total	1560.443			

LULC Rairangpura, Medium Fire Frequency Area

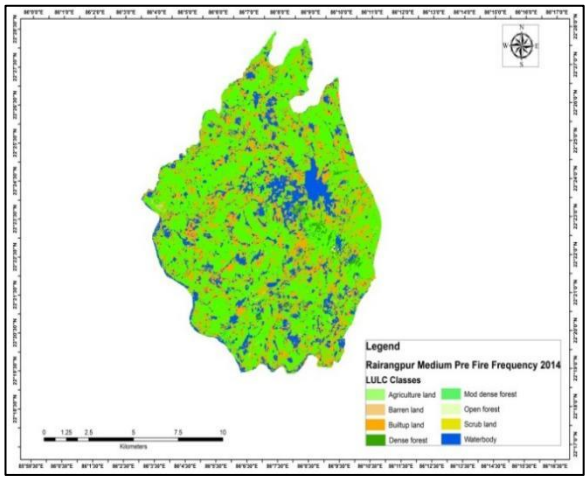


Fig 40 LULC of Rairangpur Medium Pre Fire Frequency 2014

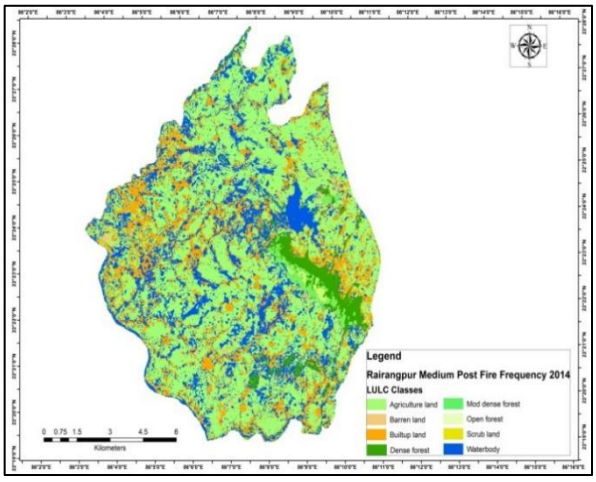


Fig 40 LULC Rairangpur Medium Post Fire Frequency 2014

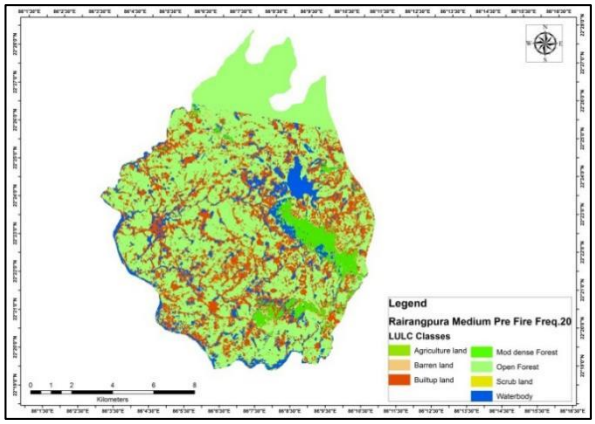


Fig 41 LULC of Rairangpur Medium Pre Fire Frequency 2020

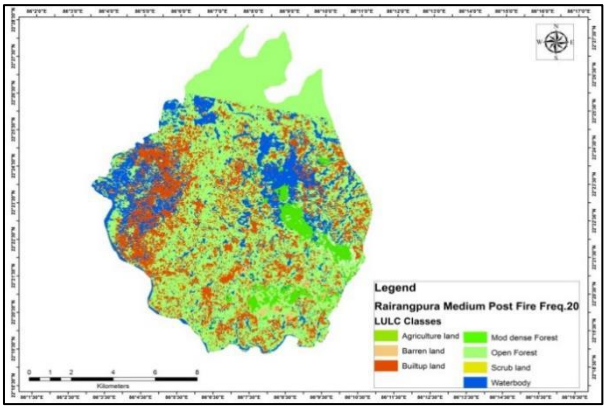


Fig 41 LULC Rairangpur Medium Post Fire Frequency 2020

Map 13: Rairangpura Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Medium Fire Category

The table below shows changes detected in land use due to medium forest fire frequency in Rairangpur range

Table 3.6 Change detection in Rairangpur Medium fire frequency area Pre and Post Fire 2014 and 2020

Sr. No.	Classes	Year 2014		Year 2020	
		Pre fire	Post-fire	Pre fire	Post-fire
1	Agriculture land	1839.475	1830.999	1529.875	1499.989
2	Barren land	59.237	139.998	440.237	189.998
3	Builtup land	736.8711	736.8711	936.8711	936.8711
4	Dense forest	464.095	464.061	364.095	354.061
5	Mod dense forest	28.365	28.3	85.852	45.3
6	Open forest	121.531	121.005	132.62	131.008
7	Scrub land	219.926	196.346	119.938	175.346
8	Waterbody	1137.301	1089.221	997.301	889.221
	Total	4606.801			

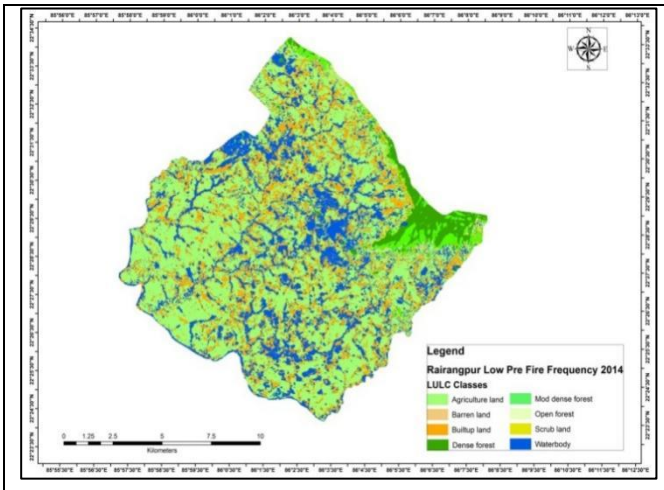


Fig 42 LULC of Rairangpur low Pre Fire Frequency 2014

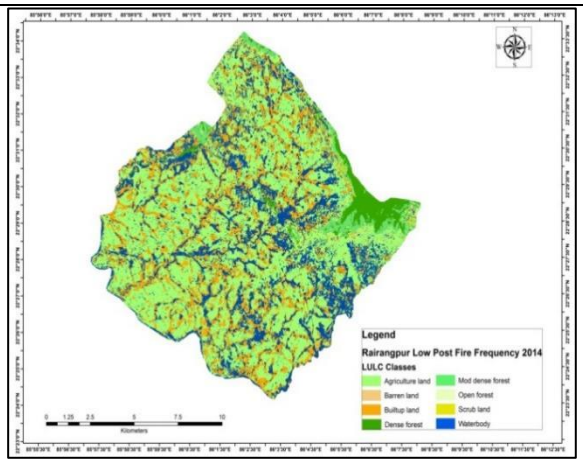


Fig 42 LULC of Rairangpur low Post Fire Frequency 2014

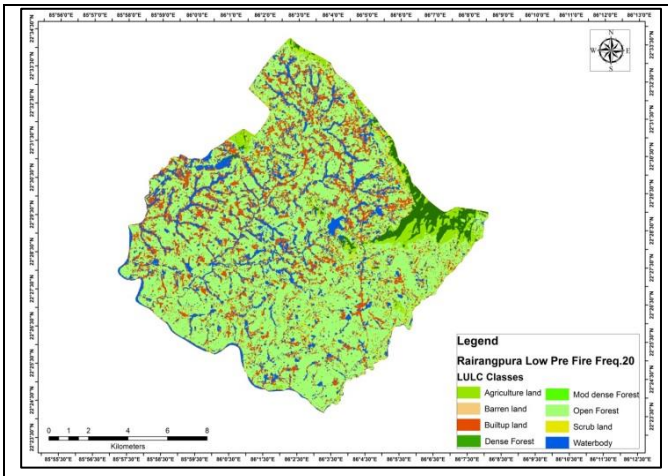


Fig 43 LULC of Rairangpur low Pre Fire Frequency 2020

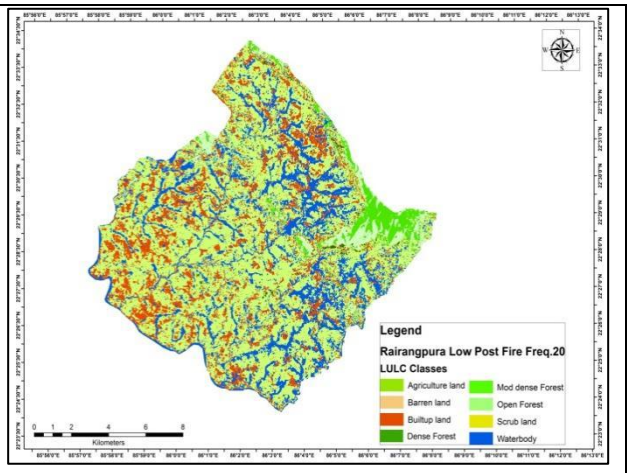


Fig 43 LULC of Rairangpur low Post Fire Frequency 2020

Map 14: Rairangpura Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Medium Fire Category

The table below shows changes detected in land use due to low forest fire frequency in the Rairangpur range

Table 3.7 Change detection in Rairangpur low fire frequency area Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	913.282	913.282	612.282	612.282
2	Barren land	313.526	897	213.526	199.7
3	Builtup land	329.142	329.142	829.142	829.142
4	Dense Forest	520.402	519.322	623.402	610.322
5	Mod dense Forest	947.658	887.131	847.658	840.131
6	Open Forest	632.191	482.273	532.191	522.273
7	Scrub Land	976.142	606.994	976.142	806.994
8	Waterbody	14.336	11.535	12.336	11.535
Total		4646.679			

Rayagada LULC, Pre and Post Fire (2014, 2020)

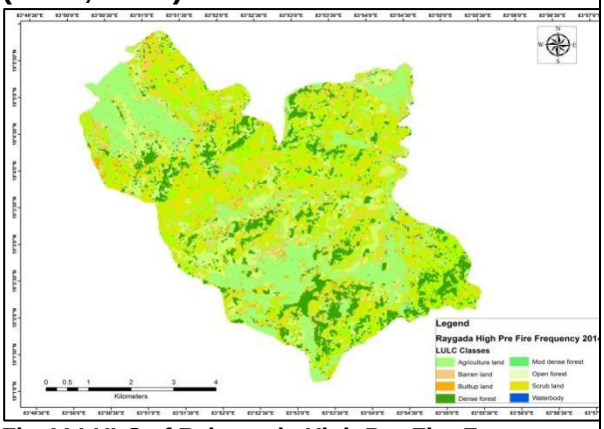


Fig 44 LULC of Raiyagada High Pre-Fire Frequency 2014

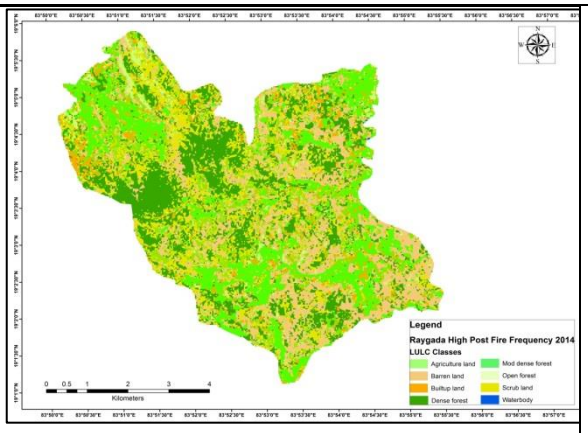


Fig 44 LULC of Rayagada High Post Fire Frequency 2014

Sr. No.	Classes	Pre-fire (ha)	Post-fire (ha)	Pre-fire (ha)	Post-fire (ha)
1	Agriculture land	8701.666	8699.659	8701.666	8699.659
2	Barren land	43.245	99.436	43.245	99.436
3	Builtup land	4089.908	3999.375	4089.908	3999.375
4	Dense forest	673.545	671.096	673.545	671.096
5	Mod dense forest	453.585	452.998	453.585	452.998
6	Open forest	169.047	165.812	169.047	165.812
7	Scrub land	17.619	12.999	17.619	12.999
8	Waterbody	4110.499	4157.739	4110.499	4109.739
	Total	**18259.11**			

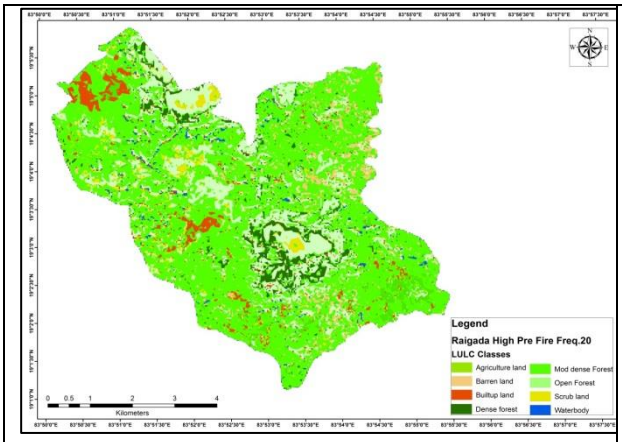


Fig 45 LULC of Raiyagada High Pre-Fire Frequency 2014

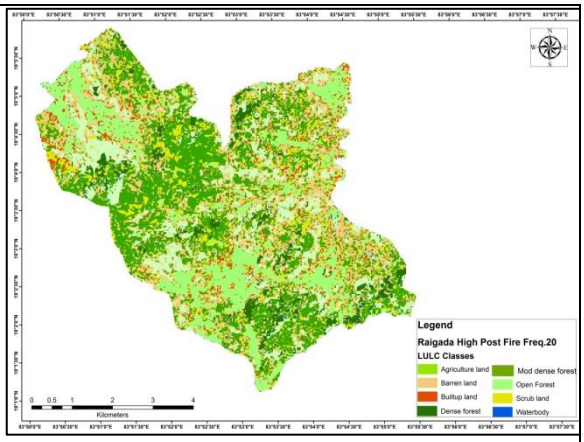


Fig 45 LULC of Rayagada High Post Fire Frequency 2020

Map 15: Raygada Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), High Fire Category

Table 3.7 Change detection in Rayagada High fire frequency area Pre and Post Fire 2014 and 2020

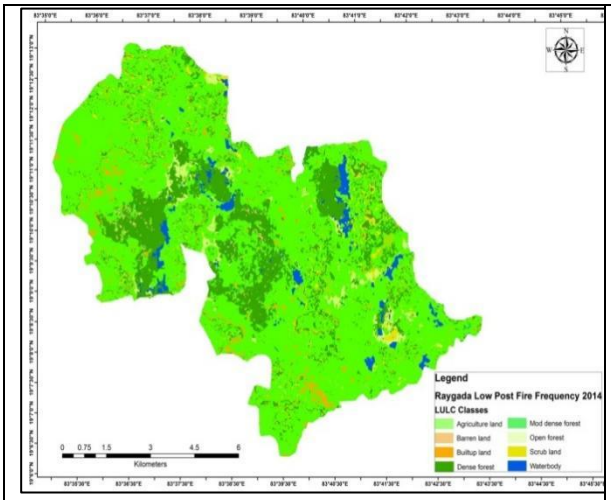


Fig 47 LULC of Rayagada Medium Pre-Fire Frequency 2014

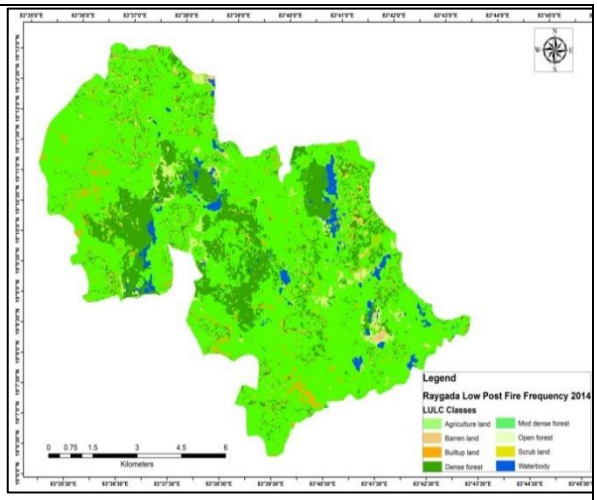


Fig 47 LULC of Rayagada Medium Post Fire Frequency 2014

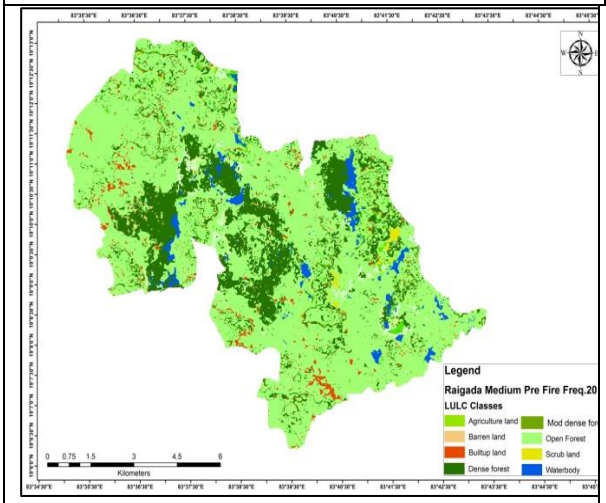


Fig 48 LULC of Raygada Medium Pre-Fire Frequency 2020

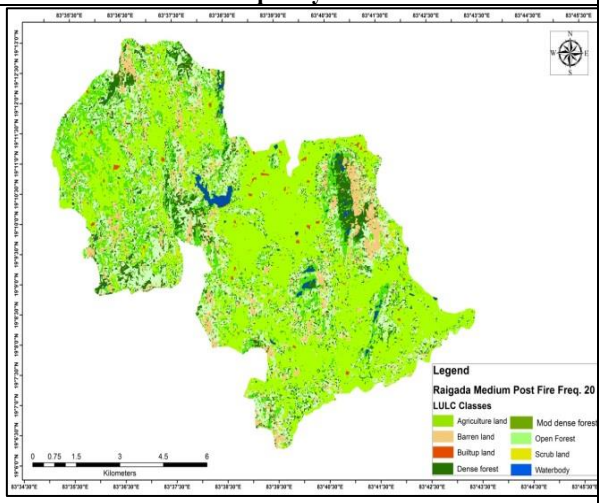


Fig 48LULC of Raygada Medium Post Fire Frequency 2020

Map 16: Raygada Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Medium Fire Category

Table 3.8 Change detection in Rayagada medium fire frequency area Pre and Post Fire 2014 and 2020

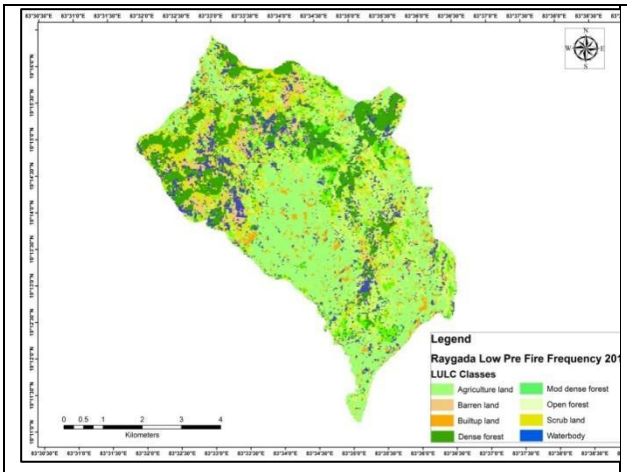


Fig 49 LULC of Rayagada Low Pre-Fire Frequency 2014

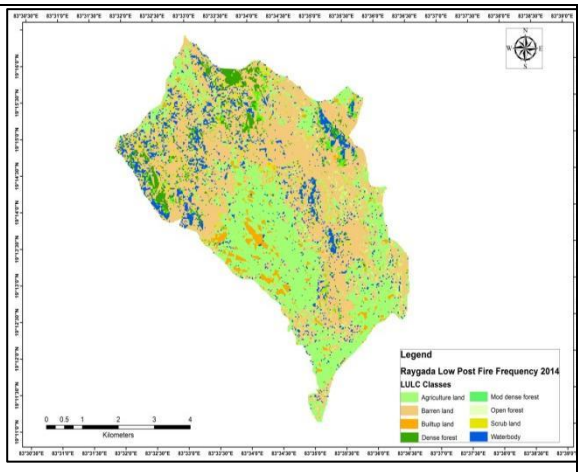


Fig 49 LULC of Rayagada Low Post Fire Frequency 2014

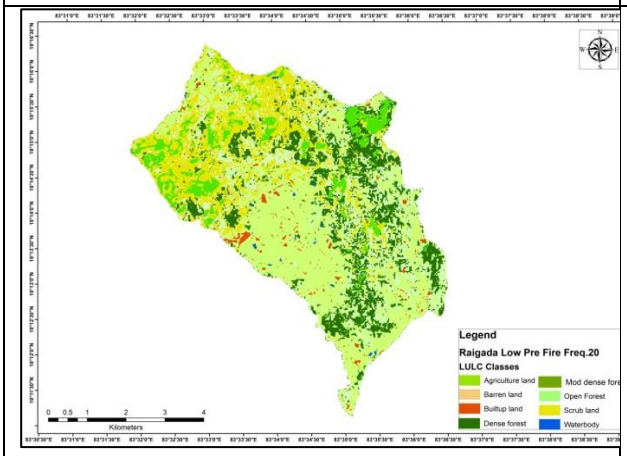


Fig 50 LULC of Rayagada Low Pre-Fire Frequency 2020

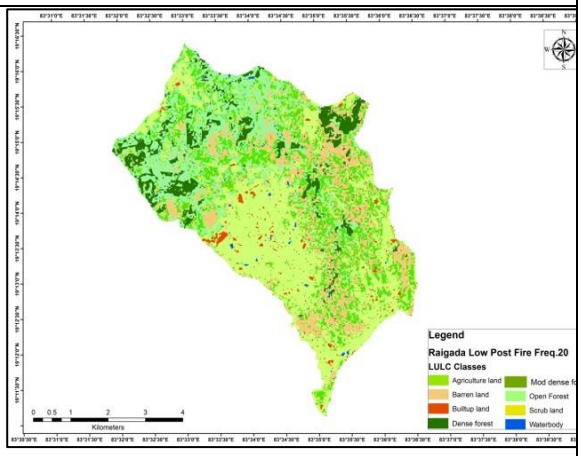


Fig 50LULC of Rayagada Low Post Fire Frequency 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	913.282	886.282	823.282	820.282
2	Barren land	357.131	1142.54	407.131	742.54
3	Builtup land	329.142	329.142	429.142	429.142
4	Dense Forest	897.002	694.982	827.002	794.982
5	Mod dense Forest	994.106	847.113	994.106	847.113
6	Open Forest	499.279	226.639	499.279	426.639
7	Scrub Land	877.48	741.803	877.48	741.803
8	Waterbody	29.535	28.456	39.535	38.456
Total		**4896.957**			

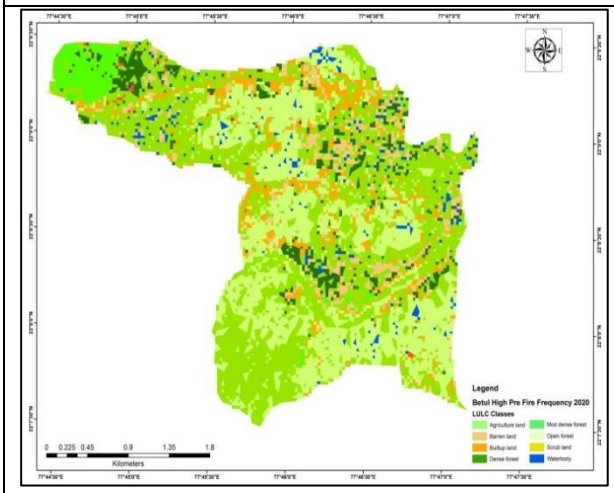
Map 17: Raygada Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Low Fire Category

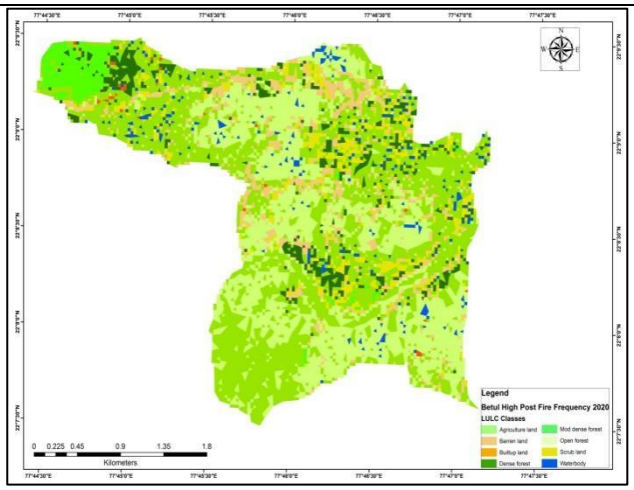
The table below shows changes detected in land use due to high forest fire frequency in the Rayagada range

Table 3.9 Change detection of Rayagada Low Pre and Post Fire 2014 and 2020

Fig 51 LULC of Betul High Pre Fire Frequency 2014

Fig 51LULC of Betul High Post Fire Frequency 2014





Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	1307.894	1299.999	1107.894	1099.999
2	Barren land	958.675	1586.089	758.675	1186.089
3	Builtup land	127.464	127.464	527.464	527.464
4	Dense Forest	473.458	422.672	573.458	522.672
5	Mod dense Forest	258.01	247.793	358.01	347.793
6	Open Forest	489.76	341.847	389.76	341.847
7	Scrub Land	525.837	169.269	325.837	169.269
8	Waterbody	379.476	325.441	479.476	325.441
Total		4520.574			

Fig 53 LULC of Betul High Pre Fire Frequency 2020	Fig 54 LULC of Betul High Post Fire Frequency 2020

Map 17: N Betul Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), HighFire Category

The table below shows changes detected in land use due to high forest fire frequency in Betul

Table 3.10 Change detection of Betul High-frequency forest fire Pre and Post Fire 2014 and 2020

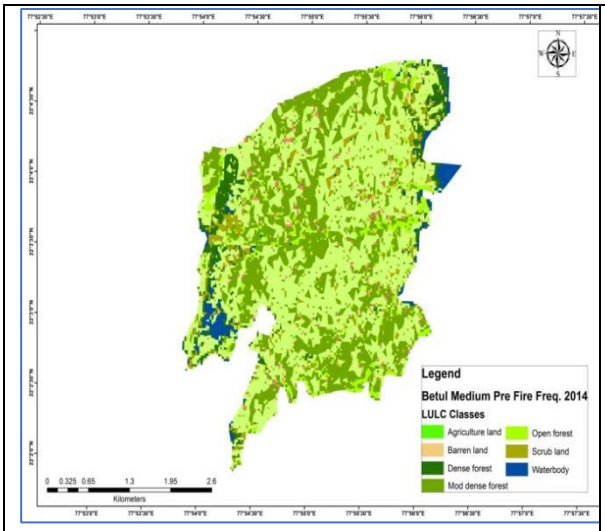


Fig.55 LULC of Betul Medium Pre-Fire Frequency 2014

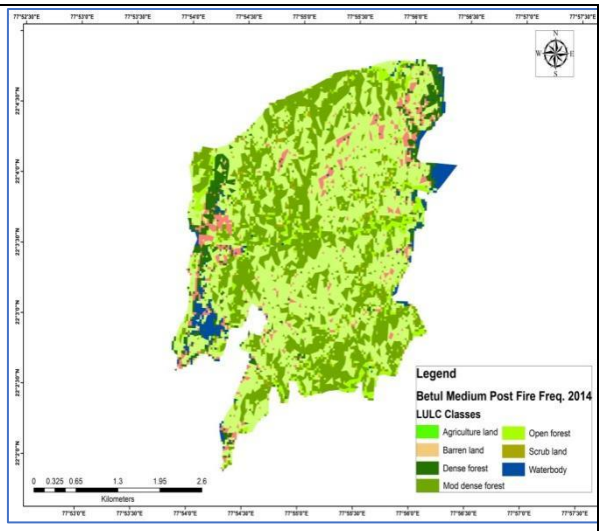


Fig. 55 LULC of Betul Medium Post Fire Frequency 2014

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	35.254	33.998	30.254	29.998
2	Barren land	63.693	70.876	60.693	70.876
5	Mod dense Forest	611.298	610.999	611.298	610.999
6	Open Forest	79.770	62.55	81.77	80.55
7	Scrub Land	85.737	97.594	88.737	81.594
8	Waterbody	47.549	47.249	50.549	49.249
	Total	**923.301**			

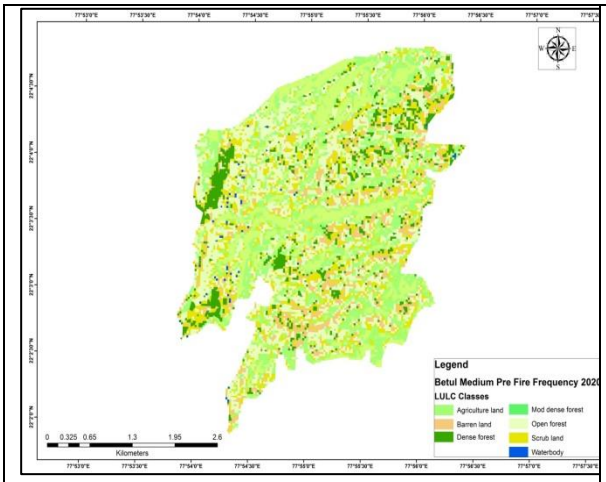


Fig.56 LULC of Betul Medium Pre Fire Frequency 2020

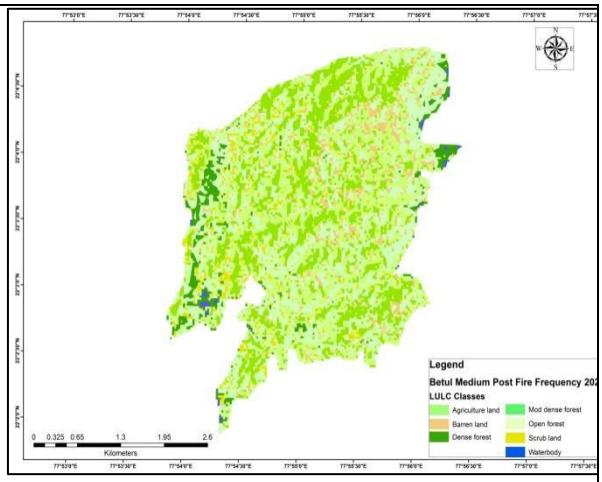


Fig.56 LULC of Betul Medium Post Fire Frequency 2020

Map 18: N Betul Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Medium Fire Category

The table below shows changes detected in land use due to medium forest fire frequency in Betul

Table 3.11 Change detection of Betul medium frequency forest fire Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	14.177	14.177	13.287	14.177
2	Barren land	184.663	192.756	186.663	192.756
3	Mod dense Forest	419.294	418.3	417.994	418.3
4	Open Forest	480.529	479.999	476.999	479.999
5	Dense Forest	13.392	12.392	13	12.392
6	Scrub Land	233.21	229.24	234.322	229.24
7	Waterbody	25.853	24.999	28.853	24.999
8	**Total**	**1371.118**			

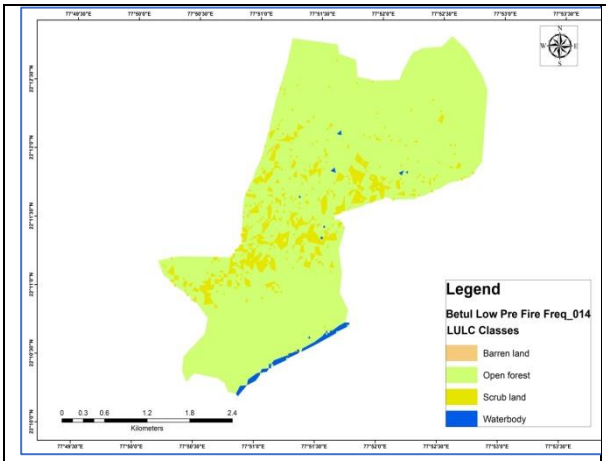


Fig.57 LULC of Betul Low Pre-Fire Frequency 2014

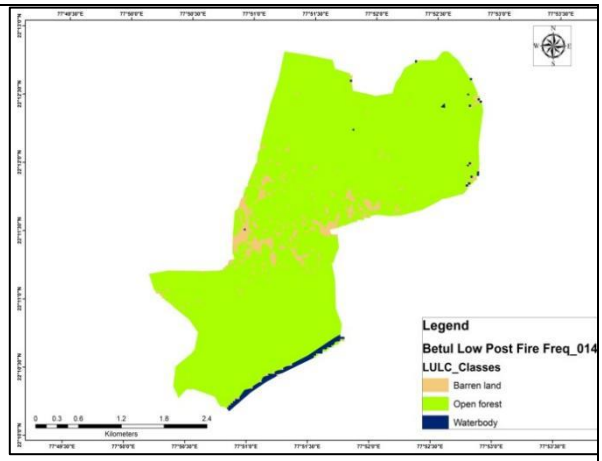


Fig.57 LULC of Betul Low Post Fire Frequency 2014

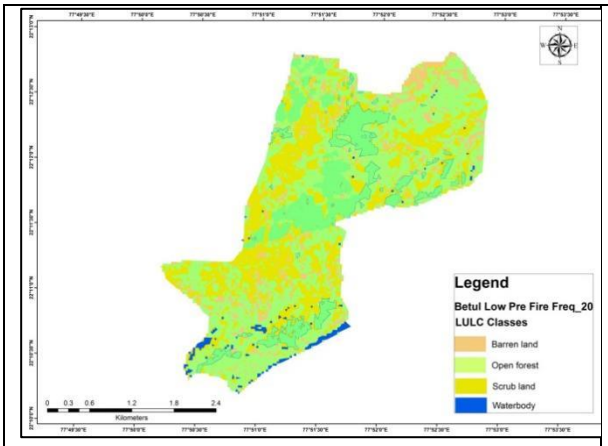


Fig.57 LULC of Betul Low Pre-Fire Frequency 2020

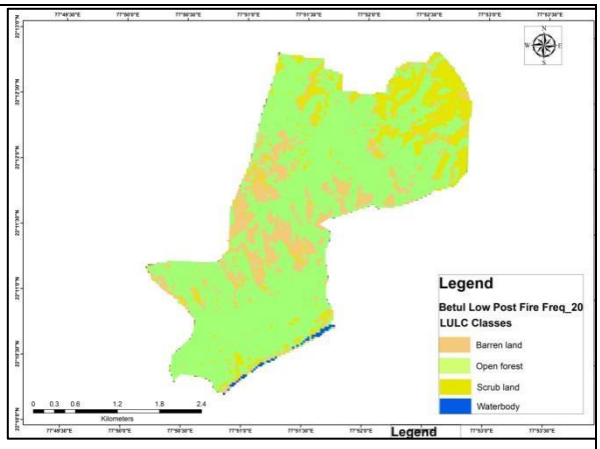


Fig.57 LULC of Betul Low PostFire Frequency 2020

Map 19: N Betul Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Low Fire Category

The table below shows changes detected in land use due to low forest fire frequency in Betul

Table 3.12 Change detection of Betul low-frequency forest fir Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Barren land	0.594	2.212	5.894	5.456
2	Open Forest	904.123	901.121	804.143	699.121
3	Scrub Land	91.155	89.978	181.835	180.579
4	Waterbody	9.727	9	13.727	11
	Total	1005.599			

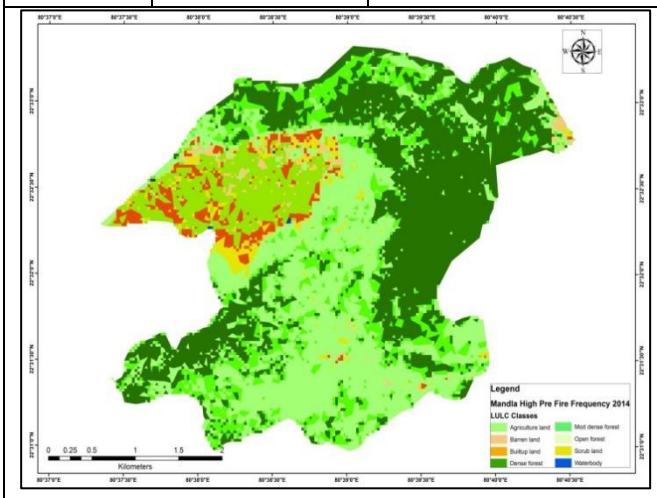


Fig 58 LULC of Mandla High Pre-Fire Frequency 2014

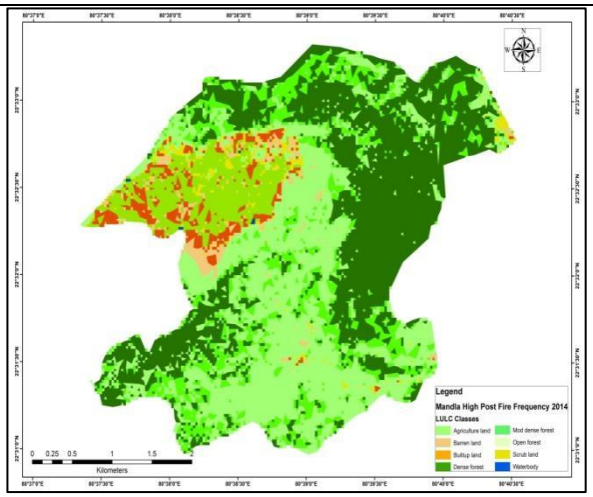


Fig.58 LULC of Mandla High Post Fire Frequency 2014

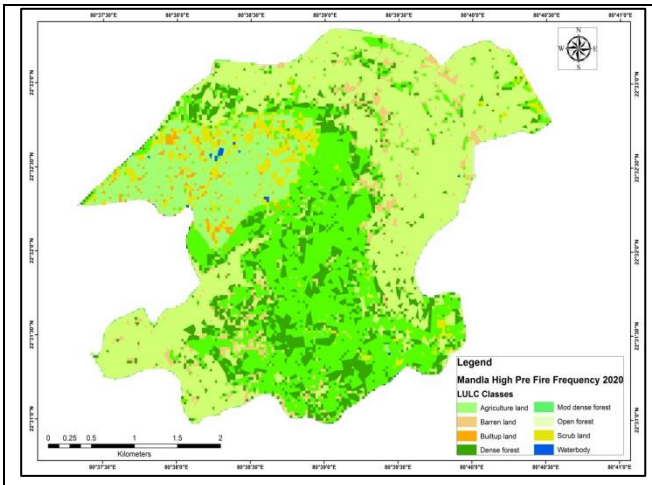


Fig.59 LULC of Mandla High Pre-Fire Frequency 2020

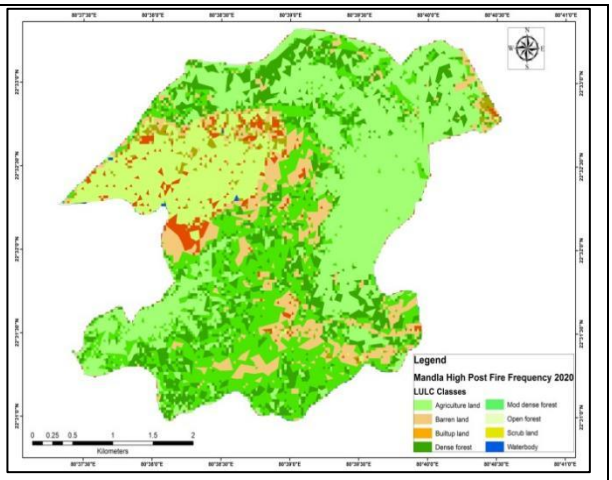


Fig.59 LULC of Mandla High Post Fire Frequency 2020

Map 20: E Manada Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), High Fire Category

The table below shows changes detected in land use due to high forest fire frequency in the Madla forest division

Table 3.13 Change detection of Mandla high low-frequency forest fir Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	113.894	113.7	115.794	113.7
2	Barren land	25.135	34.986	45.135	54.986
3	Builtup land	47.577	47.577	37.547	67.547
4	Mod dense Forest	200.905	199.999	197.035	196.999
5	Open Forest	480.57	455.63	480.57	455.63
6	Dense Forest	491.865	490.999	491.865	490.999
7	Scrub Land	33.849	28.768	23.849	18.768
8	Waterbody	0.72	0.55	2.72	2.55
9	**Total**	**1394.515**			

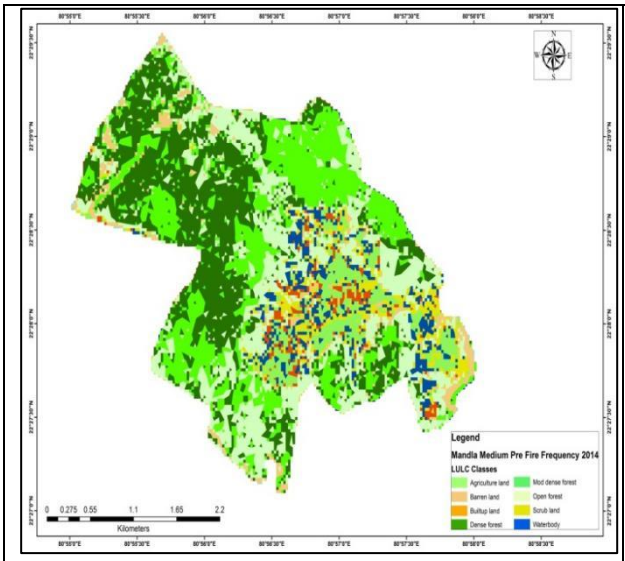


Fig.60 LULC of Mandla Medium Pre-Fire Frequency 2014

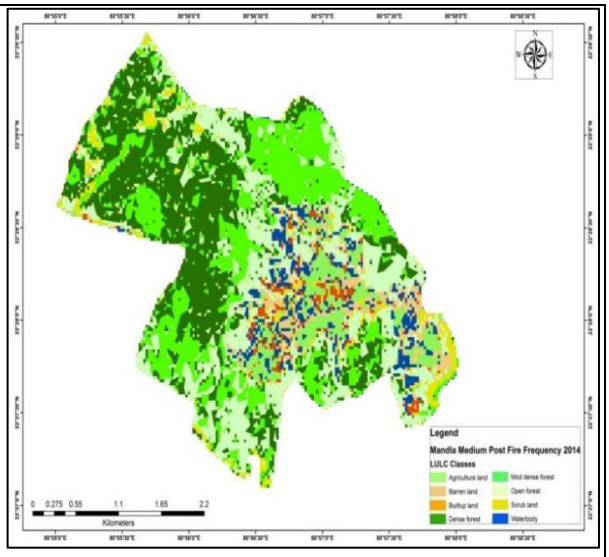


Fig.60 LULC of Mandla Medium Post Fire Frequency 2014

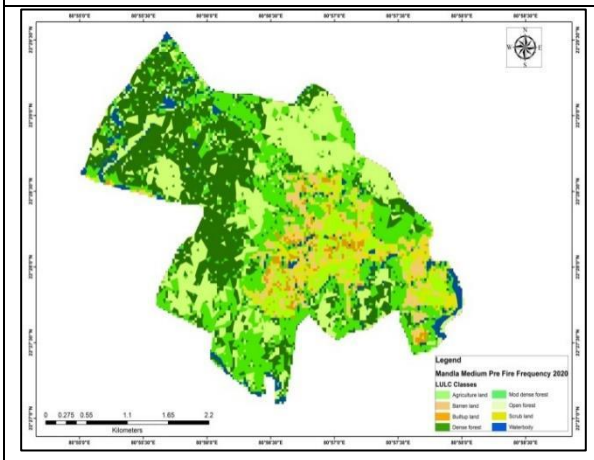


Fig.61 LULC of Mandla Medium Pre-Fire Frequency 2020

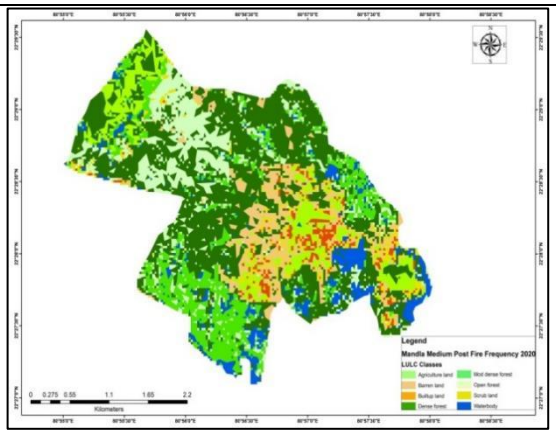


Fig.61 LULC of Mandla Medium Post Fire Frequency 2020

Map 21: E Manada Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Medium Fire Category

Table 3.14 Change detection of Mandla medium frequency forest fir Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	68.604	68	60.604	60
2	Barren land	49.706	62.356	49.906	63.556
3	Builtup land	26.272	26.272	46.172	46.172
4	Mod dense Forest	265.399	265	165.299	175
5	Open Forest	290.543	288.876	392.543	289.876
6	Dense Forest	319.244	318.999	305.244	318.999
7	Scrub Land	63.069	58.564	63.069	58.564
8	Waterbody	60.447	59.999	60.447	59.999
9	**Total**	**1143.284**			

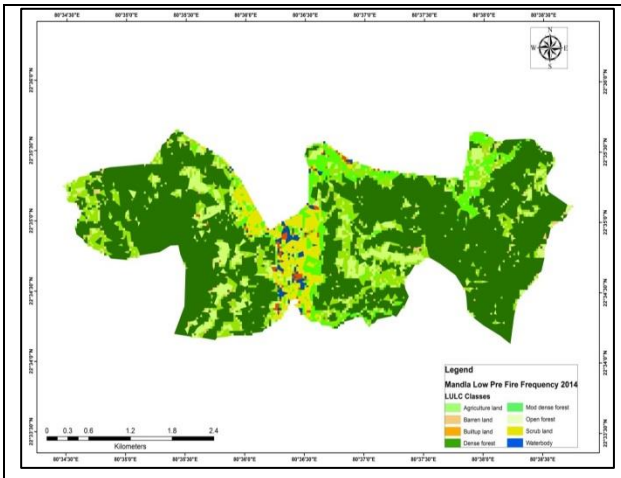


Fig 62. LULC of Mandla Low Pre-Fire Frequency 2014

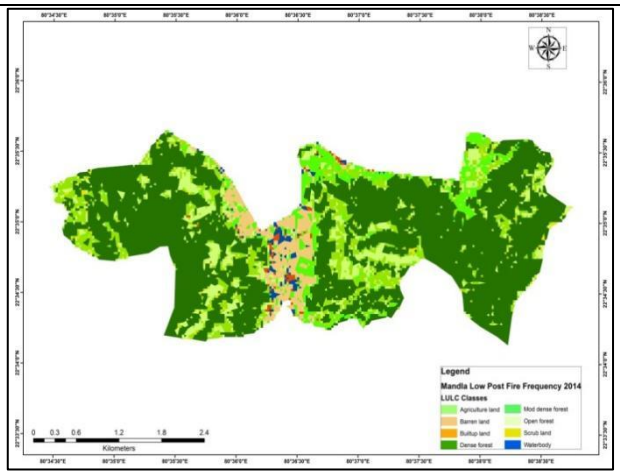


Fig 62. LULC of Mandla Low Post Fire Frequency 2014

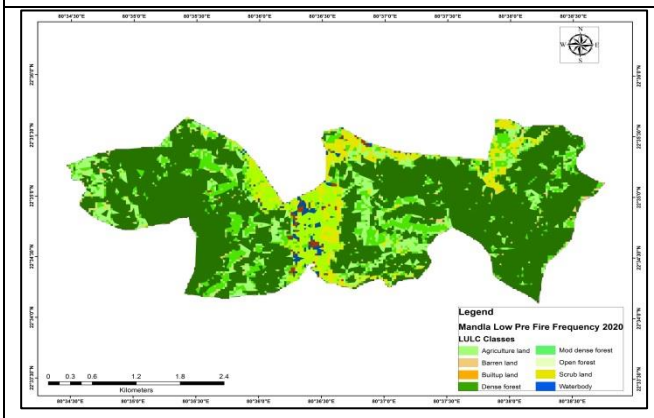


Fig 63. LULC of Mandla Low Pre Fire Frequency 2020

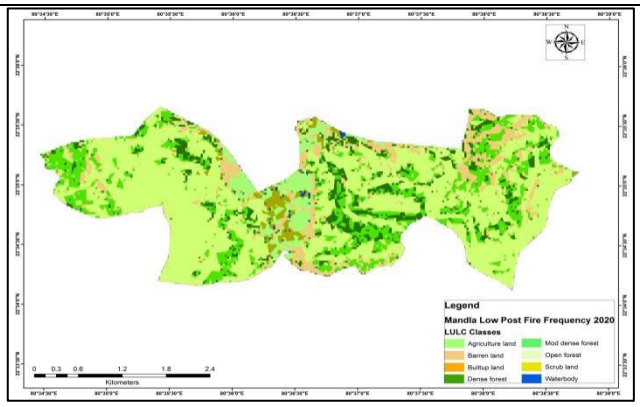


Fig 63. LULC of Mandla Low Post Fire Frequency 2020

Map 22: E Manada Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Low Fire Category

The table below shows changes detected in land use due to low forest fire frequency in the Madla forest division

Table 3.15 Change detection of Mandla low-frequency forest fir Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	78.097	78	75.097	75
2	Barren land	13.388	20.987	16.888	25.987
3	Builtup land	7.68	7.68	17.68	17.68
4	Mod dense Forest	147.594	146.987	137.594	136.987
5	Open Forest	127.282	125.867	126.582	125.867
6	Dense Forest	751.709	751	751.709	751
7	Scrub Land	65.067	63.999	65.267	63.999
8	Waterbody	11.888	11.01	11.888	11.01
9	**Total**	**1202.705**			

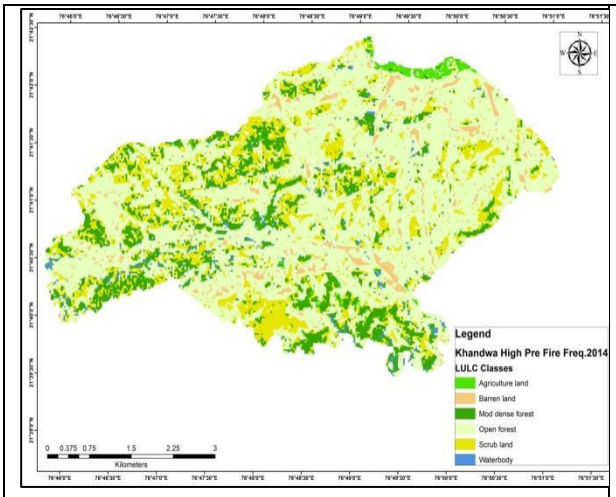


Fig.64 LULC of Khandawa High Pre Fire Frequency 2014

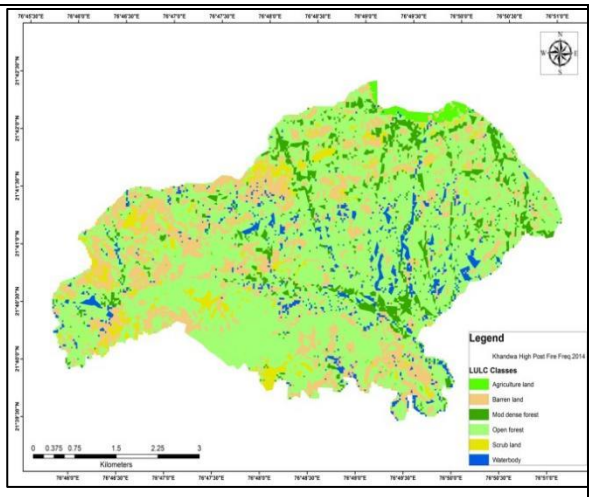


Fig. 64 LULC of Khandawa High Post Fire Frequency 2014

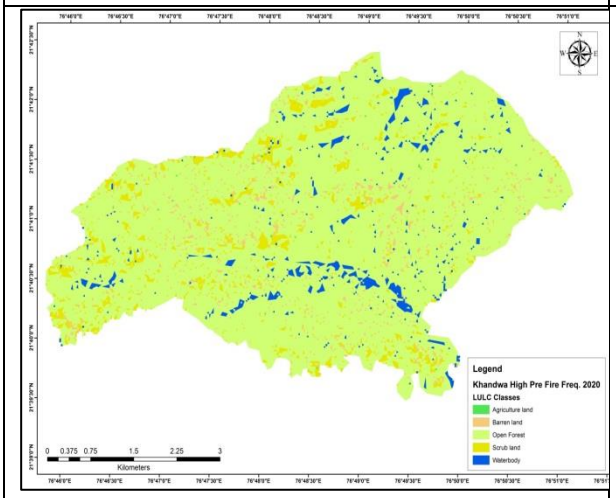


Fig.65 LULC of Khandwa High Pre Fire Frequency 2020

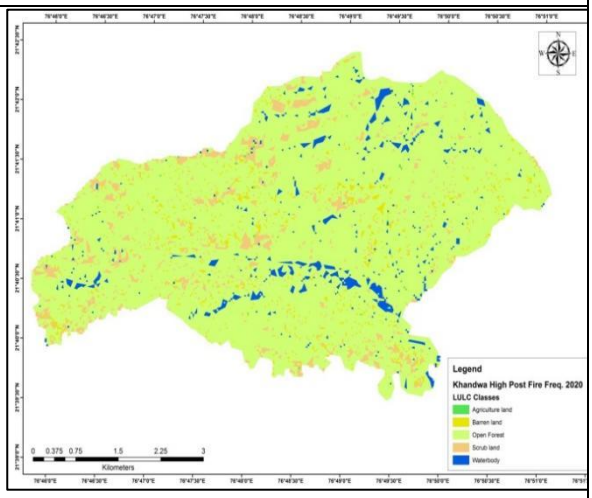


Fig.65 LULC of Khandwa High Post Fire Frequency 2020

Map 23: Khandwa Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), High Fire Category

The table below shows changes detected in land use due to high forest fire frequency in the Khandwa Forest division

Table 3.16 Change detection of Khandawa high-frequency forest fir Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	38.451	38	36.751	38
2	Barren land	99.252	115.689	96.252	115.689
3	Mod dense Forest	353.995	353	353.995	353
4	Open Forest	1732.499	1730.243	1742.499	1730.243
5	Scrub Land	505.368	499.369	500.068	499.069
6	Waterbody	51.532	51.001	51.532	51.096
7	**Total**	**2781.097**			

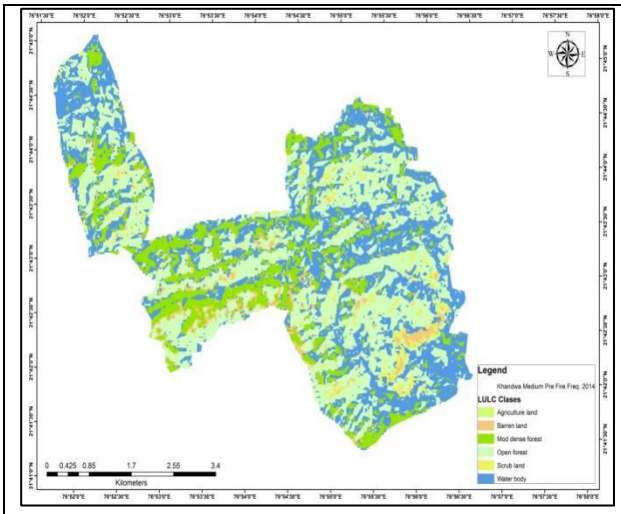


Fig 65 LULC of Khandawa Medium Pre-Fire Frequency 2014

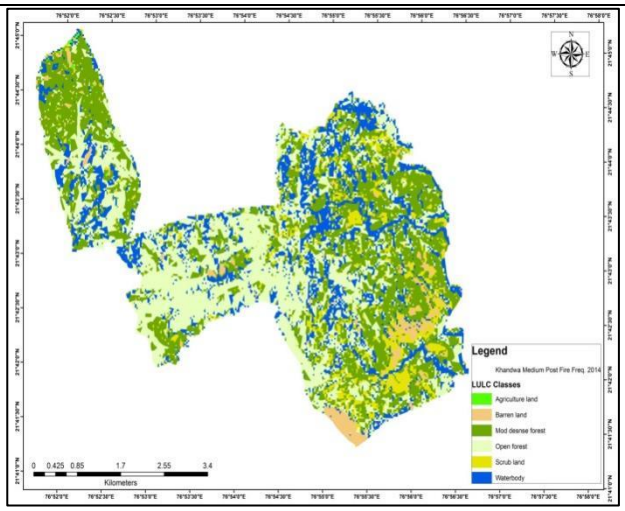


Fig 65 LULC of Khandawa Medium Post Fire Frequency 2014

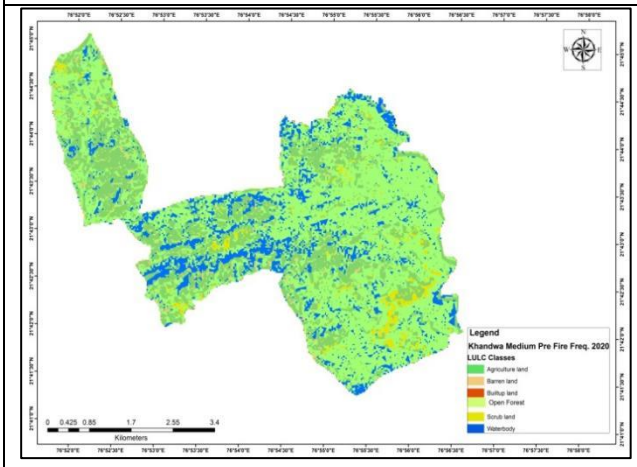


Fig 66 LULC of Khandwa Medium Pre-Fire Frequency 2020

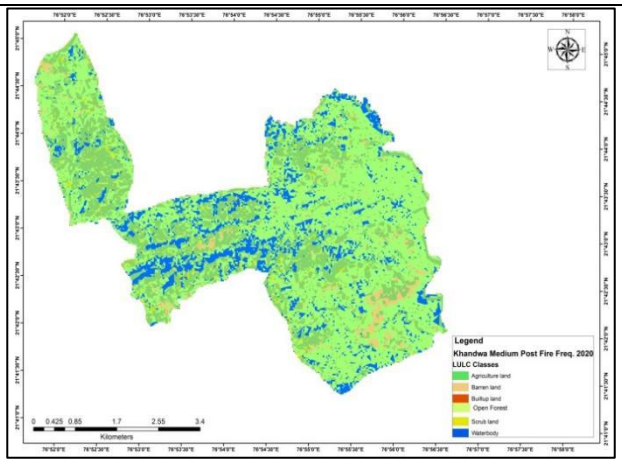


Fig.66 LULC of Khandwa Medium Post Fire Frequency 2020

Map 24: Khandwa Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Medium Fire Category

The table below shows changes detected in land use due to medium forest fire frequency in the Khandwa Forest division

Table 3.17 Change detection of Khandawa medium frequency forest fir Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	3.626	3.333	5.626	5.333
2	Barren land	124.423	130.999	120.423	132.969
3	Mod dense Forest	436.263	428.978	434.263	428.978
4	Open Forest	1027.107	1000.109	1029.107	1010.109
5	Scrub Land	103.439	98.786	105.439	98.786
6	Waterbody	922.329	921.3	922.329	921.3
7	**Total**	**2617.187**			

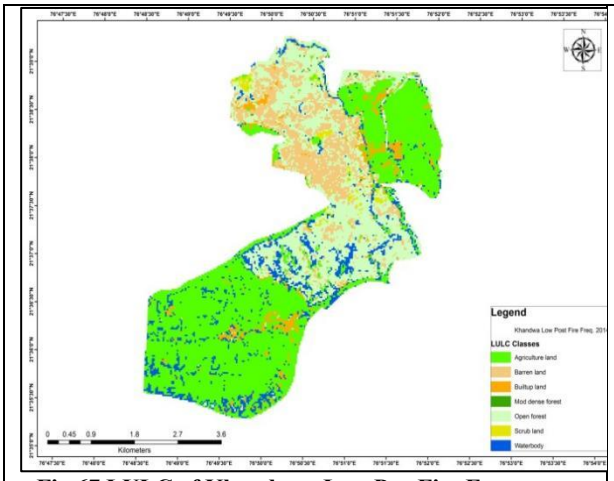


Fig.67 LULC of Khandawa Low Pre-Fire Frequency 2014

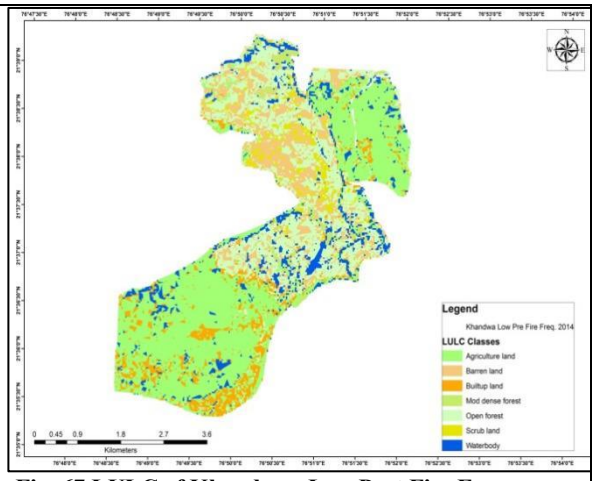


Fig. 67 LULC of Khandawa Low Post Fire Frequency 2014

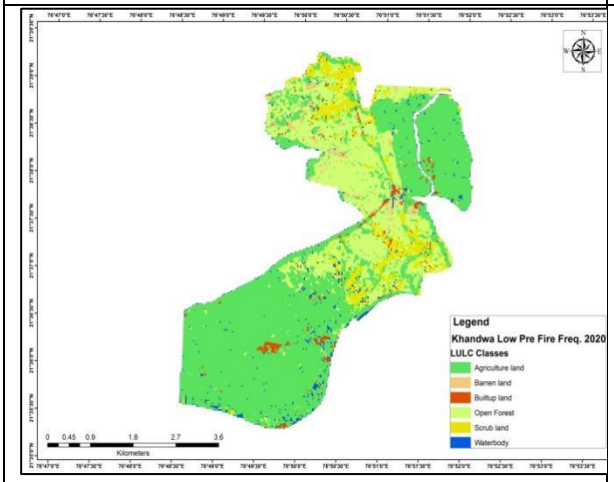


Fig.68 LULC of Khandwa Low Pre-Fire Frequency 2020

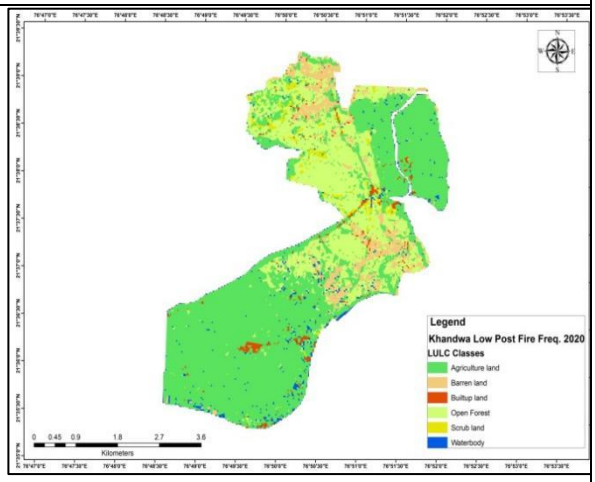


Fig.68 LULC of Khandwa Low Post Fire Frequency 2020

Map 25: Khandwa Land Use Land Cover Change of Pre and Post Fire (2014 and 2020), Medium Fire Category

The table below shows changes detected in land use due to low forest fire frequency in the Khandwa Forest division

Table 3.18 Change detection of Khandawa low-frequency forest fire Pre and Post Fire 2014 and 2020

Sr. No.	LULC Classes	Pre Area (Ha)	Post Area (Ha)	Pre Area (Ha)	Post Area (Ha)
1	Agriculture land	926.048	926	928.048	928
2	Barren land	283.831	310.567	273.831	330.597
3	Builtup land	190.322	190.322	196.322	196.322
4	Mod dense Forest	37.45	37	37.45	37
5	Open Forest	473.472	472.342	475.472	472.342
6	Scrub Land	81.406	71.324	81.406	70.324
7	Waterbody	176.018	175.989	176.018	175.989
8	Total	2168.547			

3.8 Ecological study

Forest provides innumerable resources and a variety of ecosystem services. One of the critical challenges faced by forests in recent times is a forest fire. Majority of the forest fires are caused by human activities and natural factors. Forest fire is an important issue over the years because it is responsible for ecological and economical damages. This chapter will give us an idea, to assess species diversity and divergent component assessment using different biodiversity indices which helped to understand the species response to different fire frequencies.

Fire impacts on vegetation have been studied in three divisions of Odisha (Baliguda, Rairangpura and Raygada) and Madhya Pradesh. We stratified the studied forest based on fire incidences from 2010-2020. The vegetation in the three stratified zones, high fire category (>6 fire incidences), medium fire category (3-6 fire incidences), and low fire category (<3 fire incidences) was evaluated by field visits and sampling of vegetation in the three strata respectively. The compartments cluster was selected as research study sites purposively due to fire incidences over the years (2010-2020) and Schedule tribes' residents in the forest fringes.

The species diversity and divergent component assessment is the measure of the species richness (the number of species present) and species abundance (the number of individuals present) and the relative distribution of trees and regenerative seedlings/saplings in the region. Diversity indices were calculated based on the primary data collected from the tree enumeration form and regeneration form from the sample study sites.

The calculations were done by re-stratifying the samples into High, Medium and low fire categories separately. The values have been calculated and tabulated respectively. Two types of diversity indices were computed for this, namely the Shannon index, an information statistic index which assumes all species are represented in a sample and that they are randomly sampled. The other index is the Simpsons index, a dominance index which gives more weight to common or dominant species. High Shannon index and low Simpson index values indicate greater diversity.

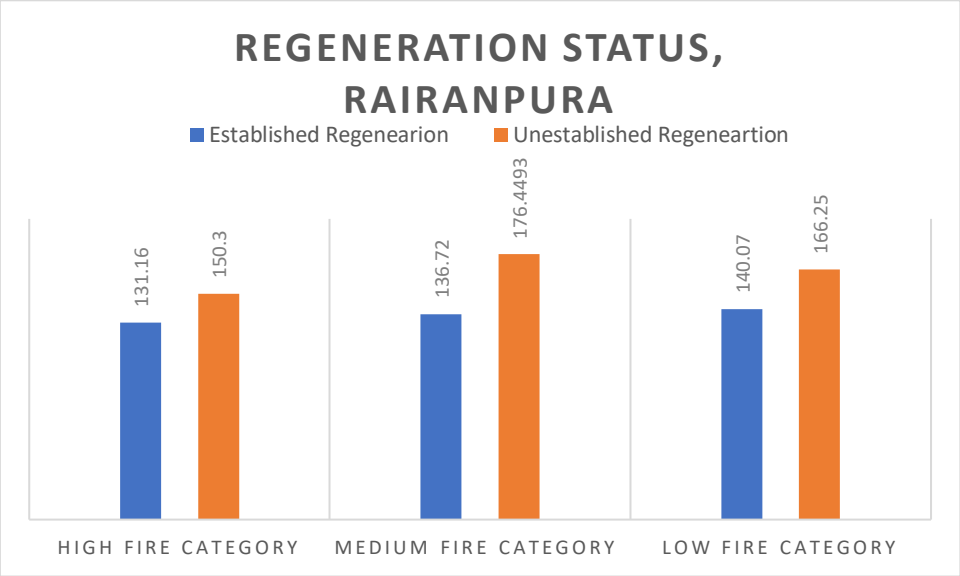
3.8.1 Importance Value Index and Regeneration Status -Odisha

1. Rairangpur Division

The following beats were selected namely; Tiring beat, Manbir beat and Bahalda beat as low, medium and high forest fire categories respectively. As per annexure VII table (table 1), Tiring beat has dominated the canopy of Sal (***Shorea robusta***) and Char (***Buchanania lanzan***). The IVI of Sal is 93.95 which is the highest among all the species and Char species is have 52.54 IVI. The IVI shows the dominancy, frequency and dominance of particular species in the sampled forest area.

Table 2 in annexure VI depicts the established and unestablished regeneration in the sampled area. Established regeneration, which is also called sapling, is more than 2 m ht. The average established regeneration is 140.7/ha and unestablished regeneration is 166.25/ha in the low forest fire category sampled plot. Highest established regeneration is of Tendu, locally called Kendu i.e 327/ha and the highest unestablished regeneration is of Arjuna i.e 300/ha. The Bahalda beat has a major canopy of Sal (Shorea robusta) and Mahua. The IVI of Sal is 56.53 and Mahua, which have 52.54 IVI. Kendu is also present in good number, which provides a livelihood income source to many tribal populations

The established and unestablished regeneration in the medium forest fire category was assessed in the sampled forest is Bahalada beat. The highest established regeneration is Tendu tendu, Khajuri and karada are the new recruiters for the sampled site



Graph: 3 Regeneration Status of Rairangpura

The average number of established regeneration is 131/ ha and unestablished regeneration is 150.3/ha. Sal regeneration is quite in good numbers.

Established regeneration - The table in annexure VII shows the result itself that, in the low fire category, established regeneration is high, i.e., 140.07/ha,136.7 in the medium fire category and least in the high fire category, 131.76/ha. There is a small difference in the three categories but there is a clear reducing gradient, more fire frequency reduces the established regeneration i.e. it has an adverse impact.

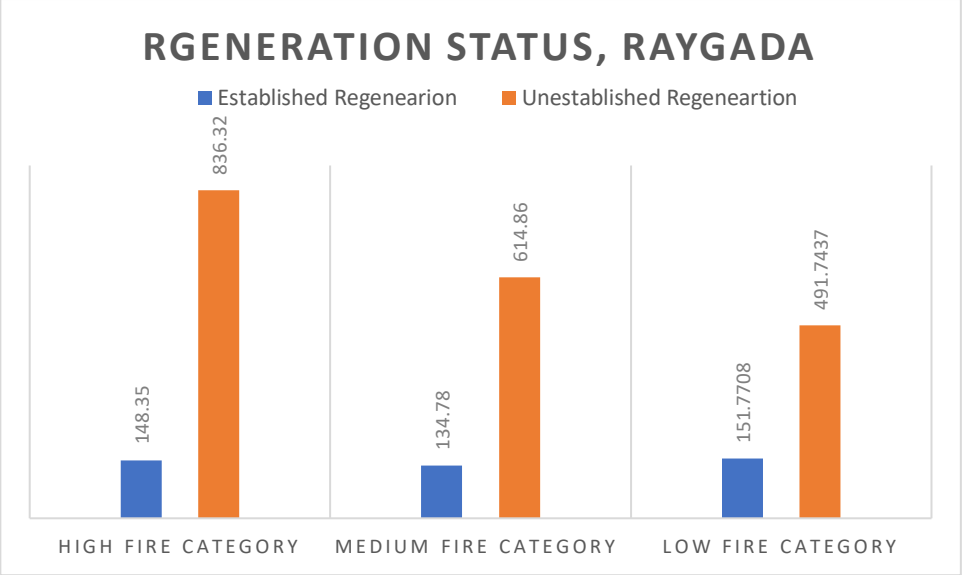
Unestablished regeneration - We find in the studies that regeneration is 166.2 in the low fire frequency zone,176.4 in medium and 150.3 in the high fire frequency zone. This indicates that though there is reduced regeneration in the high fire zone the highest number of regenerations in the medium fire zone indicates that light fire may

induce better regeneration. Here is the study area was Moist Sal forests so more undecomposed leaf litter is there, so due to fire it may be removed giving space availability to the seeds to regenerate.

2. Raygada Forest Division

Importance Value Index shows the dominancea of forest tree species over the area, Rayagada forest have major tree species of Teak (*Tectona grandis*), Karada (*Cleistanthus collinus*), Bada mai, Char (*Buchanania lanzan*), and Piasal (*Pterocarpus marsupium*).

We have sampled Hatikhamba (low fire category), Sikabadi (Medium Fire category), and Chinsari (Low Fire Category) for ecological study



Graph: 4 Regeneration Status of Raygada

Established regeneration - In the Raygada Forest division established regeneration is not much affected by the forest fire because from the results we find regeneration is 151.7 in the low fire zone and 148.3 in the high fire zone. There is not much difference between these two.

Unestablished regeneration- Studies indicate that there is an increase in the number of un-established regeneration -It is 491.7 in the low fire zone whereas 614.8 in medium and 836.3 in the high fire zone. Higher regeneration is found in Shorea robusta (Sal), Diospyros melanoxylon (Kendu)and Bambusa bamboos (Karada)

3. Baliguda Forest Division

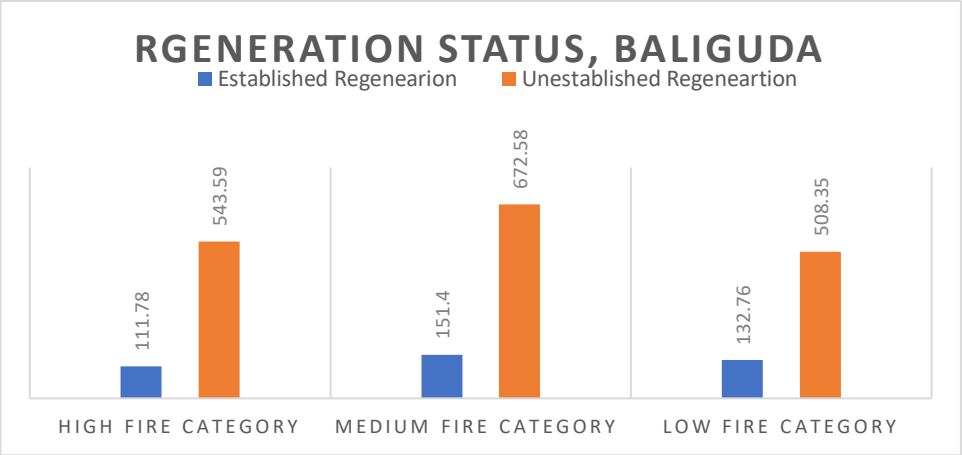
Baliguda forest have major tree species of Salai and Karada. Karada found in domination in both medium and high category of forest fire frequency.

We have studied Angul beat (Low fire category), Landagaon beat (Medium fire category) and Daka beat (Low fire category) for ecological study.

Established regeneration - In the present study, it is found that established regeneration is highest in the medium fire zone at 151.4 and lowest being in the high fire zone at 111.7and the low fire zone has 132.7. This indicates that a light fire has improved regeneration. Baliguda forest division has moist Sal forest, so the fire may not be very intensive to cause harm to regeneration.

Un-established regeneration - The study shows that regeneration is lowest in the low fire zone508.3, followed by 543.5 in the high fire zone and highest in the medium fire zone 672.5.

This also indicates that in moist forests where rainfall is higher, then there is a positive impact of light fire in the forest regarding regeneration.



Graph: 5 Regeneration Status of Baliguda

3.8.2 Importance Value Index and Regeneration Status- Madhya-Pradesh

1. Khandwa Forest Division

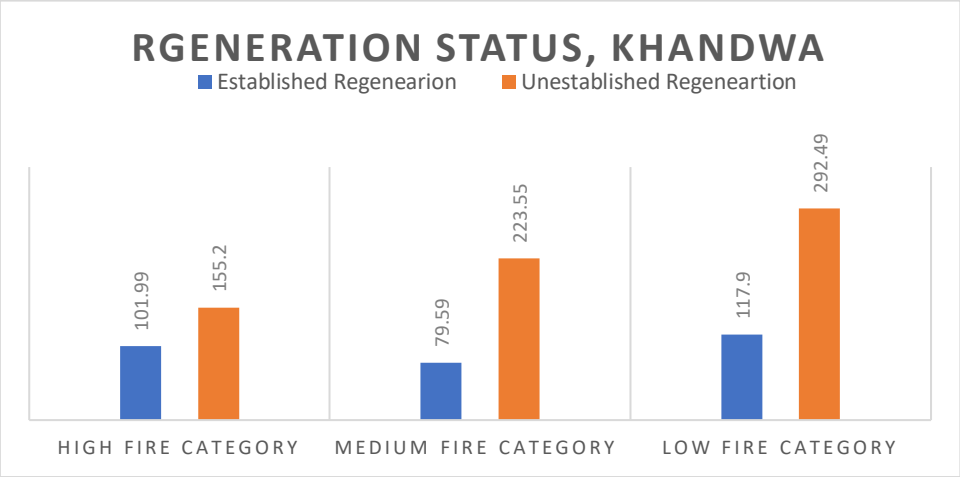
Khandwa forest comes under dry deciduous forest, and during the summer intensity of heat is also very high in this region of Madhya-pradesh. The dominated tree species in Khandwa Forest are teak (*Tectona grandis*) with the association of Saja (*Terminalia* elliptica) and dhawdha (*Anogeissus latifolia*). Dhawdha face critical challenges in these area due to extraction of dhawdha gum.

From the study here the graph shows a clear difference in regeneration.

Established regeneration - The study shows the highest regeneration in the low fire zone 117.9 followed by 101.9 in the high fire zone and a minimum of 79.5 in the medium fire zone. The minimum found in the medium fire zone is found because the sample plots laid out were in the vicinity of the village facing high interference from local villagers, who used to damage the young saplings. Sample plots were laid out in the field as per the studies through GIS studies.

Unestablished regeneration - The graph below shows the results as follows-

The highest regeneration is found in the low fire zone 292.4, followed by medium fire zone 223.5, and the minimum is in the high fire zone 155.2. This clearly shows the impact of fire in the area. The area being Dry Deciduous Teak Forest is very susceptible to forest fires. The intensity of the fire is also higher which reduces the number of seedlings survive which are young and have a thin bark which allows heat from the fire to damage the plant.



Graph: 6 Regeneration Status of Khandwa

2. North Betul Forest Division

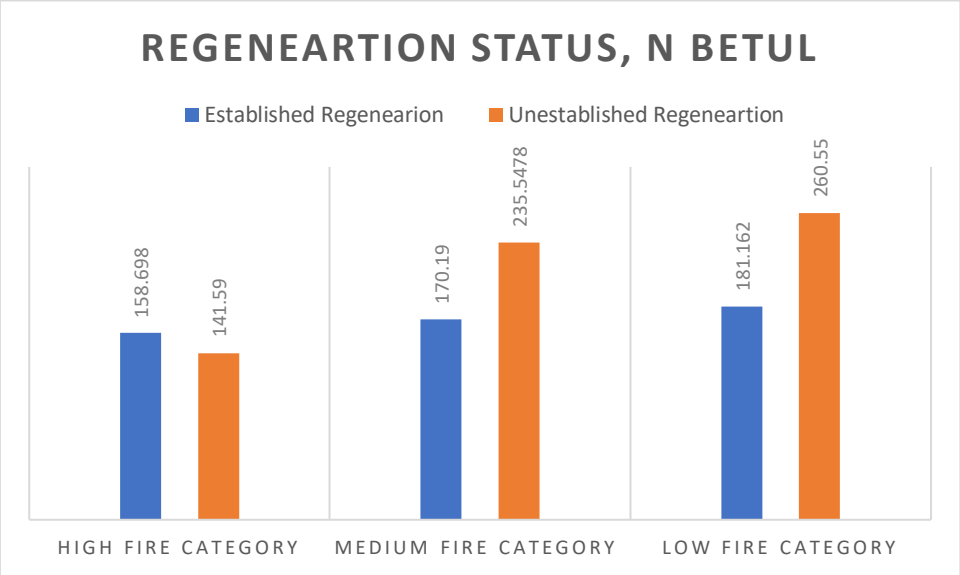
The forest in the North Betul forest division is Dry Deciduous Teak Forest and Misc forest. Major tree species is Teak (*Tectona grandis*), Saja (*Terminalia elliptica*) and Ghiriya (*Chloroxylon swetenia*).

The graph of the regeneration status shows the following results **-**

Established regeneration **-** The established regeneration is highest in low fire zone 181.1 followed by medium fire zone 170.1 and minimum being in high fire zone 158.6.

Unestablished regeneration - The unestablished regeneration is highest in low fire zone 260.5, followed by medium fire zone235.5 and the minimum in high fire zone 141.5.

This data clearly shows the impact of forest fires on the regeneration of the forest. Where there are more fire regeneration decreases.



Graph: 7 Regeneration Status of North Betul

3. East Mandala Forest division

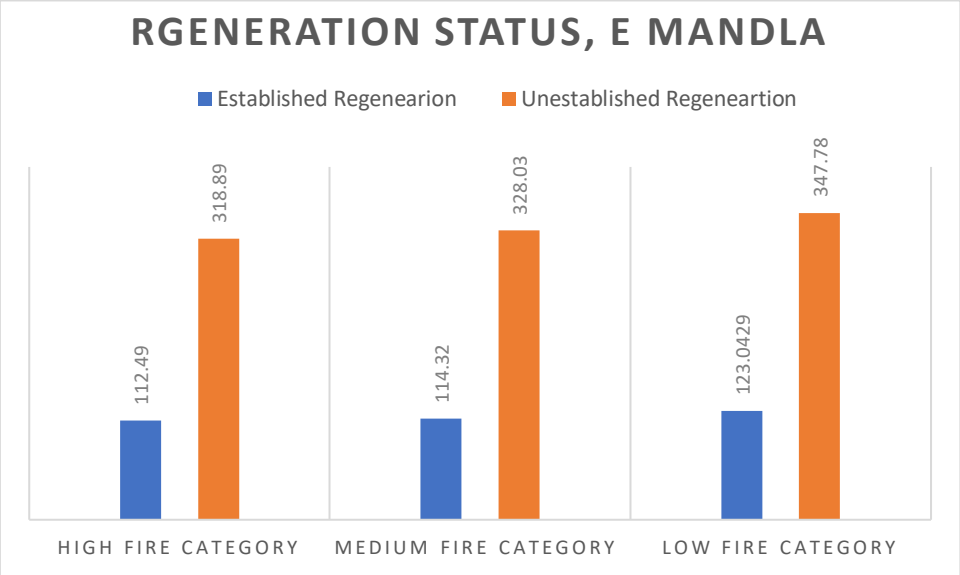
East Mandla of Madhya Pradesh has Moist Sal forests. The major forest tree species is Teak (tectona grandis), Sal (Shorea robusta) and Lendia (Lagerstroemia; parviflora).

The graph above shown gives us the following results.

Established regeneration – The highest number of established regeneration is seen in the low fire zone 123.0, followed by the medium fire zone 114.3 and the lowest in the high fire zone 112.4. here we find that there is a decrease in the regeneration status of the plants but the difference is very measured.

Un-established regeneration - We find the highest regeneration found in the low fire zone 347.7, followed by medium fire zone 328.0 and the minimum being in high fire zone318.8. Here again, it is found that there is an impact of fire on regeneration but it is very marginal.

If we visualize the forest of Mandla it is found that the forest is mainly Moist sal which is progressing towards Semi-evergreen forests. This type of forest has higher humidity hence the severity of the fire is less and because of this the damage to the young plants is less.



Graph: 8 Regeneration Status of East mandala

3.8.3 Plant Biodiversity - Odisha

Two types of diversity indices were computed for this, namely the Shannon index, an information statistic index which assumes all species are represented in a sample and that they are randomly sampled. The other index is the Simpsons index, a dominance index which gives more weight to common or dominant species. High Shannon index and High Simpson index values indicate greater diversity.

1. Rairangpur

Table 3.19 Species Diversity Index of Raitangpura Division

Species Richness	Low Fire Category	Medium Fire Category	High Fire Category
Dominance *D*	0.136095	0.125204	0.283287
Simpson index 1-*D*	0.863905	0.874796	0.716713
Shannon index	2.216441	2.48038533	1.563115
Gini- Simpson Index 1/D	7.347826	7.98696	3.529984

According to the presented table, the 2.1.1 Shannon index is higher in the medium fire category i,e 2.48 and lower in the high fire category i.e 1.56, which means species richness is high in the Medium fire category and low in the High fire category. There is a slight difference between the low and medium fire categories. Simpson index measures community diversity, meaning the higher the number, the higher the diversity so here medium and low fire category is more diverse than the high fire category.

2. **Rayagada**

Table 3.20 Species Diversity Index of Raygada Division

Species Richness	Low Fire Category	Medium Fire Category	High Fire Category
Dominance *D*	0.408112	0.115468	0.12013
Simpson index 1-*D*	0.591888	0.884532	0.87987
Shannon index	1.583214	2.561582	2.562115
Gini- Simpson Index 1/D	2.450306	8.660408	8.324334

Shannon index is higher in both medium and high fire categories and low in low fire categories. And also, community diversity is higher in the high fire category and almost similar in the medium and high fire categories. Rayagada Forest Division shows different results trends. It might be because of the low fire category sample area presented nearby of the village so disturbance might be there.

3. **Baliguda**

Table 3.21 Species Diversity Index Baliguda

Species Richness	Low Fire Category	Medium Fire Category	High Fire Category
Dominance *D*	0.147234	0.099986	0.100838
Simpson index 1-*D*	0.852766	0.900014	0.899162
Shannon index (H)	2.714634	2.668088	2.169299
Gini- Simpson Index 1/D	6.791925	10.00135	9.916934

Baliguda Forest division shows positive trends as per our hypothesis, that if the frequency is high then diversity will decrease. We can see in table 2.2.3, the data to support this. Species richness is high in medium and high forest fire categories and less in high fire category and the same with the community diversity.

3.8.4 Plant Biodiversity - Madhya Pradesh

1. **Khandwa**

As per the below table, it has been seen that Diversity indices are not much affected by forest fire, because, in central India, a forest fire is mostly of Surface and ground fire types. Fire effects on the tree will be seen on a long-term basis. This is also because, in the dry deciduous forest like the Khandwa Forest division, the dominant tree is the Teak (*Tectona grandis*), which does not favour the other species to compete with this. so diversity might be affected by this also.

Table 3.22 Species Diversity Index Khandwa

Species Richness	Low Fire Category	Medium Fire Category	High Fire Category
Dominance *D*	0.553701	0.522278	0.459091
Simpson index 1-*D*	0.446299	0.477722	0.540909
Shannon index (H)	1.216657	1.396933	1.331033
Gini- Simpson Index 1/D	1.80603	1.914689	2.178215

2. North Betul

North Betul forest comes under miscellaneous forest type, where diversity of plant species presents in good numbers. Betul forest diversity indices represent that the Shannon index is higher in the Low fire category and least in the High fire category. Meaning diversity loss in the high-frequency fire category. And Simpson index is also high in the low fire category and low in the high and medium fire category.

Table 3.23 Species Diversity Index North Betul

Species Richness	Low Fire Category	Medium Fire Category	High Fire Category
Dominance *D*	0.208375358	0.349454	0.260026
Simpson index 1-*D*	0.791624642	0.650546	0.739974
Shannon index (H)	2.059994	1.853497	1.713216
Gini- Simpson Index 1/D	4.799031941	2.861603	3.845767

East Mandala

In East mandala forest low and high category forests are comes under Deciduous teak and Miscellaneous Forest category respectively and medium fire comes under moist sal forest. Because of this Simpson indices is high in the medium fire category. Shannon indices are high in the high forest fire category because due to moist condition intensity and frequency of fire are very low in the Mandla forest division, so effects can not be seen in a short period.

Table 3.24 Species Diversity Index East Mandala

Species Richness	Low Fire Category	Medium Fire Category	High Fire Category
Dominance *D*	0.265182	0.186115	0.21979
Simpson index 1-*D*	0.734818	0.813885	0.78021
Shannon index (H)	1.939632	2.247403	3.604266
Gini- Simpson Index 1/D	3.770994	5.373021	4.549795

3.9 Conclusion

One of the objectives of this study was to investigate the effect of fire on forest crops. The results of NDVI and LULC of selected regions, i.e., high, low, and medium fire frequency areas of pre- and post-fire seasons, were computed. The parameters, i.e., LULC and NDVI, were calculated using the remote sensing data, i.e., Sentinel-2 and Landsat-8 satellite data. These sets of data give us very accurate results because of their resolutions, and due to this, image interpretation becomes easy. The accuracy of the results was maintained by using GIS software (ARC GIS 10.8, QGIS, and the Google Earth engine).

In LULC findings are

- the area under barren land has increased in post-fire season and, in the same period, the area under scrub land has decreased. It proved that when the fire started, scrubland in a selected area burned very easily and got converted to barren land. The very little effect is found in dense forests, and a medium effect is found in moderately dense forests, open forests, etc.

There are many indices available in the remote sensing environment, but out of these indices, NDVI plays a very important role in forest fire study, because based on this index we can exactly compute the damage to vegetation, i.e., trees, shrubs, herbs, etc. The NDVI interpretation provided accurate results for both the pre and post-fire remotely sensed data. As a result, this index (NDVI) is also very important in forest fires for identifying vegetation damage in specific areas.

Land surface temperature (LST) is the radiative skin temperature of the land derived from the infrared band of solar radiation. LST measures the emission of thermal radiance from the land surface where the incoming solar energy interacts with and heats the ground or the surface of the canopy in vegetated areas. In the present study, an attempt was made to estimate the relationship between the land surface temperature and forests. As explained in the methodology, the Statistical analysis method was used to observe the changes in LST.

In the study of Madhya Pradesh and Odisha it is found that when LST increased up to 32°c- 33ºc hence, there will be a big possibility of a forest fire. This details the IVI (importance value index) and species composition and distribution and different forest types and the impact of forest fires on the regeneration and biodiversity. The study revealed that fire frequency and intensity are higher in the dry deciduous forest, and because of this, it highly impacts the established and unestablished regeneration. In the moist deciduous forest, fire does not much affect the young crop, though perhaps fire helps the young crop to regenerate in the forest field.

Chapter IV

Causes of forest fire, NTFP, Community Institutional capacities in the management of forest fire

One of the objectives of the study was to identify and analyse the underlying causes of forest fires in the study area and the technical and organizational capacities of the local community concerning the management of forest fires. Another was to assess the ecological vulnerability of the forest (successional stages, species diversity, regeneration, biomass, invasive species management etc.) and livelihood vulnerability of forest-dependent communities (NTFP, medicinal plants and tubers availability, agriculture and farm forestry/agricultural practice, provisioning of ecological services etc.) due to forest fire. This section also discusses the cultural practices and their relation to the forest fire.

The community residing adjoining the forest area are most vulnerable to a forest fire. Multiple factors are associated with forest fires in nature as well as anthropogenic factors. Majority of the forest fires are caused by human activities and natural factors. Forest fires are accidental or intentional for land conversion, collection of timber and non-timber forest produce, grazing land management, settlement fires, etc., About 98 million ha (4%) of world forests were affected by fire in 2015 which may take decades for the area to recover (FRA, 2020). There are many large fire incidents seen in recent years in many parts of the world, which have caused major concerns.

4.1 Causes of Forest Fire - In Odisha

In the three divisions of Odisha, the causes of forest fires in the villages' nearby forests are either ‘accidental’ or ‘intentional’. The main reason for a forest fire is the use of fire during the collection of Mahua flowers. The forests of Jharkhand state are adjacent to the forest boundary of the Rairangpur division every year, fire from the Jharkhand Forest area spread to the forest area of the Rairangpur Division. That's why the onset of forest fire season, the forest department makes fire lines to protect the forests from a forest fire. Also, forest fires occur when the source of fire such as cigarette or bidi comes in contact with inflammable material. Villagers also set fires for hunting purposes so that animals can be easily hunted. Sometimes the adjoining village set fire to the village forest over a dispute with the villagers or any other community conflicts.

Similarly, in the Baliguda Division, the main reason for a forest fire is the use of fire during the collection of Mahua flower, Tendu leaf and fruit. The forests of the Kalahandi and Boudh districts are adjacent to the forest boundary of the Baliguda division, so every year the fire from both the district forests (Kalahandi and Boudh) spread to the

forest of baliguda division. When people travel through the forest at night, then they set fire to the forest due to fear of wild animals. Sometimes Bamboo trees rub against each other in high wind velocities that cause friction and fire to the forest.

In the Rayagada Division Podu cultivation (shifting cultivation) is practised by the PVTG community, which is the main reason for the forest fires. The tribal people in these areas have been practising Podu, or the slash and burn, or the shifting form of agriculture for subsistence for ages. The shifting cultivation practised has a direct impact on the forest and the soil erosion is very heavy which reduces the regeneration on the slopes.

The division are dependent on cashew plantations for their income. Forest fire is not good for cashew plants. Most of the cashew plantations are near the forest, so people prevent forest fires to protect the cashew plantations. One of these two things is the cause of the forest fire and the other is the solution to the forest fire.

Box -1

Similipal Park Forest Fire in 2021 in Rairangpur Division

The massive fire in Similipal caused extensive damage last year. To avoid such casualties this summer, as many as 700 forest officials were engaged in forest control in the dense forest. Because of it, the forest department has intensified community awareness involving villagers across all territorial and wildlife forest divisions to minimize fire outbreaks in forests this year. Drawing learning from last year's damage due to a massive wildfire in Similipal, the forest department has conducted mock drills besides deploying mechanical fire blowers. Every year before the forest fire season the forest department prepares fire lines to protect forests from fire.

4.1.1 Village Institution

In three forest divisions – in Rairangpur, VSS is constituted in 5 villages and in Gambharia village (Bahalda beat) VSS is not constituted. In the Baliguda division, only one village VSS was formed (Mediatundi) but that VSS is not as active. In the Rayagada division, VSS is constituted and actively working in all 6 sample villages.

VSS meetings are held in the villages 3 to 4 times a month. The Forest department conduct meetings to create awareness of forest fire. The Forest Department has constructed a community hall for the VSS, where meetings are held. The villagers of this division are aware of forest fire and they take precautions not to set fire in the forest. Owing to it cases of forest fire are decreasing in this division and the past 2-3 years there have been any incidents of forest fire surrounding these villages.

VSS members are given training to extinguish the fire. Everyday 4 to 5 people from the village monitor and guard the forest during the summer month to prevent the forest from forest fire. The villagers always help the forest department for extinguishing the forest fire. As soon as they notice smoke in a forest, they are immediately alert and inform the forest department about the incident. The villagers rush to the spot and

sometimes before the arrival of the forest guards, they put off the fire by using small branches of trees/shrubs. The forest guard and forest fire fighting squads use an Air blower to extinguish the fire. Subsequently, a fire line is drawn between the affected and unaffected areas to prevent its spread.

However, there are organisational behaviour issues related to forest department personnel as they sometimes do not reciprocate in village institutions in a matter related to the forest. For this reason, gradually people's trust and participation are on the decline in forest protection. Due to a lack of payment for the services in forest fire control villagers are not interested in participating in extinguishing the forest fire. There is no technological equipment support provided to VSS to extinguish the forest fire. No fund is being to village institutions to the VSS for forest fire protection.

Box – II

Forest fire Management in Baliguda Division

Every year the fire from Kalahandi and Boudh Forests spread to the forest of Baliguda Division. Therefore, during the forest fire period, the forest department makes fire lines to protect their forests from the forest fire. The People are helping the Forest Department a lot in protecting the forest and extinguishing forest fires. On seeing the smoke in the forest, People immediately try to inform the forest watcher or Forest Guard. But there is a major problem with network and communication. In such a situation, people have to face a lot of problems while giving information about the fire in the forest to the guard or watcher. That's why Forest guards visit villages and forests on their bikes every day to be alert for a forest fire. Sometimes the villagers go into the forest before the guards or watchers come to extinguish the forest fire and start extinguishing fire by hitting small branches of trees on the fire.

4.1.2 Cultural Aspects and forest fire

The forest of Simlipal is of the dry deciduous type. The forest of Simlipal usually catches fire 2-3 times between January and April. The period from January to April coincides with the *'Akhand Shikar'* ritual of many forest-dwelling communities. Akhand Shikar is a mass hunting practice wherein a large number of poachers from several forest areas in the Rairangpur forest division sneak inside the forest and kill animals as part of their religious rituals. During *Akhand Shikar,* the tribals usually clear the ground bushes and grasses by setting them on fire to enhance their visibility in the forest. Another reason for setting the ground on fire is to help them see animals, especially carnivores such as tigers to thwart any possible attack. This helps them to safely collect minor forest products.

4.2 Causes of Forest Fire - In Madhya Pradesh

In the three divisions of forest in Madhya Pradesh, the main reason for a forest fire is the use of fire during the collection of Mahua (flower, seeds) and Tendu (leaf, fruit). Secondly, anthropogenic factors are responsible for the spread of the forest. Villagers

also set fire to the forest in anger toward the forest watcher. Forest fire is et due to village disputes with adjoining villagers or any other community conflicts. Strong wind velocity rubs bamboo trees against each other causing friction and fire in the forest. Those who collect honey also set fire to the forest to collect honey and forest intruder set the forest on fire for theft of forest produce.

4.2.1 Village Institution

In Madhya Pradesh Forest divisions JFM Samiti are constituted and actively working in all division villages. In all JFMC, meetings are held in the villages two to three times a month. The Forest department conducts an awareness program on forest fire once a month during Fire season. Nowadays people are more aware of forest fires and do not set fire to the forest. People understand that forest fire is harming them and is not good for their life and livelihood. Because of this, the cases of forest fires are decreasing. The community is participating with the forest department, when they see smoke in the forest, they immediately inform the forest watcher or guard over the phone or they go to the Beat office to inform them about the fire. Also, people help the guards in extinguishing the forest fire. Now the number of fire cases is decreasing as people are more aware of forest fires. In the forest of Rathipur village of North Betul division, people are afraid to go deep into the forest to take NTFP due to the fear of the tiger. This is the reason, there is no possibility of fire deep inside the forest.

Finance is a major factor for non-participation in forest fire management and villagers are not paid remuneration for extinguishing forest fires. Therefore, they are not interested in extinguishing forest fires. The grass of the forest has been destroyed by the forest fire. Medicinal plants are decreasing due to forest fires**.** Regeneration affected by the forest fire. Medicinal plants and grasses are decreasing in large numbers due to forest fires. There is a lack of technological support to extinguish forest fires. Also, the fire line was not built before the fire season. Due to forest fires, the Number of Dhavda and Salai trees is decreasing. Bamboo trees are destroyed because of the forest fire. The people worship the Sal tree, so they protect sal trees and do not cut it.

4.3 Availability NTFPs in the study village of Odisha and Madhya Pradesh.

Non-timber forest products (NTFPs) are an important source of livelihood for significant rural and tribal communities living on the forest fringe. In India, NTFPs play a vital role in the livelihood and cultural life of forest-dependent communities inhabiting wide ecological and Geo-climatic conditions throughout the country. They collect forest produce throughout the year, for a variety of purposes like food, fodder, agricultural amenities, domestic material, traditional medicine, construction material etc. Odisha and Madhya Pradesh are rich sources of NTFP and are given importance by the people.

4.2.1 Season-wise collection of NTFPs

The collection of NTFP is done by every household in the rural areas for their livelihood and it acts as food and social security. Throughout the year, men and women of different age groups collect NTFP in different seasons. A total number of 360 respondents were interviewed in both states and information was collected through FGDs and ecological surveys on the availability of NTFPs. The table below provides data on the season-wise NTFPs collected in the sampled divisions. **Kendu/ Tendu and Mahua** are the common NTFPs, available and collected in both states. Other NTFP collected are fuel wood, toothbrush, Kendu (leaf), Musli, Ground Potato and Amla (fruit) in both the states.

Table No 4.1 List of NTFPs collected in the Winter season

Seasons	NTFP	Parts used	Madhya Pradesh			Odisha		
			Betul	Khandwa	Mandla	Rairangpur	Baliguda	Rayagada
Winter	fuel wood	Body	Available	Available	Available	Available	Available	Available
	Toothbrush	body	Available	Available	Available	Available	Available	Available
	Kendu	leaf	Available	Available	Available	Available	Available	Available
	Musli	Tuber	Available	Not available	Not available	Available	Available	Available
	Kanaja	seed	Not available	Not available	Not available	Available	Available	Available
	Amla	Fruit	Available	Available	Available	Available	Available	Available
	Tamarind	seed	Not Available	Not Available	Not Available	Not Available	Available	Available
	Ground potato	vegetable	Available	Available	Available	Available	Available	Available

Source-Field Survey, SCSTRTI, 2022

Table No 4. 2 List of NTFPs collected in the Summer season

Seasons	NTFP	Parts used	Madhya Pradesh			Odisha		
			Betul	Khandwa	Mandla	Rairangpur	Baliguda	Rayagada
Summer	fuel wood	Body	Available	Available	Available	Available	Available	Available
	Tooth Brush	body	Available	Available	Available	Available	Available	Available
	mango	Fruit	Available	Available	Available	Available	Available	Available
	Mahua	Seeds, flower	Available	Available	Available	Available	Available	Available
	Imili	fruit	Available	Not Available	Available	Available	Available	Available
	Bahada	fruit	Available	Available	Available	Available	Available	Available
	Harida	fruit	Available	Available	Available	Available	Available	Available
	Bhilua	fruit	Available	Not available	Available	Available	Available	Available

	Achar	seeds	Available	Available	Available	Available	Not Available	Available
	Bel	fruit	Available	Not Available	Available	Available	Not Available	Available
	Aeita	fruit	Available	Available	Not Available	Not Available	Not Available	Not Available
	kendu	fruit	Available	Available	Available	Available	Available	Available
	Palasia	Climber	Not Available	Not Available	Available	Available	Available	Available
	Dhawda	Gum	Available	Available	Available	Not Available	Not Available	Not Available
	Neem	seed	Not Available	Not Available	Not Available	Available	Available	Available
	khajur	seed	Not available	Not available	Not available	Available	Available	Available
	Salai	Gum	Available	Available	Available	Available	Available	Available

Source-Field Survey, SCSTRTI, 2022

The table shows there are many common NTFPs, which are collected in the monsoon season in both Madhya Pradesh and Odisha. These are Jamun, Mushroom, Bamboo, Green leafy vegetable, Ground Potato, Jackfruit, Kokoda, Sal and Salai, besides these common NTFPs, Koronda, *Menhar* are found in Madhya Pradesh and *Simaruba* found in Odisha.

Table No 4.3 List of NTFPs collected during Monsoon Season

Seasons	NTFP	Parts used	Madhya Pradesh			Odisha		
			Betul	Khandwa	Mandla	Rairangpur	Baliguda	Rayagada
Rainy	fuel wood	Body	Available	Available	Available	Available	Available	Available
	Tooth Brush	Body	Available	Available	Available	Available	Available	Available
	Jamun	Fruit	Available	Available	Available	Available	Available	Available
	Mushroom	vegetable	Available	Available	Available	Available	Available	Available
	Green leafy vegetable	vegetable	Available	Available	Available	Available	Available	Available
	Bamboo	shoots	Available	Available	Available	Available	Available	Available
	Kusum	Fruit	Available	Not available	Not Available	Available	Available	Available
	Custard apple	Fruit	Available	Not available	Not Available	Available	Not Available	Available
	Kakoda	Fruit	Not available	Not available	Available	Available	Available	Available
	Ambada	Fruit	Not available	Not available	Available	Available	Available	Available
	Karonda	vegetable	Available	Not available	Not Available	Not available	Not available	Not available
	Menhar	vegetable	Available	Not available	Available	Not available	Not available	Not available
	Ground potato	vegetable	Available	Available	Available	Available	Available	Available

	Jack fruit	Fruit	Available	Available	Available	Available	Available	Available
	Sal	Leaf, Gum	Available	Available	Available	Available	Available	Available
	Salai	Leaf	Available	Available	Available	Available	Not Available	Available
	Simaruba	Seeds	Not available	Not available	Not available	Available	Available	Available

Source-Field Survey, SCSTRTI, 2022

4.3 Indigenous Knowledge system and health system

Tribal have traditional knowledge system which deals with technological, ecological, cultural and health issues of tribal communities. The use of herbal medicines by tribal communities is inclined by distinct socio-cultural practices, religious, beliefs, support of traditional abilities and services of traditional medicine men. These people are closely connected with their ambient environment and ecology and depend on it for the primary health care system because they live in remote areas as compared to modern facilities. Medicinal plants are the base of many societies/communities, for their primary health care system. The study reveals that from ancient times tribal people depend on plants for medicinal purposes. Based on the initial survey, personal interviews with the traditional medicine man and group discussions where the emphasis was on the identification of knowledgeable resource persons it was found that information on the medicinal uses of plants now seems to be confined to elder people (above 50 years of age) only, that is especially on the utilization of plants for medicinal purposes and herbs are found in the nearby forest areas.

4.1.Photo Gallery - 01

Sl. No	Name of the species (Local Name)	Medicinal Used for treatment

1	 *Parsa Manji*	Cancer, (Kurmi)
2	 *Ladd*	Asthma, Breathing problems
3	 Amla leafs	Headache, Dizzy head
4	 *Gandha Karpura*	low energy states and general exhaustion

5	 *Gulachi*	Sexual problems like - Premature ejaculation
6	 *Gaduu*	Stomach Pain
7	 Mix herbs	Caner mix

Source - Field Survey,SCSTRTI, 2022

"My father was practising traditional medicines. I learned from my father but still don't know many medicines and their uses. Due to forest fire, most of the herbs are decreased now a day, it is very difficult to save for the next generation."

-Tradional Medicine Man, Pahadpur

Rairangpur Division is a tribal-dominated place in Odisha. "Santal" tribe is residing in this district of Odisha, they possess knowledge of medicinal plants, herbs and their uses. Based on the present study, it has been found that the tribal community of the Mayurbhanja district is rich in ethnobiological knowledge, which has been transmitted from one generation to another for many years. The Santals, one of the populous tribal communities of India, are mainly found in the districts of Mayurbhanj, Keonjhar and Balasore of Odisha. The word 'Santal' is derived from two words; Santa meaning calm and peaceful and ala meaning man. Among the Odisha tribes, the Santals are an

advanced tribe. The primary occupation of the Santal has settled agriculture. According to the 2011 census, the total population of Santal is 894764 in Odisha.

The central part of India, Madhya Pradesh is a veritable niche for growing healing herbs, which are being used in the Indian system of medicine like Ayurveda, Siddha and Unani. Madhya Pradesh Large Tribal communities like Korku, Bhil, Gond and Baiga tribes inhabit all these species (below) and use plants for curing various disorders. Local names, Latin names, parts used and uses for which the disease. The plants listed below are the species found in the study divisions (North Betul, Khandwa and East Mandla) of Madhya Pradesh.

Table No 4.4 NTFP and Use as a Medicine

SL.No	Local Name	Latin Names	Parts Used	Used as a Medicine for treatment
1	Aam	Mangifera indica	Bark	Jaundice, Headache, Malaria
2	Brahmi	Centella asiatica	Leaf	Memory loss
3	Charmukhi	Abelmoschus moschatus	Root	Malaria, Itching, Lice, Hair loss, Jaundice, Body pain
4	Chikoda	Cassia tora	Seeds	Cough
5	Chirchita	Achyranthus aspera	Root	Asthma, cough
6	Dahiman	Cordia macleodii	Bark	Fever, Poisoning, Intoxication
7	Dhawa	Anogeissus latifolia	Bark	Cough
8	Dudhiya	Euphorbia hirta	Whole plant	Wound
9	Haldu	Adina cordifolia	Bark	Wounds, Malaria, Ulcer
10	Harra	Terminalia chebula	Fruit	Digestion, Ulcer, Cough, Hiccups, Leprosy, Cardiac disorder, Wound
11	Kakai	Flacourtia indica	Bark	Delivery convalescence
12	Kalmegh	Andrographis paniculata	Leaf	Fever, Malaria, Liver problems
13	Karonda	Carissa spinarum	Root	Cardiac disorder
14	Mahua	Madhuca indica	Fruit, Flower	Delivery convalescence, Skin cracks, Weakness
15	Mainhar	Catunaregam spinosa	Root	Snakebite
16	Neem	Azadirachta indica	Roots, Fruits	Malaria, Itching, Lice, Hair loss, Jaundice, Body pain
17	Papita	Carica papaya	Caricaceae Fruit	Delivery convalescence, Cough, Digestion
18	Patwan	Diospyros montana	Bark	Jaundice, Vomiting, Dysentery
19	Safed musli	Chlorophytum borivilianum	Tuber	Weakness, Sexual debility
20	Saja	Terminalia alata	Bark	Diarrhoea
21	Sarso	Brassica campestris	Seed	Skin disease, Ear cleaning
22	Tendu	Diospyros melanoxylon	Root	Snake bite, Vomiting
23	Tinsa	Desmodium oojeinense	Bark	Bloody stool

Source - Field Survey, SCSTRTI, 2022

4.5 Community Economic status in Both states

The study has classified the community of the study villages into 3 economic categories as per the Government policy. From the table, it has been shown that the majority of families are BPL card holders. Out of 180 Participants, 81.7% (147) are under the BPL category, 17.2% (31) families come under the APL category and only 3.3% (2) families are under the Antodaya category in Odisha. On the other side similarly, it revealed that higher numbers of families are also BPL card holders. Out of the total 180 Participants, there is 87.2% (157) come under the BPL category, 11.7% (21) are under the APL category and only 3.3% (2) families are under the Antodaya category in Madhya Pradesh. It shows that the majority of the families are poor.

Agriculture is the main occupation of the Indian villagers. The tribals are close to the forest for their day-to-day lives. The tribals are engaged in many occupations for their earnings. Besides the forest dwellings, the study finds that they are engaged in many jobs like - Teaching, Business, Agriculture/Agricultural Labour, Farmer/Dairy Farmer, Wage Labour and Seasonal Migrant labour. A normal tribe used to involve in different types of occupations for their income as Primary, secondary and other occupations.

In Odisha, 50.6% (91) participants are found as Forest dwellers according to their primary occupation. 26.7% (48) of participants are found doing forest dwelling as their second occupation. In Madhya Pradesh, 26.7% (48) participants prefer forest dwelling as their primary occupation and 28.3% as their secondary occupation. The number of agriculture labour/farmers prefer it as their primary occupation; the percentage is high in both the states which are 43.3% and 48.9%. The result shows that forest dwelling is considered a primary occupation by 39% (139) of the participants and a secondary occupation by 27.5% (99) participants. Besides forest-dwelling Agriculture is considered the second most popular occupation in the study states. Whereas, the percentage of wage labour and business is very less.

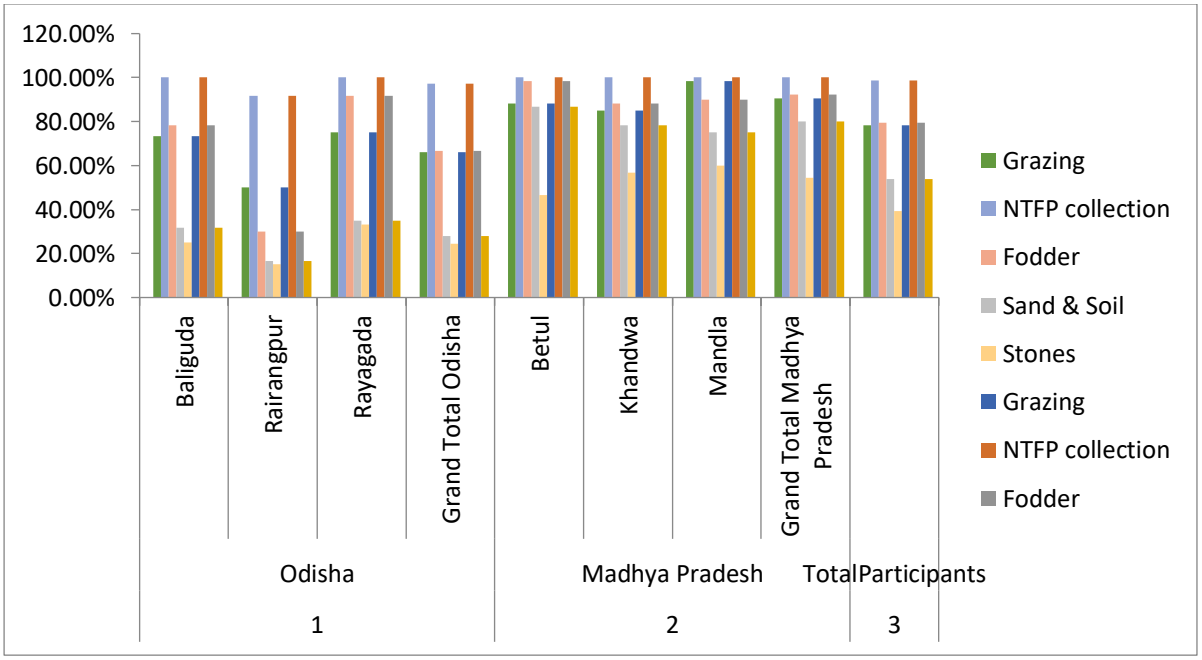
4.6 Community Dependency and Income from the Forest in Both states

Both the study states Odisha and Madhya Pradesh are tribal dominant states. The Tribal are mostly dependent on the forest for their day-to-day life and livelihood. The other traditional forest dwellers (non-tribal) are also dependent on the forest for their daily needs. The forest dwellers depend on the forest for collection of NTFPs, Grazing their domestic animals, fodders, sand/soil and stones. In Odisha, most of the forest dwellers go to the forest for collecting NTFPs. Out of the total of 180 participants, 97.2% (175) people are going to the forest to collect NTFPs, 66.7%(120) are going for fodder, 66.1%(119) are going for grazing purposes, 27.8%(50) are going to collect soil and sand and 24.4%(44) are going for collection of stones from the forest in Odisha.

In Madhya Pradesh, all the 180 interviewed forest dwellers are going to the forest for the collection of NTFPs. Out of the total of 180 participants, 100%(180) people are

going to the forest to collect NTFPs, 92.2%(166) are going for fodder, 90.6%(163) are going for grazing purposes, 80.0%(144) are going to collect soil and sand and 54.4%(98) are going for collection of stones from the forest in Madhya Pradesh. From the sampled villages total of 78.3% of participant visits the forest with their domestic animals for grazing. 98.6% of the participants are found as NTFP collectors from the total participants of both states.

The Annual income of a participant is derived from different sources. These sources are including Income from the forest, agricultural income, wage labour income and many more. The tribals and the other traditional forest dwellers fully depend on the forest for their food and income sources. Most of the NTFPs are collected for their consumption and selling purposes. Consumption includes their daily food habits, medicinal uses and traditional practices. Besides consumption, it plays an important role as their source of income. They earn money by selling it to the local markets, village Hatt, NGOs and government agencies. In Odisha, 73.3% NTFPs are used for their consumption purpose, whereas only 26.7% NTFPs are for selling. In Madhya Pradesh, 55.1% NTFPs are used for their consumption purpose, whereas 44.9% NTFPs are for selling.

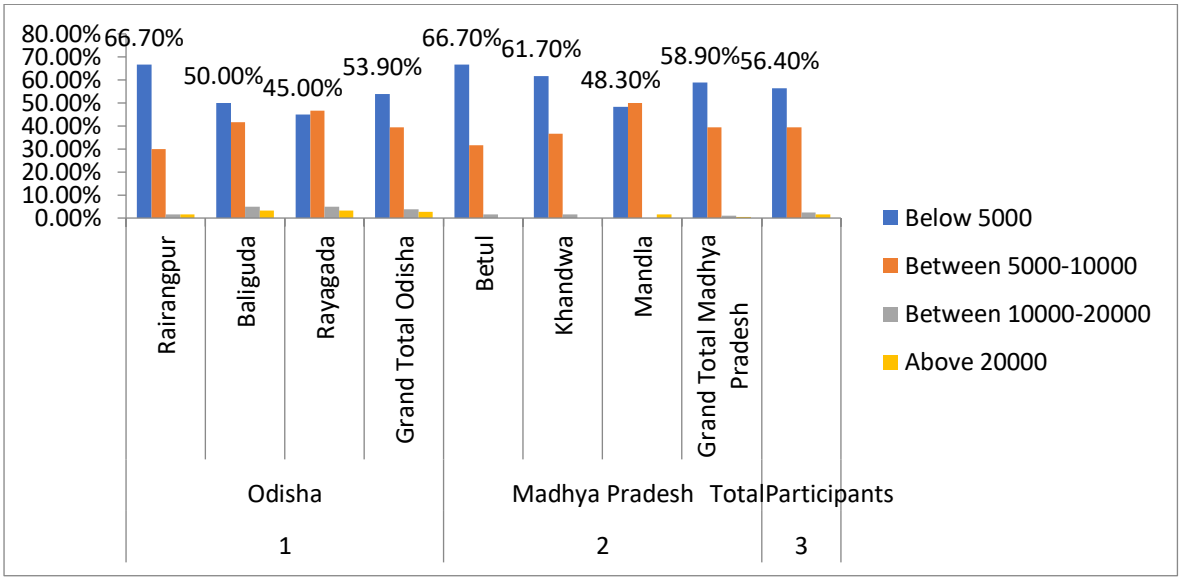


Graph: 9 Dependency on Forest

(Source- Field Survey, SCSTRTI, 2022)

The study categories of income (yearly) of the forest dwellers from the NTFPs are divided into four groups, where the least amount is below 5000 and the highest amount is above 20000. The categories are classified as “Below 5000”, “Between 5000-10000”, “Between 10000 - 20000”, and “Above 20000”. In Odisha, 53.9% of people are generating amounts below 5000 from the forest annually. 2.8% of

participants in Odisha are earning more than Rs 20000 yearly. On the other hand in Madhya Pradesh, 58.9% of participants' annual earnings are below Rs 5000. When it comes to income from forest Madhya Pradesh has very less in numbers. The total sample size reveals that 56.4% (203) participants are earning below 5000 from the forest. Similarly, 39.4% (142) participants are earning between 5000-10000, only 2.5% (9) participants are earning between 10000-20000 and only 1.7% (6) participants are earning above 20000.



Graph: 10 Income from Forest Resource

(Source- Field Survey, SCSTRTI, 2022)

4.7 Community perception of Forest fire in Both states

The table below is a reflection of the people's precipitation about a forest fire. A maximum number of people expressed that forest fire is not good under any circumstances. 86.4% of participants are agreeing that forest fire is harmful to their life, livelihood and environment. 7.8% of people believe that forest fire is good for the reasons 1) better leaves of tendu, 2) for Hunting etc.

Table No 4.5 Forest fire – perception

SL.No	States	Divisions	Forest Dweller	Forest fire is healthy			
				Agree	Disagree	Unable to Answer	Total Participants
1	Odisha	Baliguda	Number	4	55	1	60
		%	%	6.7%	91.7%	1.7%	100%

		Rairangpur	Number	14	43	3	60
		%	%	23.3%	71.7%	5.0%	100%
		Rayagada	Number	5	48	7	60
		%	%	8.3%	80.0%	11.7%	100%
		Grand Total Odisha	Number	**23**	**146**	**11**	180
			%	**12.8%**	**81.1%**	**6.1%**	100%
			Number	180	180	180	180
			%	100%	100%	100%	50%
2	**Madhya Pradesh**	Betul	Number	0	55	5	60
		%	%	0.0%	91.7%	8.3%	100%
		Khandwa	Number	5	52	3	60
		%	%	8.3%	86.7%	5.0%	100%
		Mandla	Number	0	58	2	60
		%	%	0.0%	96.7%	3.3%	100%
		Grand Total Madhya Pradesh	Number	**5**	**165**	**10**	180
			%	**2.8%**	**91.7%**	**5.6%**	100%
			Number	180	180	180	180
			%	100%	100%	100%	50%
3	**Forest Dwellers**		**Grand Total**	**28**	**311**	**21**	**360**
			%	**7.8%**	**86.4%**	**5.8%**	100%
	Total Study Sample		**Grand Total**	360	360	360	360
			%	100%	100%	100%	100%

(*Source- Field Survey, SCSTRTI, 2022****)***

4.8 Community views on damage from the forest fire

Wildfire is a part of nature. It plays a key role in shaping ecosystems by serving as an agent of renewal and change. But fire can be harmful, destroying homes, wildlife habitats and timber, and polluting the air with emissions harmful to human health. The study loss parameters are codified into three main categories 1) Health 2) Goods and livestock and 3) Environmental. These parameters have some indicators which are measured as in health- Physical injuries, internal injuries, in Goods and Livestock- fodder, NTFP, cultivated crops, houses, and livestock.

In case of environmental losses, the study has tried to record the opinion of the forest dwellers on the loss of water quality, air quality and soil quality. Odisha has only 1.7% of physical injuries and 0% of internal disease cases from the 180 sample participants. Interestingly 69.4% of participants have to bear the losses of NTFPs from the forest fires. In Madhya Pradesh, 55.6% of people are affected by forest fires. Damages of fodder are stands at 33.3%. Damages of cultivated corps are stands at 33.3% in Madhya Pradesh. The Table reveals that the loss % of the NTFP is high (62.5%) followed by cultivated corps (22.8%). Although village people are unaware of the environmental losses that occur due to forest fire from the survey 14.7% of people agreed on the degradation of soil quality, 10% on Air quality and 3.3% on water quality.

Table No 4.7 Losses and types of losses from the forest fire

SL.No	States	Divisions	Forest Dweller	Loss Parameters									
				Health		Goods & Livestock					Environmental (perceptions)		
				Physical injuries	Internal Disease	Fodder	NTFP	Cultivated Corps	Houses	Livestock	Water quality	Air quality	Soil Quality
1	Odisha	Rairangpur	Number	0	0	20	35	20	2	3	2	30	4
		%	%	0.0%	0.0%	33.3%	58.3%	33.3%	3.3%	5.0%	3.3%	50.0%	6.7%
		Baliguda	Number	1	0	1	50	1	0	0	3	3	7
		%	%	0.6%	0.0%	0.6%	27.8%	0.6%	0.0%	0.0%	1.7%	1.7%	3.9%
		Rayagada	Number	2	0	1	40	1	0	2	2	2	7
		%	%	1.1%	0.0%	0.6%	22.2%	0.6%	0.0%	1.1%	1.1%	1.1%	3.9%
		Grand Total Odisha	Number	**3**	**0**	**22**	**125**	**22**	**2**	**5**	**7**	**35**	**18**
			%	**1.7%**	**0.0%**	**12.2%**	**69.4%**	**12.2%**	**1.1%**	**2.8%**	**3.9%**	**19.4%**	**10.0%**
			Number	180	180	180	180	180	180	180	180	180	180
			%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2	Madhya Pradesh	Betul	Number	1	1	10	30	10	2	1	1	5	2
		%	%	0.6%	0.6%	5.6%	16.7%	5.6%	1.1%	0.6%	0.6%	2.8%	1.1%
		Khandwa	Number	1	2	30	50	30	10	2	3	10	1
		%	%	0.6%	1.1%	16.7%	27.8%	16.7%	5.6%	1.1%	1.7%	5.6%	0.6%
		Mandla	Number	10	5	20	20	20	1	1	2	3	1
		%	%	5.6%	2.8%	11.1%	11.1%	11.1%	0.6%	0.6%	1.1%	1.7%	0.6%
		Grand Total Madhya Pradesh	Number	**12**	**8**	**60**	**100**	**60**	**13**	**4**	**6**	**18**	**4**
			%	**6.7%**	**4.4%**	**33.3%**	**55.6%**	**33.3%**	**7.2%**	**2.2%**	**3.3%**	**10.0%**	**2.2%**
			Number	180	180	180	180	180	180	180	180	180	180
			%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3	**Total Losses by Numbers of Forest Dwellers**		**Grand Total**	**15**	**8**	**82**	**225**	**82**	**15**	**9**	**13**	**53**	**53**
			%	**4.2%**	**2.2%**	**22.8%**	**62.5%**	**22.8%**	**4.2%**	**2.5%**	**3.6%**	**14.7%**	**14.7%**
	Total Study Sample		**Grand Total**	360	360	360	360	360	360	360	360	360	360
			%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source- Field Survey SCSTRTI, 2022

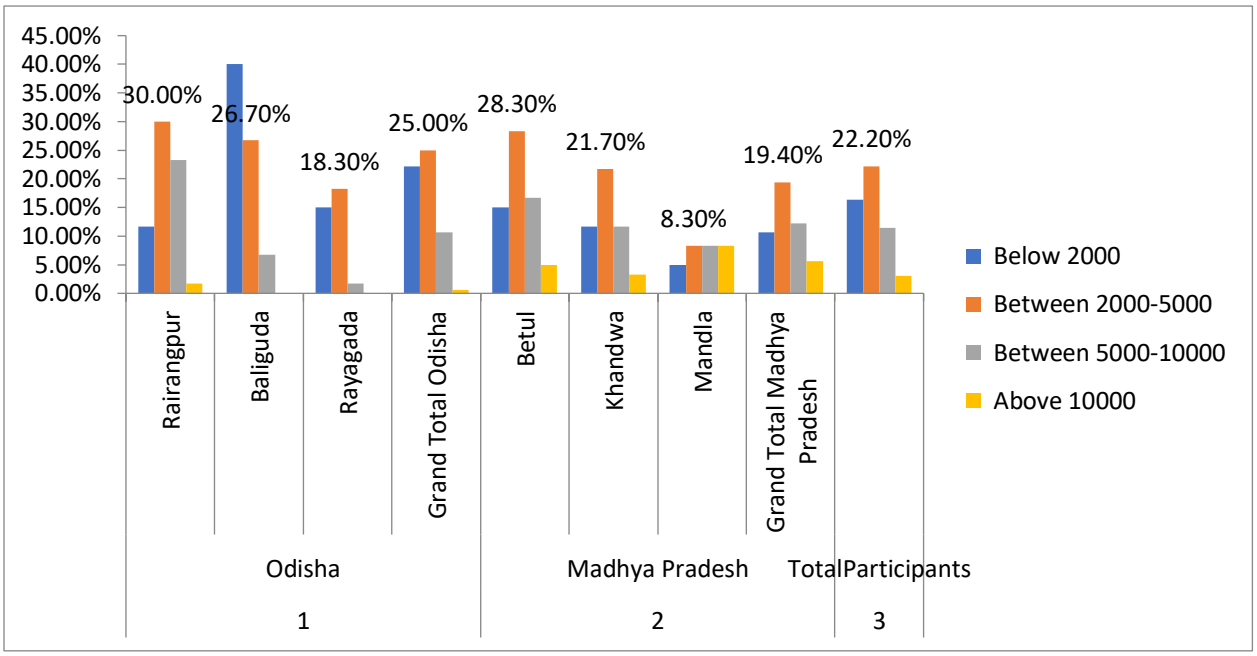
4.9 Community Human causality and monetary losses from the forest fire

Forest fire causes different types of human casualties like health, habitat, cultivated crops etc. Table no 5.2.3. Reveals the causalities and their losses from the forest fire. In Odisha, 57.8% are the causalities of the forest fire. The cases are 47.8% in the Madhya Pradesh state. Of the total participants around 52.8%, people are affected by the forest fire. When it is classified into economic loss 22.2% of participants have lost Rs 2000-5000 tangible economic income. There are only 3.1% of participants have lost above Rs 10000, out of 360 participants in the last 5 years.

Table 4.8 Human casualty and monetary losses from the forest fire

SL. No	States	Divisions	Forest Dweller	Losses from Forest fire						
				causalities		Below 2000	Between 2000-5000	Between 5000-10000	Above 10000	Total Participants
1	Odisha	Baliguda	Number	39	Monetary Loss	7	18	14	1	60
		%	%	65.0%		11.7%	30.0%	23.3%	1.7%	100%
		Rairangpur	Number	44		24	16	4	0	60
		%	%	**73.3%**		40.0%	26.7%	6.7%	0.0%	100%
		Rayagada	Number	21		9	11	1	0	60
		%	%	35.0%		15.0%	18.3%	1.7%	0.0%	100%
		Grand Total Odisha	Number	**104**		40	**45**	19	**1**	180
			%	**57.8%**		22.2%	**25.0%**	10.6%	**0.6%**	100%
			Number	180		180	180	180	180	180
			%	100%		100%	100%	100%	100%	50%
2	Madhya Pradesh	Betul	Number	**39**	Monetary Loss	9	17	10	3	60
		%	%	**65.0%**		15.0%	28.3%	16.7%	5.0%	100%
		Khandwa	Number	29		7	13	7	2	60
		%	%	48.3%		11.7%	21.7%	11.7%	3.3%	100%
		Mandla	Number	18		3	5	5	5	60
		%	%	30.0%		5.0%	8.3%	8.3%	8.3%	100%
		Grand Total Madhya Pradesh	Number	**86**		**19**	**35**	**22**	**10**	180
			%	**47.8%**		**10.6%**	**19.4%**	**12.2%**	**5.6%**	100%
			Number	180		180	180	180	180	180
			%	100%		100%	100%	100%	100%	50%
3	**Losses by Forest Dweller**		**Grand Total**	**190**	Total	59	**80**	41	**11**	**360**
			%	**52.8%**		16.4%	**22.2%**	11.4%	**3.1%**	100%
	Total Study Sample		**Grand Total**	360		360	360	360	360	360
			%	100%		100%	100%	100%	100%	100%

Source- Field Visit SCSTRTI, 2022



Graph: 11 Losses from forest-Fire

(Source- Field Survey, SCSTRTI, 2022)

4.10 Community Participation in forest fire fighting squad

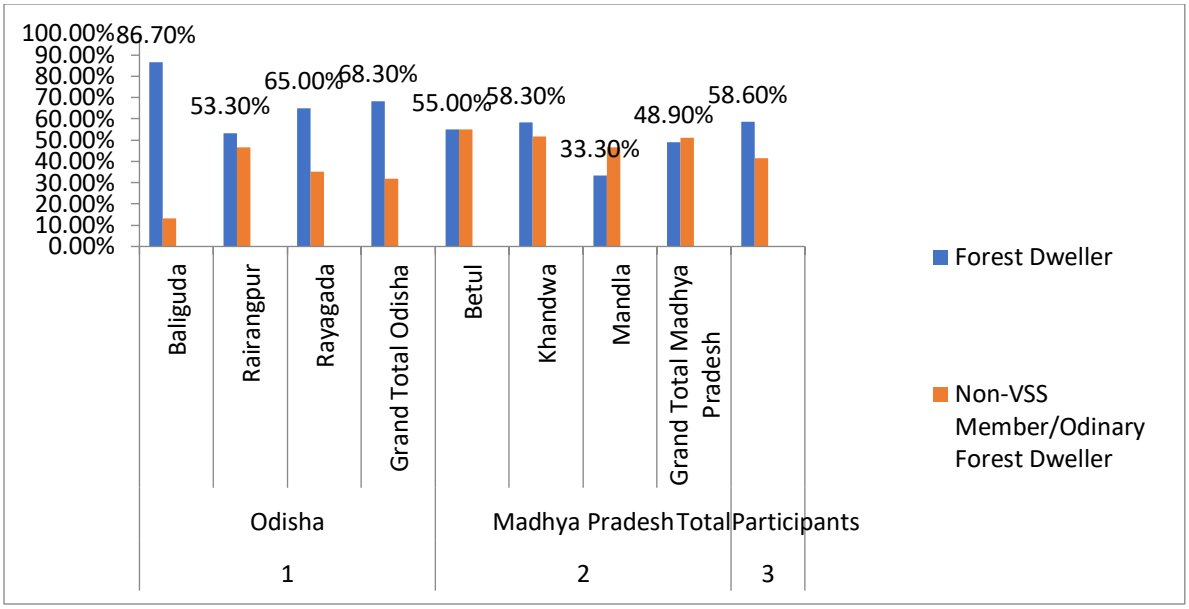
The Forest Department has appointed community members from the villages in forest fire fighting squads for the season of the fire period. The forest fighting squad helps the forest watcher and guards to extinguishing the forest fire. They are paid by the forest department on a daily wage basis. Besides, the forest fire fighting squads, the other community members participate in supporting fire squads in extinguishing forest fires. In Odisha, the community members participate in extinguishing the forest fire. 62.8% of community members reported that they participate in extinguishing the forest fire. In Madhya Pradesh the scenario is different. The difference between the number of forest fire fighting squads and that of tribal community members for forest fire extinguishing is very low. Out of the total participants, 50% are from the forest fire fighting squad and 49.4% are the tribal community members participating in extinguishing forest fires.

The role of the community in participation in extinguishing forest fires is to know about the interest of people to protect the forest from forest fires. Out of the total surveyed people, 67.8% are involved in extinguishing the forest fire in Odisha state. Similarly, in Madhya Pradesh out of the total participants, 55.6% of people are involved in extinguishing the forest fire. More than 61.7% are extremely concerned about the forest fire in their area for the last 5 years.

Table No 4.9 Members of the forest fire fighting squad

SL.No	States	Divisions	Forest Dweller	Forest fire Squad			involved in extinguishing forest fire (Participants)		
				Member	Non-Member		Yes	No	Total Participants
1	Odisha	Baliguda	Number	13	47	Involvement in forest fire	30	30	60
		%	%	21.7%	78.3%		50.0%	50.0%	100%
		Rairangpur	Number	23	37		55	5	60
		%	%	38.3%	61.7%		91.7%	8.3%	100%
		Rayagada	Number	31	29		37	23	60
		%	%	51.7%	48.3%		61.7%	38.3%	100%
		Grand Total Odisha	Number	**67**	**113**		**122**	58	180
			%	**37.2%**	**62.8%**		**67.8%**	32.2%	100%
			Number	180	180		180	180	180
			%	100%	100%		100%	100%	50%
2	Madhya Pradesh	Betul	Number	31	29	Involvement in forest fire	38	22	60
		%	%	51.7%	48.3%		63.3%	36.7%	100%
		Khandwa	Number	30	30		34	26	60
		%	%	50.0%	50.0%		56.7%	43.3%	100%
		Mandla	Number	30	30		28	32	60
		%	%	50.0%	50.0%		46.7%	53.3%	100%
		Grand Total Madhya Pradesh	Number	**91**	89		**100**	80	180
			%	**50.6%**	49.4%		**55.6%**	44.4%	100%
			Number	180	180		180	180	180
3	**Losses by Forest Dweller**		**Grand Total**	**158**	**202**	**Total**	**222**	**138**	**360**
			%	**43.9%**	**56.1%**		**61.7%**	**38.3%**	100%
	Total Study Sample		**Grand Total**	360	360		360	360	360

Source- Field Visit SCSTRTI, 2022



Graph 12 Participation of forest dwellers and non-VSS members for the study

(*Source- Field Survey, SCSTRTI, 2022)*

4.11 Conclusion

During the field survey of the study project, the team found that almost 99% of forest fire is caused by human intervention, it may be intentionally or unintentionally.

i. Encroachments

People residing near the forest keep on trying to extend their fields towards the forest. For doing this, fire is an important instrument. First, they girdle the trees on the periphery of their cultivated land. After these girdled trees are dead, they set fire to the area. In this fire, the girdled trees also burn and convert to ash. Thus, a new area is developed for the offenders. While burning this area, the people also leave the fire burning, which extends to larger areas. Initially, when a fire is set up, the extent is low and if it is beaten or extinguished in time, the damage is less, but with a lapse of time, this fire spreads to hectares of forest area. When the spread is in larger areas, then fighting that fire becomes more difficult.

ii. Grazing

The pastoral groups and cattle herds are legally permitted to free grazing in the forest. Villagers adjoining forest areas use the forest for grazing their cattle. The graziers set fire to the forest before the rains to get a better flush of grass the rains. Graziers go to the forest secretly, without being noticed by forest staff. As a result, when a grazier

starts a fire, the protection staff learns about it only when they see a large number of fumes and smoke. The firefighting team also needs a minimum of one hour to reach the site. In the meantime, the fire extends to a large area, thus creating a huge fire in the forest. Though setting fire in any forest area is an offence under the Indian Forest Act of 1927, it needs the person responsible for the offence. Finding out that particular person is very difficult and hence the culprit escapes every time. Because of this reason, forest fires are very common and remain un-recorded. With the intervention of satellites recording various fires in the forest, now at least, we are in a position to know the frequency of fire, but as the culprits are not being punished, it is very difficult to protect the forest from such fires.

iii. Mahua collection-

The flowers of the Mahua (*Madhuca Indica*) tree are used for preparing liquor by the tribal community. The Gonds use the traditional way of making liquor. The flowers of Mahua are pale yellow and fall at the time of ripening. The flowering season is from March to May in dry deciduous forests. Villagers go early morning to collect the fallen flowers. Wild animals also compete with tribals in eating these flowers. These flowers (juicy petals) mix in with the fallen leaves of trees. Therefore, to clear the area of all leaf litter and other debris, the villagers set fire to the area just below the tree, which helps in a quick collection of Mahua flowers. This resulted in the spread of fire in the forest. This is one of the major causes of devastating fires in deciduous forests

iv. The fire spread due to agricultural practices

Villagers in the month of March-April harvest their crops, agriculture residue is burnt, to clear their fields of this debris. Burning material spread through the wind into the nearby forest and thus causes huge damage to the forests nearby. But now, because of the Tribal Right Act 2006, the tribals were given rights to forest land which they have been cultivating since 2006, the cultivation area is in the centre of the forest, which causes fire in all directions. Hence, forests have become more susceptible to fires. Again, this fire is used for the extension of the cultivation area, so this process becomes cyclic.

v. Collection of Tendu leaves

A large number of tribals are involved in the collection of Tendu leaves. The income of one tribal family from the collection of Tendu leaves ranges from 3 to 5 thousand rupees per year. Villagers or the contractors involved in the Tendu leaves the business to try to set fire to the Tendu leaves production area-forest to get a better flush of Tendu leaves. This is done about 30 days earlier than the collection period of Tendu leaves—the month of April. This period is the most sensitive regarding forest fires. Large forest areas

are burnt because of this activity. By this method, though, they get a better yield of Tendu leaves, but at the cost of forest degradation.

vi. Vengeance

A forest guard protects the forest, as a part of his duty, he arrests offenders and takes them to court. These offenders are frequently sentenced to prison by the court. Such offenders, as a vengeance, set fire to the forest area under the jurisdiction of that forest guard. Vengeance between the two groups also affects the forest. In this case, one group sets fire to the area under the protection of one JFMC or the group.

vii. Poaching and Delinquency

Poachers set fire to a particular area so that the wild animals can be confined to that particular area. Fire is used to escape from another offence. Poachers usually do it. They set fire to an area where proof of killing animals was found. It may have been skin, blooded soil, or other carcasses of the animals. Sometimes fire is set by poachers to destroy the path which is formed by the movement of vehicles in a grassy area.

viii. Recreational activities

In the present scenario, many people from cities travel to the forest nearby their city and enjoy being in the forest and performing campfire activities. Sometimes these visitors leave the fire without extinguishing it. This fire frequently spreads over a large area. Thus, unknowingly, damage to the forest is caused.

ix. Negligence during heating coal tar for the construction of roads

During the construction of roads, the coal tar is heated using firewood. When it is done near a forest and the burning material escapes into the forest, the fire spreads into the forest. If this is not controlled in time, then great damage is caused to the forest due to fire.

x. Lightening.

Sometimes lightning initiates fires in the forest. Even large-sized trees are turned into blazes. This further expands into large forest fires. This was the main reason why dried bamboo trees were available in the forest, but now they have partially vanished from the forest.

xi. Traditional Beliefs

In one of the studied forest ranges (Khalwa, Madhya Pradesh), there is a ritual in the tribe community that they set fire to a particular hill (aforesaid) as their votive to offer their god or goddess to fulfil their desire.

The Technical and Organizational Capacity of Local Community concerning Forest Fire Management is now done through the use of modern technology using satellite. Forest Survey of India immediately sends out forest fire alert messages to all divisions at the beat level in Odisha and the compartment level in Madhya Pradesh. The message is sent to all forest departmental or non-departmental people who are registered in the FIRMS (**Fire Information for Resource Management System). FIRMS provides real-time** data within 3 hours of satellite observation.

The participatory institution is playing a vital role in controlling forest fires in forest fringe villages. The forest department appoints fire watchers from the villages to prevent forest fire along with the fire fighting squads in the season of fire.

Chapter V

Policies, and Institutional frameworks for the management of forest fire

The objective associated with this section is to map out the existing forest policies and practices of forest fire management, control and prevention and develop an Action Plan on Forest Fire Management and recommend measures to be taken at the policy and field level for effective forest fire management (including institutional setup, stakeholders' coordination, policy framework, knowledge management, technical options etc.

5.1 Policies in the Indian Context

The policy on fires in Indian forests has first officially articulated in the Indian Forest Act of 1927, in which the setting of fires is a punishable offence. In addition, it made it mandatory for all forest-dependent people to assist in preventing and controlling fires. The National Forest Policy (1988) also stresses forest protection against encroachment, grazing, and fire. Furthermore, it advocates the adoption of modern fire management practices for the prevention and control of forest fires. In the wake of this, there have been a series of centrally sponsored forest fire protection and control schemes since 1985, each of which has laid particular emphasis on the adoption of modern techniques and equipment in the prevention and control of forest fires. In addition, a set of national guidelines on forest fires, which was issued to all states in 2000, stressed the importance of community involvement in forest fire prevention and control through the existing joint forest management program.

The Union Ministry of Environment and Forests initiated one project "Modern Forest Fire Control Project" in 1984 –1990 assisted by the United Nations Development Program in the two States of U.P. and Maharashtra. The purpose of this project was to introduce and evaluate integrated forest fire management systems in both States and come out with an appropriate plan of action. The project was highly successful from the standpoint of technical soundness and economic efficiencies. Motivated by the success of this project the Ministry of Environment and Forests has introduced a centrally sponsored scheme namely "Modern Forest Fire Control Methods" from 1992-93 in the eleven selected States of Andhra Pradesh, Bihar, Gujarat, Himachal Pradesh, Kerala, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu and Uttar Pradesh.

The project continued during the first three years of the Ninth Plan period i.e., from 1997 to 2000. In 2000 the scheme was extended to all the states and union territories of the country. The objectives of this scheme are:

(i) To control forest fires to protect and conserve forests.

(ii) To devise, test and demonstrate the principles and techniques of forest fire management.

(iii) To improve the productivity of forests by reducing the incidence and extent of the fire.

(iv) To create awareness among the masses about the effects of forest fires on the forests and environment.

(v) To conduct training programmes for the forest officials and local people to prevent, detect and control forest fires.

5.1. Details of Policies that have a salient feature on forest fire management

S.No	Policy	Salient features
1	The Indian Forest Act, 1927	• The Forest Act, of 1927 consolidated the law relating to forests, the transit of forest produces and the duty leviable on timber and other forest produce. The Forest was classified into three as reserved, protected and village forests • Special provision was made to deal with shifting cultivation. The debuted officer was supposed to record the claims related to the Shifting Cultivation, and inform the state govt with his opinion as to the permissibility or otherwise of the practice. The state government was finally to decide on the issue of permission or prohibition (IFA 1927, section 10). • The practice of shifting cultivation was in all cases deemed to be a privilege subject to control, restriction and abolition by the state government. • Acts prohibited in Reserve Forests under IFA 1927, section 26— (1) Any person who— (a) makes any fresh clearing prohibited by section 5, or (b) sets fire to a reserved forest, or, in contravention of any rules made by the 2 [State Government] in this behalf, kindles any fire, or leaves any fire burning, in such manner as to endanger such a forest; or who, in a reserved forest— (c) kindles keep or carry any fire except at such seasons as the Forest officer may notify on this behalf; (d) trespasses or pastures cattle, or permits cattle to trespass;

2	Forest Policy 1952	• Policy withdrew the concession of the release of forestland for cultivation. • Decided that there should be village forests for the needs of the villagers as against the provision of allowing into the outlying areas of reserve forests given in Forest Policy Resolution 1894. • Applied some controls also on private lands. • Imposed fee on grazing.
3	The Forest (Conservation) Act, 1980	• Restriction on the de-reservation of forests or use of forest land for non-forest purposes. • The power is given to Central Govt to carry out the law of this Act. • An advisory committee may be formed to advise the Central Govt on the conservation of Forest.
4	PESA, 1996	• every Gram Sabha shall be competent to safeguard and preserve the traditions and customs of the people, their cultural identity, community resources and the customary mode of dispute resolution; (clause d of rule 4). • planning and management of minor water bodies in the Scheduled Areas shall be entrusted to Panchayats at the appropriate level; (clause j of rule 4). • the ownership of minor forest produce; (subrule II, clause (m) of rule 4)
5	The Biodiversity Act, 2002	• association of Indian scientists, benefit claimers and the local people with research and development in biological resources and bio-survey and bio-utilisation; (21, 2, d) • The State Biodiversity Fund shall be applied for— (a) the management and conservation of heritage sites; (b) compensating or rehabilitating any section of the people economically affected by notification under sub-section (1) of section 37; (c) conservation and promotion of biological resources; (d) socio-economic development of areas from where such biological resources or knowledge associated thereto has been accessed subject to any order made under section 24, in consultation with the local bodies concerned; (e) meeting the expenses incurred for the purposes authorised by this Act. (Clause 32, 2).

		• The Biodiversity Management Committees may levy charges by way of collection fees from any person for accessing or collecting any biological resource for commercial purposes from areas falling within its territorial jurisdiction. (Clause 41, 3) • The Fund shall be used for the conservation and promotion of biodiversity in the areas falling within the jurisdiction of the concerned local body and for the benefit of the community so far, such use is consistent with the conservation of biodiversity. (Clause 44, 3).
6	Forest Rights Act, 2006	**Section- 3** (b) community rights such as nistar, by whatever name called, including those used in the erstwhile Princely States, Zamindari or such intermediary regimes; (c) right of ownership, access to collect, use, and dispose of minor forest produce which has been traditionally collected within or outside village boundaries; (d) other community rights of uses or entitlements such as fish and other products of water bodies, grazing (both settled or transhumant) and traditional seasonal resource access of nomadic or pastoralist communities; (e) rights including community tenures of habitat and habitation for primitive tribal groups and preagricultural communities; i) rights to protect, regenerate or conserve or manage any community forest resource which they have been traditionally protecting and conserving for sustainable use; (k) right of access to biodiversity and community right to intellectual property and traditional knowledge related to biodiversity and cultural diversity; **Section – 5** The holders of any forest right, Gram Sabha and village level institutions in areas where there are holders of any forest right under this Act are empowered to – (a) protect the wildlife, forest and biodiversity; (b) ensure that adjoining catchments areas, water sources and other ecologically sensitive areas are adequately protected;

		(c) ensure that the habitat of forest dwelling Scheduled Tribes and other traditional forest dwellers is preserved from any form of destructive practices affecting their cultural and natural heritage; (d) ensure that the decisions are taken in the Gram Sabha to regulate access to community forest resources and stop any activity which adversely affects the wild animals, forest and biodiversity are complied with
7	Revised FRA. 2012	• The transit permit regime in relation to transportation of minor forest produce shall be modified and given by the Committee constituted under clause (e) of sub-rule (1) of rule 4 or the person authorized by the Gram Sabha. • The collection of minor forest produce shall be free of all royalties or fees or any other charges; • The Gram Sabhas shall be convened by the Gram Panchayat and in its first meeting it shall elect from amongst its members, a committee of not less than ten but not exceeding fifteen persons as members of the Forest Rights Committee, wherein [6 at least two-thirds members shall be the Scheduled Tribes. • Constitute Committees for the protection of wildlife, forest and biodiversity, amongst its members, in order to carry out the provisions of section 5 of the Act. Clause (e) of sub-rule (1) in rule 4, inserted by G.S.R. 669(E), dated 06.09.2012. • monitor and control the committee constituted under clause (e) which shall prepare a conservation and management plan for community forest resources in order to sustainably and equitably manage such community forest resources for the benefit of forest dwelling Scheduled Tribes and other Traditional Forest Dwellers and integrate such conservation and management plan with the micro plans or working plans or management plans of the forest department with such modifications as may be considered necessary by the committee (Clause (f) of sub-rule (1) in rule 4, inserted by G.S.R. 669(E), dated 06.09.2012)
8	National Agroforestry Policy 2019	The Agriculture Development Strategy, 2014 focused on the Agroforestry system to enhance production and productivity through an integrated management system of Agriculture and

		Forestry. The National Forest Policy, 2018 also emphasises on development, extension and promotion of biological diversity programmes for livelihood, medicinal herbs production programme, and livelihood and food security through agroforestry and community forest programme at village and block levels.
9	The Indian Forest Act, 2019 (Amendment to The Indian Forest Act, 1927)	• "An act to provide for conservation, enrichment and sustainable management of forest resources and matters connected therewith to safeguard ecological stability to ensure the provision of ecosystem services in perpetuity and to address the concerns related to climate change and international commitments." • Treatment of claims relating to the practice of shifting cultivation— (1) In the case of a claim relating to the practice of shifting cultivation, the Forest Settlement officer shall (a) entertain claims to the practice of shifting cultivation in the manner hereinafter provided with reference to the forest rights defined and granted under individual or community rights in accordance with to the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. (b) in all other cases not covered under the Forest Rights, the Forest Settlement Officer will submit the statement to the State Government, incorporating the viewpoints of the presenting officer and Divisional Forest officer, together with his own opinion as to whether the practice should be permitted or prohibited, wholly or in part. (Clause 10) • If such practice is prohibited under sub-section (2), the State Government --- (a) shall give direction as to the period, not exceeding five years, by which the practice of shifting cultivation is to be extinguished. (b) may give directions for the management of such areas during the proposed period not exceeding five years. • If such practice is permitted, wholly or in part under section (2) then a Forest Settlement-officer shall arrange for its exercise based on the law.

		• Whenever a fire is caused wilfully or by gross negligence in a reserved forest, or theft of forest produce or grazing by cattle occurs on such a scale as to imperil the regeneration and future yield of such forest, the State Government may (notwithstanding that any penalty has been inflicted under section 78) direct that in a such forest or any portion thereof, the exercise of all rights of pasture or to forest-produce shall be suspended for such a period as it may think fit. (Clause 26, 3) • Formation of village forests- The State Government may constitute any forestland or waste-land which is the property of Government or over which the Government has proprietary rights as village-forests and modify and amend the such constitution of village-forests Such village forests shall be managed by the community through Joint Forest Management Committee by whatever description, constituted in consultation with Gram Sabha and the Forest Department, as per the provisions prescribed by the Rule. • sets fire to a protected forest, or kindles a fire without taking adequate precautions to prevent its spread; Penalties for acts in contravention of provisions of the (Chapter IV) or the rules made there under. • permits cattle to graze in the area closed under clause (b) of section 30 or causes damage to any forest-produce therein, through such grazing in such area, or to any tree reserved under clause (a) of section 30, or to the forest produce therefrom; • Provided that no shifting cultivation shall be recommended in forests which had not been subjected to shifting cultivation in the past twenty years. (34, d). • Conservation of forests and lands not owned by the Government. • Cattle-trespass Act, 1871, to apply Cattle trespassing in a reserved forest or in any portion of a protected forest which has been lawfully closed to grazing shall be deemed to be cattle doing damage to a public plantation within the meaning

		of section 11 of the Cattle-trespass Act, 1871, and may be seized and impounded as such by any Forest-officer or Police officer (Clause 70). • Management of forests or waste-lands in the joint interest of Government and other people (s) or public interest (Clause 80)
10	Joint Forest Management Committee	A Joint Forest Management approach has been initiated in the context of the National Forest Policy, 1988, in which state governments support forest dwellers and fringe villagers to manage their adjacent forest and share the cost and benefits from the forest under the Joint Forest Management programme. Under the JFMCs programme, fringe communities protect and manage the nearby forests. A Van Suraksha Samiti has been constituted in Odisha from the villages on the periphery of the forest area (within 2 km of the forest area). Madhya Pradesh also initiated the process of formalisation of joint forest management. The government also realised that, without public participation, forest protection and forest management is not possible. In an effort to re-forest degraded land and reduce biotic pressure on the forest, a committee was formed to protect the forest from degradation while also giving fringe villagers the opportunity to produce from such forest.

The annual occurrence of forest fires, and especially, the large extent to which they occur, presents a striking contradiction between fire policy, and fire reality. Given that nearly a century of the ban-and-punish approach to fires in Indian forests has not worked, a more effective approach might involve the integration of fire into existing forest management systems. Such integration would need to take into consideration the management goals of different stakeholders — whether to conserve biodiversity and wildlife habitat, restore degraded ecosystems, or ensure a supply of goods and services required by forest-dependent communities.

5.2 National Plan for Forest Fire Management

Continue effort has been done by the Ministry to deal with the issue of the forest fire. MoEFCC has made an essential provision in the draft National Forest Policy, 2018. The MoEFCC has addressed a systematic plan for forest fire management under the modified National Forest Policy, according to those special precautions would be taken at the time of fire season along

with the improved and modern management tools and techniques to combat forest fire. The action plan is more emphasizes awareness generation, capacity building, community involvement etc.

5.3 Administration and Institutional framework to combat forest fire

A. Forest Fire management

Central government entities	
MoEFCC	• Overall policy guidance and standard setting for FFPM • Administers centrally-sponsored schemes and provides funding to states
FSI (under MoEFCC)	• Issues pre-warning alerts for high fire danger to state forest departments nationwide • Nationwide monitoring and alerts for active fires, provided to state forest departments and the public • Nationwide estimation of burnt forest area
ICFRE (under MoEFCC)	• Apex research organization for forestry in India • Research institutes under ICFRE include FRI, which has developed training modules for the SFDs and firefighting equipment kits
DFE (under MoEFCC)	• Coordinates training for frontline staff across the country, including forest rangers and state forest service officers
NRSC	• Provides near-real-time satellite data to FSI for fire monitoring
NDMA	• Policies and planning for disaster management across the country, So far, have played a minor role in FFPM • Deployed NDRF during 2016 forest fires in Uttarakhand • Organized mock drill for forest fire response in April 2017
Military, Paramilitary, and Home Guards	• Local units may be called by the SFD to assist in response to large forest fires from time to time
State government entities	

State forest department (SFD)	• The primary agency responsible for implementing FFPM • Approves forest working plans for forest divisions within the state, laying out required forest fire prevention activities • Issues state-specific instructions, standard operating procedures, and manuals for field staff • Monitors and collects field-reported data on fire occurrence, burnt area, damages, and forest offences in forest divisions across the state
SDMA	• Policies and planning for disaster management at the state level • Approves district-level disaster management plans, so far, has played a minor role in FFPM
Community/village-level institutions	
Joint Forest Management Committee	• Primary institution for community-based forest management in India and entry point for SFD engagement with communities on FFPM • Responsible for developing forest micro-plans for JFMC areas, with technical support from the SFDs • Carries out FFPM activities in coordination with the SFD and may organize labour from the local community for clearing fire lines, conducting controlled area burning, seasonal firewatchers, etc.
Other community institutions	• A diverse variety of other community-level institutions have evolved in the different states for community-based forest management, such as the Van Suraksha Samiti in Odisha

Reference (Strengthening Forest Fire Management in India) year author **National**

5.4 Action Plan on Forest Fire

The National Action Plan has been made with the broad objective to minimize forest fire by empowering and strengthening forest fringe communities, enhancing communication and may be encouraging villagers to work together with the forest department. This will lead to reducing the vulnerabilities of Forest Fire across the diverse forest ecosystem of our country and also enhance the capabilities of the forest, forest personnel, and other institutions to combat forest fire.

Action proposed to minimize forest fire incidences

A. Technical Approach

i. Register more villagers to FIRMS (Fire Information for Resource Management System) services

more people to be involved in forest fire protection. The CEO of revenue block should also be involved in the protection of the forest against fire. With the involvement of the CEO, a greater number of villagers will be involved in forest fire protection. The villagers who may be of help during firefighting should be listed and connected through FIRMS. Thus, after being connected, more hands would be available for mitigating the fire in the forest.

ii. post-fire treatments in the forests

Presently, there is no plan for post-fire treatment of the forest areas because some intellectuals say that forest fire is not harmful, rather it is beneficial in the regeneration of plants. However, the studies which are being conducted in this project covering the Teak and Sal forests of Odisha and M.P. indicate that tropical forests are damaged and impact the regeneration of plants. The working plan should develop a post-fire treatment plan.

While reporting damage due to forest fires, the forest department reports that no loss is caused by the forest fire as there is no timber or fuelwood loss found due to fire. But the satellite shows that most forest fires, cause loss. A few policy suggestions for post-fire treatments are given below.

a. **Restocking of forests:** The area affected by the forest fire should be restocked by planting saplings. During a fire, most of the young crop gets damaged, so to recover, a sufficient number of plants need to be planted in the area. A good nursery having the plants of the species which are best suited to the area affected should be kept ready. For this, the seeds of those forest fire plants which survive in that forest area should be collected and saplings prepared in the nursery. Such plantations may not be in rows, but plants can be planted scattered in the blanks. The following tree species can be planted -*Cassia fistula, Terminallia tomentosa, Wrightia tinctoria, Tectona grandis, Acacia catechu etc*. in the dry deciduous forest area.
b. **Proper soil conservation measures** should be taken so that the damaged soil does not get washed away with rain. This includes the construction of check dams and contour bunds. Locally available boulders can be used for the construction of small contour bunds. If we could dig a small contour trench of size 30cm x 30cm just above the contour bund and fill the gaps in the boulder contour bund, then it would still be very effective to check the runoff of soil and water.

c. Proper records regarding fire and its extent are to be maintained to keep the track of fire and according to this future planning and requirement of budget can be prepared.

d. **Fire-prone areas can be marked in advance**

During our current study, we identified that when the land surface temperature (LST) of any forest area, as measured by satellite, rises above 32 degrees Celsius, the land becomes vulnerable to the forest fire. Such areas are to be marked and a report regarding this is to be given to related officers so that these spots can be prioritised for forest fire protection. For such areas, special fire squads can be provided. Satellite studies can provide data on the susceptibility of any area to fire.

e. **Construction of road network, especially on slopy areas**

Forest fires become more aggressive and out of control, especially on slopy hills, because the firefighting squad is not able to reach the spot in time and with every minute the fire extends into a large area. No vehicular movement is possible in such an area, so the fire goes on damaging larger areas. Most of the project area under study is full of steep slopes. To counter this, a network of fair-weather roads should be constructed in the fire-sensitive area. This will help in two ways i. The forest fire squad will be able to approach the area more easily, and ii. these roads will also serve as fire lines.

f. **Providing various equipment for fighting fire**

The availability of fire-fighting equipment at the forest beat level is important because it is the beat guard or the JFMC village who reaches the spot at the time of any fire. Instruments include fire safety kits, helmets with headlights, torches, water bottles, shoes, fire beaters and fire blowers. Presently, fire blowers are provided at the fire squad level. These fire squads are posted in fire-sensitive areas. These blowers are very effective also, but the problem lies in the portability of these blowers when the area is sloppy and when we have to move on foot, then it becomes very difficult to carry. Portable light-weighted fire beaters, which are fire-resistant flaps with a one-metre handle.

B. Social approach

i. Capacity building Training and motivation

The capacity building of frontline forest personnel and villages institutions members should be training forest fire control and management. Those villages who contribute to

controlling fires in the forest should be rewarded with tangible or intangible means to motivate forest conservation. A Fire Free Village programme should be started. In this, the village near which, no forest fire was observed can be rewarded (This has already been adopted by Indonesia in July 2015).

Seminars and workshops are to be conducted regularly throughout the year regarding fire protection. Seminars should be aimed to ensure the active participation of politicians, the Panchayat department, Teams of Disaster Management, District collector and other line departments.

ii. Encourage indigenous community conservation ethos like Sacred groves

The indigenous groups conserve and preserve the bio-diversity and its forests flora and fauna in sacred groves; otherwise, this flora and fauna might have disappeared from the natural ecosystem. The sacred groves are the natural forests that are located in northeast, central and peninsular India. The interference of all kinds of human activities is prohibited in sacred groves.

These sacred groves can be a source of inspiration to tribals of M.P. and Odisha. Priest and other spiritual leaders should be involved in the cultural conservation of the values of forests. The language of these preachers is easily understood by villagers.

(vi) Conservation and Value addition of NTFPs-

Village institution needs to be trained in three dimensions.1 -The importance of habitat for the sustained availability of NTFPs 2 - Sustainable harvesting of NTFPs. 3- Processing and value addition of NTFPs.

CHAPTER-VI

Suggested Guidelines and Action Plan for Forest Fire Management

Action Plan on Forest Fire

The National Action Plan has been made with the broad objective to minimize forest fire by empowering and strengthening forest fringe communities, enhancing communication and may be encouraging villagers to work together with the forest department. This will lead to reducing the vulnerabilities of Forest Fire across the diverse forest ecosystem of our country and also enhance the capabilities of the forest, forest personnel, and other institutions to combat forest fire.

6.1 Preventing Forest fires

Most forest fires are manmade and are linked to socio-economic and livelihood issues of the forest fringe communities. It should, therefore, be possible to greatly reduce the forest fire incidences by making these communities aware of the many tangible and intangible benefits lost to them, both individually and collectively, due to forest fires. Following actions are proposed to be taken in this regard:

Action Points	Strategy	Responsibility
Effective communication strategy for awareness generation	• A mass communication strategy with adequate financial provisions for five years needs to be framed by the State Forest departments for sensitization of the state in general and local communities in particular. • It should be specifically targeted at students/youth, farmers, women groups, cattle herders, NTFP collectors, urban dwellers, tourists and pilgrims, among others. • Information on forest fire and its adverse effects should also be included in the school curriculum at several levels. • The strategy would identify most effective means for reaching out to different target groups like school campaigns, campaigns on Radio, TV, and social media, mobile campaigns during festival season, organization of music festivals, and setting up information portals, among others.	State Forest Department State Tribal Departments
Empowering Communities to deliver on their responsibilities	• The existing forest laws mandate the forest officials to seek participation of local communities in fire management. Under the Forest Rights Act (FRA, 2006) the forest areas recognized under community rights are mandated to be sustainably used by the right holding forest dweller community which places on them the responsibility of conservation of these areas.	State Forest Departments and MoEFCC

	• Similar responsibilities rest on the communities practicing shifting cultivation for protection of forests against damage by fires under their respective state laws. • Similar expectations are also placed on the CFRMCs/JFMCs/EDCs/Van Panchayats in relation to the forest lands under their jurisdictions. • The forest dependent communities would be better placed to shoulder these responsibilities if they are adequately empowered with delegated authority and funds. The communities could also be incentivized for their cooperation in fire prevention and control measures in the form of money, rewards, social recognition, preference in Government schemes, etc. • The State Forest Departments may evolve state specific mechanisms for this purpose in tune with relevant laws and traditional practices.	State Tribal Welfare Departments and MoTA Local community-based organisations
Capacity building of communities	• The capacity of community organizations in prevention and control of forest fires should be enhanced by periodical training and capacity building programmes. • Forest fire alerts information should also be provided to CFRMCs/JFMC/EDC/Van Panchayat members and they should also be provided with firefighting equipment including leaf litter blowers, other tools and protective clothing. • The community members should be duly involved during the mock drills on forest fire before fire season. • In the Micro plan of the CFRMCs/JFMCs, should be a separate chapter for forest fire management which should contain the details of vulnerable areas, location of natural & man-made water sources, other infrastructure available for fire prevention and management etc.	State Forest Departments and MoEFCC State Tribal Welfare Departments and MoTA Tribal Research Institutes of different States Local community-based organisations
Encourage indigenous knowledge and community conservation ethos like Sacred groves	• The indigenous groups conserve and preserve the bio-diversity and its forests flora and fauna in sacred groves; otherwise, this flora and fauna might have disappeared from the natural ecosystem. The sacred groves are the natural forests that are located in northeast, central and peninsular India. The interference of all kinds of human activities is prohibited in sacred groves.	Tribal Research Institutes of different States

	• These sacred groves can be a source of inspiration to tribals. Priest and other spiritual leaders should be involved in the cultural conservation of the values of forests. The language of these preachers is easily understood by villagers.	

6.2 Increasing the resilience of forests to fires:

Management interventions for increasing resilience to forest fires may be planned according to the vulnerability to forest fires as reflected in the risk zonation maps. Following are some of the measures which could be adopted in this context.

Action Points	Strategy	Responsibility
Moisture and water conservation	• As fire hazard is more in drier and deciduous habitats and areas with predominance of grasses, management action would need to aim at moisture retention for longer time after rains and appropriate preventive measures to ensure that minor fire incidences do not escalate into major fire events. • A long term plan for improving the water regime of the forest areas based on opportunities and feasibility will be useful in reducing vulnerability to fires. • Several existing programs for eco-rehabilitation and catchment area treatment plans provide scope for this kind of work.	State Forest Departments Policy support by MoEFCC
Forest floor biomass management	• Necessary management interventions may be planned aiming at minimizing accumulation of dry fuel material on forest floor in the fire season. • The litter and other biomass on the forest floor leading to fire danger could be gainfully utilised for the benefit of the society in identified areas. • A framework for biomass management is suggested below and SFDs are encouraged to experiment with appropriate caution. a. Collection of forest floor biomass such as fallen pine needles for use in briquets may be encouraged by the waiver of royalty and transit fee for such collections. b. Policies for promoting biomass based off-grid micro power plants in remote areas may be put in place. Space heating in high altitude areas could be tried using excess biomass from forest floors vulnerable to fires.	State Forest Departments Policy support by MoEFCC

	c. Guidelines may to be framed for sustainable removal of dead bamboo in the event of mass flowering to reduce risk of fire and also to conserve biodiversity. d. Policies for permitting women SHG to use forest floor biomass with appropriate safeguards for micro entrepreneurship may be put in place by the SFDs.	
Weed Management	• Invasive weeds such as Lantana need to be controlled as they contribute significantly to the fire danger and pose a threat to native biodiversity. The following actions are recommended: i. A baseline study to quantify the extent and spread of invasive weeds may be initiated by SFDs in consultation with Forest Research Institutes of national repute. ii. Lantana removal strategies adopted should ensure it does not regrow on treated lands. Removal should be organized as an attractive economic opportunity for the local communities. iii. Rehabilitation of treated areas with appropriate species and soil and moisture conservation measures should form part of the weed removal plan.	State Forest Departments and Forest Research Institutes of national repute) Monitoring by MoEFCC

6.3 Forest Fire Preparedness:

Preparedness in forest fire management leads to effective response to fire disasters resulting in reduced impact and quicker recovery. The following steps may form the basis of preparedness against forest fires:

Action Points	Strategy	Responsibility
Forest fire detection and alert	Satellite based Forest Fire Alerts are already operational across the country led by FSI. The following steps may be taken to improve the efficacy of the FSI fire alert system: i. Digitization of forest boundaries: In the absence of digitized boundaries in many forests across the country, the FSI screens fire detections using approximations leading to reduced efficacy of the alert system. The states may, therefore, complete the	State Forest Departments Monitoring by FSI and MoEFCC

		digitization of forest boundaries at the earliest. ii. Promoting greater adoption of the Forest Fire Alert System: FSI has put in place a robust forest fire alert system. The States shall encourage the involvement of all field functionaries in the same, so that the forest fire alert system can percolate down to beat level in least possible time. This may be institutionalized through a protocol. iii. Improving Ground based Detection: Even with the advances in new remote sensing technologies for fire detection, ground-based detection continues to be essential and should be sufficiently resourced. The SFDs shall perform an assessment of the efficacy of the existing network of watchtowers by a review of the level of functionality and operational use of the existing towers. The WPOs (DFOs in the case of divisions where approved working plans are already in existence) may propose new locations for fire watchtowers based on coverage, visibility, ignition sources, and other relevant factors. iv. Strengthening engagement with local communities: Local communities are often the first to spot fires and alert the forest department. Locally suitable mechanisms should be developed by the SFDs for sourcing reliable and quick information from local communities. v. Dedicated phone line: A toll-free telephone number for fire detections and other required support needs to be established at state level to obtain information on forest fires from tourists, passersby and local people. vi. Monitoring and evaluation: FSI has put in place a system to review all fire alert detections, and their ground verification. This is a critical step and may be monitored by MoEFCC in the month of December every year. SFDs must ensure that feedbacks	

	on fire alerts are sent to FSI for validation. vii. Wireless network: In most remote forest areas mobile telephony is not well developed and frontline staff are unable to get the information coming on the Forest Fire Alert Alarms. In such cases, forests communication system may be supplemented by a dedicated wireless network.	
Digitize the location of critical resources and assets	• The IT Cells of the state forest departments shall conduct inventory mapping of critical resources for forest fire prevention and management and make relevant information available to the forest divisions. • Resources and assets to be inventoried may include forest department resources, such as watchtowers, ground crew stations, controls rooms and fire lines as well as non-department resources, such as the locations of fire stations, fire tenderers and National and State Disaster Response Forces, and army and paramilitary camps. • They may also include important infrastructure such as roads, railways, and telecommunications networks and natural resources such as water bodies and natural fire breaks that could assist in preparedness and planning for response to forest fires.	(Action by SFDs) (Monitoring by MoEFCC)
Forest Fire Lines	• Mapping and digitizing of the location of existing fire lines and other infrastructure such as roads, transmission lines, and rail lines that may function as fire breaks. • A review of the maintenance status, functionality, and adequacy of these fire lines, and an assessment of the need for new fire lines, may be undertaken considering past fire data, forest types, habitations, and other relevant factors. • Proposals for new fire lines should be made on a scientific basis considering their potential efficacy in reducing fire risk and their proximity to people, property, and areas of special concern (e.g., protected areas). • Plantations should not be raised on existing or proposed fire lines	State Forest Departments Monitoring by FSI and MoEFCC
Control Burning	• Control burning may be necessary in some places for preventing spread of fire. • The following actions are recommended to improve the consistent performance and	State Forest Departments

	effectiveness of control burning wherever necessary: i. Prioritization of areas for control burning as part of the fire risk zonation analysis; ii. Monitoring of the performance of control burning at the Circle level, and integration of monitoring data into a database maintained by the SFDs; iii. Timely release of funds for control burning prior to the onset of the peak fire season and the provision of advance/ad-hoc release as needed; iv. Development of state-specific guidelines for control and prescribed burns to be notified and revised as may be necessary.	Monitoring by FSI and MoEFCC

6.4 Fire Suppression

Immediate response to forest fires after receipt of information is of utmost importance. The State Forest Departments must develop a culture of emergent response to fire alerts under which all available resources are used to douse the fire. This needs intense training at all levels, strengthening of infrastructure, and coordination with other relevant agencies.

Action Points	Strategy	Responsibility
Training for field staff, firewatchers, and local community (youth)	• The principal need for forest fire suppression is to have adequate competent, trained, and equipped workforce on the ground, ready to respond and take immediate action. Training should be provided to field officers, seasonal firewatchers, and community volunteers involved in firefighting. All these firefighters should understand basic principles of forest fire management for using the most effective suppression technique at their disposal and know when retreat is necessary. The type of training provided to firefighters should be tailored according to the landscape, nature of terrain, their level of responsibility and role in the command structure in responding to fires. i. Mock drills should be organized before fire season at various fire prone areas involving all the stakeholders such as District Administration, Police, Fire Department, NDRF, SDRF personnel, community organizations etc. for identification of gaps in the existing	State Forest Departments and DFE) Monitoring by the MoEFCC District Administration, Police, Fire Department, National Disaster Response Force, State Disaster Response Force

	mechanism and better preparedness during crisis time. ii. Provision of training, equipment, and coordination should extend beyond state-managed forests to community institutions where communities are responsible and involved for managing most of the forest.	
Equipping the firefighters	i. The firefighting squad including field staff, seasonal firewatchers, and community firefighters should be provided with adequate firefighting equipment including leaf litter blowers, and protective clothing. ii. The SFDs should take the lead in this process of identifying and providing firefighting equipment suitable to local needs in consultation with the Forest Research Institute like ICFRE iii. Focus on development of user friendly fire fighting equipment, tools and protective clothing suitable for various regions of the country. iv. There should be sufficient practice sessions for the firefighting personnel in the use of the firefighting equipment including leaf litter blowers, and protective clothing so as to enhance their efficiency in actual firefighting.	State Forest Departments, ICFRE Monitoring by the MoEFCC)
Development of adequate infrastructure for fire suppression	i. An effective communication network should be ensured in all fire prone forest areas using wireless where necessary. ii. SFDs should develop, and enforce, a protocol for ensuring prompt access to field vehicles from nearby forest divisions for movement of firefighting personnel to the fire spots at the earliest. iii. Advance technologies such as use of drones should be explored in identification of exact location, intensity & direction of fire to facilitate fire extinguishment at the earliest. iv. Forest road network should be properly maintained for quick movement of firefighting forces to the fire site.	State Forest Departments Monitoring by the MoEFCC
Arrangements for adequate	i. The SFDs should fill all vacancies especially at the level of frontline forest officials in the fire prone areas on priority basis.	State Forest Departments

manpower in fire prone areas	ii. Trained manpower may also be mobilized form other agencies such as Police, District Fire services, NDRF, SDRF etc. iii. The Communities living near the fire prone areas should also be sensitized and may be incentivized towards fire suppression activities. iv. There should be a mechanism for mobilization of forest fire fighting volunteers and providing them with adequate training on an urgent basis. A database of the firefighting volunteers should be maintained at district level.	

6.5 Post Fire management

Action Points	Strategy	Responsibility
Assessment of loss due to forest fires	i. FSI may develop a national level database for burnt area assessment on an yearly basis. Standardized protocols and procedures are needed to facilitate the reporting of the area affected and losses due to forest fire which may be developed by the ICFRE in association with FSI and other institutions. ii. MoEFCC may assign ICFRE the responsibility of developing and standardizing methodologies for assessing losses due to forest fire including loss of intangibles such as ecosystem services. iii. Based on standardized methodologies, the ICFRE may further standardize protocols for estimating area affected and losses due to forest fire and reporting the same at successive levels. iv. The ICFRE may assist the DFE in designing and organizing adequate training programs for forest officials at various level for this purpose. (Monitoring by MoEFCC)	State Forest Departments, ICFRE and FSI)
Restoration of fire affected areas	i. A proper restoration plan should be prepared at once for the fire affected areas with the objective of restoring to its natural profile. Appropriate silviculture practices should be	State Forest Departments

	prescribed taking into account the ecological successional dynamics. ii. Adequate soil moisture conservation measures may be taken up in the fire affected areas for enhancing the moisture retention capacity of the land. iii. Indigenous vegetative barriers may be identified and planted around the fire affected areas.	

6.6 Coordination with Other Agencies:

Forest fire management is a multifarious activity in which a frictionless interface with a range of institutions and social groups becomes very important for effective functioning. The SFDs are already working in coordination with the FSI for past many years. Forest fires of disastrous proportions already come under the purview of the National Disaster Management Authority (NDMA) and the Disaster Management Authorities at the state and district levels and institutional mechanisms for combating forest fires at disaster scale has already been formalized for incorporation in the National, State, and District level disaster management plans. Institutionalization of close coordination with relevant institutions is thus already a reality but it needs to be strengthened further. For this purpose there are existing procedures developed by the DMAs at all levels and the SFDs may take urgent steps to update, upgrade and integrate their systems with those of the DMAs.

In addition, the following steps may be taken by the SFDs.

Action Points	Strategy	Responsibility
Coordination with Other Agencies	i. Functioning of the Crisis Management Groups for Forest Fires at all levels may be reviewed to ensure that Standard Operating Procedures (SOPs) are in place related to command and control, compilation of availability of extent and location of resources required in case of occurrence of fires and for monitoring its spread. ii. Organizing mock drills is a very efficient way of ensuring preparedness. MoEFCC and NDMA may provide guidance for action at the state level. Joint trainings and mock exercises with all relevant agencies may be organized to facilitate coordination during a fire event.	Tribal Welfare Departments Forest Department Forest Survey of India Tribal Research Institute National Disaster Management Authority (NDMA) Disaster Management Authorities at the state and district levels

6.7 Mobilization of Financial resources:

Forest fires pose the foremost threat to India's forests and the threat is projected to become more serious with the changing climate. Therefore, emphasis on the adequate protection of existing forest resources from fire hazards should become high priority attracting adequate funding. Specifically,

i. The SFDs should make sufficient financial resources available at district, range and local level well in advance of fire season with enough imprest money for ensuring that lack of money does not hamper emergent fire management works.
ii. While budgetary allocations for fire protection must be earmarked it should be possible to make fire protection integral to many other programs of forest protection. Community development works and entry point activities in forest enclosures and fringes could develop fire protection arrangements on the borders of habitations.
iii. Climate funds under existing global bilateral or multilateral mechanisms for activities leading to adaptation to the changing climate can be a good source for money and must be accessed.
iv. For promotion of use of Information and Communication Technology (ICT) standing instructions are already in place for mandatory use of a minimum 20 proportion of total sectoral allocation in ICT in the respective sector. This should be made use of for ICT part of the forest fire detection and protection activities.
v. MGNREGA and community development/welfare programs aimed at generating employment through creation of assets with labour intensive activities are a good source of funding for some aspects of forest fire protection and should be made use of.
vi. Community Forest Rights have been recognized in forests under The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. The Act also empowers the right holders to sustainably use the resources under the community forest rights thus recognized. Activities related to sustainable use of community right forests must also include protection of such areas from overuse and destruction by disasters like fire also. For this purpose Forest Administration needs to come to assist the stakeholder communities in planning and managing the community rights areas on priority. As the areas under community rights are expected to experience regular human presence, vulnerability to fire hazard is high and is needed to be minimized.
vii. India has technical cooperation arrangements with several countries where technical and financial assistance can be tapped for augmenting forest fire management capabilities. External financial aid should be accessed for investment on infrastructure for this purpose.
viii. In the large infrastructure projects particularly river valley projects, Environmental Management Plans and Catchment Area Treatment Plans are mandatorily prepared and implemented at the cost of the user agencies. Such activities can be very useful in augmenting moisture retention capacity of the catchments thus minimizing fire hazards.
ix. Crowd Funding is a popular means of financial resource mobilization for any common cause where interested people can contribute. Environmental causes like forest fire protection can garner enormous support from public. Local community organizations working in vicinity of vulnerable forests can thus be encouraged to organize crowd funding for work at community level. This could be particularly effective in and around areas of tourist, cultural or religious significance located near or within forests etc.

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Annexure I

Diagnostic Study on Forest Fire in the TSP Areas of Madhya Pradesh and Odisha

Questionnaire for Range Forest Officer

Name of the Circle:	
Name of the Division:	
Name of the Range:	
District:	
State:	
Name:	
Contact No:	

1. From how long you are posted in this forest area?

2. How frequently the forest fire occurred here? Please specify the time period?

3. Whether fire alert messaging system operational in your area?

4. After getting message of fire incidences, how fast our fire-fighting team arrives on the spot?

5. Whether every fire incidence is reported and preliminary offence report is registered.

6. What are the possible causes of forest fire you have reported?

a. Gathering any non-timber forest products (NTFPs)

b. Ritual fulfilment

c. To Cultivate

d. Any other means

7. What damage caused to this forest area due to forest fire?

8. Do you think, due to forest fire, the amount of NTFP collection has gradually been decreased?

9. If yes, which NTFPs are no more found here?

10. What is your role & responsibility in controlling the forest fire? How JFMc are helpful.

11. Were there any delays and shortages of funding last year that prevented fire watchers from being paid infull and on time?

Please suggest some measures to stop forest fire in this area?

Diagnostic Study on Forest Fire in the TSP Areas of Madhya Pradesh and Odisha

Questionnaire for the Forest Guard

Name of the Circle:	
Name of the Division:	
Name of the Range:	
Name of the Beat:	
Name of the Compartment	
District:	
State:	
Name:	
Contact No:	

12. From how long you are posted in this forest area?

13. How frequently the forest fire occurred here? Please specify the time period?

14. What are the possible causes of forest fire you have reported?

e. Gathering any non-timber forest products (NTFPs)

f. Ritual fulfilment

g. To Cultivate

h. Any other means

15. What damage caused to this forest area due to forest fire?

16. How you fight against forest fire.

a.
b.
c.
d.
e.
f.
g

17. Do you find any challenges in fire frightening?

a. Unable to say/I don't know
b. Fire watchers needed
c. More fire-safety equipment's needed
d. More Fire-Battle equipment's needed
e. More training needed on fire control measures
d. Awareness to the Community/villagers

18. Do you think, due to forest fire, the amount of NTFP collection has gradually been decreased?

19. If yes, which NTFPs are no more found here?

20. What is your role & responsibility in controlling the forest fire? How JFMc are helpful.

21. Please suggest some measures to stop forest fire in this area?

Schedule for Forest Dwellers

A) General Information

1. Name of the Village: ……..……..
   Name of GP……..
   Name of Block: ……..
   District: ……..
   Name of the respondent: ……. Age…..……
Sex…….
   Contact No of the respondent……..
2. Are you a member of any local forest-committee?
   If yes,

a) The name of the committee……

b) The role you play in that committee……..

B. Social Characteristics

3. Name of the Head of Household: _____
   Religion: ……..
   Caste/Tribe: SC-1, ST-2, OBC-3, General-4
   Sub Caste/ Sub Tribe (Specify): ……..
   Number of family members Total: Male…….. Female……
   Type of Family: Joint-1 Nuclear-2 Extended -3
   Economic Category: BPL APL Others

C. Economic condition

4. What is your occupation?
   Primary Occupation

   Secondary Occupation

   Other Occupation
5. Dependency on forest

a) Do you visit forest for benefits? (Yes / No)

If yes, state the benefits…

(1. Grazing 2. NTFP 3. Fuel Wood 4. Fodder 5. Sand, Soil, Boulders, 6. Other- Specify----------
----------)

6. Annual Income details (Rs.)

a) Income from Forestry

b) Agriculture & other source

D. NTFP questions.

7. Do your family members collect forest products (NTFP) from nearby forests?
   If yes, please specify the name of the NTFPs and quantity they collect.
   Types of NTFP

SL. No	Name	Parts Used	Quantity Collected (Unit) 5 Yrs before	No of Household members of involved 5 Yrs before	Distance Travelled 5 Yrs before	Quantity Collected (Unit) present	No of Household members of involved present	Distance Travelled present

8. NTFP assessment table.

Sl.No	Seasons	NTFP	Parts	Vol. (KG)	Own consumption (KG)	Selling purpose (KG)	Price in the Market (Rs.)
1	Winter (Sept-Feb)						
2	Summer (March-June)						
3	Rainy (July-Sept.)						
5	Total						

E. Forest-Fire Involvement

8. According to you causes of forest-fire in your area,

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9. Are you a member of Forest-fire squad?

Yes No

10. Have you ever tried/involved in extinguishing the forest fire?

Yes No

11. If yes, what is the method of extinguishing fire? ----------
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12. Did your livelihood ever been affected by forest-fire? Yes No

If yes, what is the nature of loss?

a) Goods----------(Fodder, NTFP, Habitat, Fuel Wood, Cultivated Crops)
b) Services……...(Water Quality, Pollinators, Air Quality)
c) Health……..(physical injured, internal disease, death)
d) If yes, how much?

Not-much Highly Medium Low

13. Monetary loss evaluation

a. less than Rs.2000

b. Between Rs.2000-500

c. Between Rs.5000-10000

d. Above Rs. 10,000

F) View regarding Forest-fire

14. Do you think forest fire is good?

Yes No can't say

15. if yes, how it can be managed? Suggest a measure to control the forest-fire.

PLOT ENUMERATION FORM

Division_____Range_Compartment_Plot No._____

Latitude	Longitude	Physiography*[a]	Type of forest*[b]	Remark
*[a] 1- Plain land; 2- Sloppy land; 3- Valley; 4- Plateau; 5- River/ water body buffer; 6: Denuded; 7: Rocky outcrop; 8: Others				
*[b] 1-Natural Forest; 2- Plantation; 3 – Tree cover outside forest; 4. Community grazing land; 5. Others				

Date of Survey_____

General observations

Distance from the settlement and name of the settlement:__(Kms)

Site Quality:----------

Age Class: Young……. Middle Mature

Slope Characteristics: 1. Steep slope; 2. Moderate; 3. Slight; 4. Flat land

Soil: Depth 1-Shalow; 2- Moderately deep, 3- Deep, 4- rocky Texture:

Erosion category: 1- 25% of the 'A' layer lost; 2 – 50-75% of the A layer lost and 25% of the 'B' layer lost; 3- Absence of 'A' layer and 50 or more of B layer lost; 4- C layer only present along with few exposures of D layer; 5- 100% A layer and Humus present

Fire incidences: 1- No fire incidence; 2 – leaf litter and other fallen burnt; 3 – fire affected the seedlings and saplings; 4 – fire affected barks/ stem; 5- fire affected the crown/ canopy

Incidents of grazing: Yes/ No

Incidence of felling: 1- No felling; 2- Illicit felling; 3- legal felling; 4- wind; 5-Pest and disease; 6 – Other (Specify)

NTFP and fuelwood collection:

Fodder (grass and leaf) collection	Fuelwood collection	Tendu patta	Gum and resin collection
Fruit	Bamboo collection	Flower Tuber/ rhizome	Bark
Fiber and flosses	Pattal (leaf)	Herbs/ medicinal plants	Stone (mining)
Soil (mining)	Honey	Others (specify)	

List of Medicinal Plants

Tree enumeration form Sample Plot Size (m) 20 x 20 m Plot no._____

Sl. No. of the tree	Species Name (local/ English)	Circumference at DBH (cm)	Tree Height (m)	Crown Width (m) Average of 3 readings	Status*

*Status – 1- Dead/ dry; 2- Healthy 3- Deformation/ infected; 4- Plus tree; 5 – fallen/tilt/ slanting; 6: Others Specify

PLOT ENUMERATION FORM FOR SEEDLINGS/ SAPLINGS

Sl. No.	Sample plot No.	Plot size: 2 x 2 m
Lat:___ Long:_		

Sl. No.	Species Name (Local and English)	Collar girth (cm)	Height (m)	Origin*	Representative (Yes/ No)	Remark

Sl. No.	Sample plot No.	Plot size: 2 x 2 m
Lat:___ Long:_		

Sl. No.	Species Name (Local and English)	Collar girth (cm)	Height (m)	Origin*	Representative (Yes/ No)	Remark

Sl. No.	Sample plot No.	Plot size: 2 x 2 m
Lat:___ Long:_		

Sl. No.	Species Name (Local and English)	Collar girth (cm)	Height (m)	Origin*	Representative (Yes/ No)	Remark

Sl. No.	Sample plot No.	Plot size: 2 x 2 m
Lat:___ Long:_		

Sl. No.	Species Name (Local and English)	Collar girth (cm)	Height (m)	Origin*	Representative (Yes/ No)	Remark

Sl. No.	Sample plot No.	Plot size: 2 x 2 m
Lat:___ Long:_		

Sl. No.	Species Name (Local and English)	Collar girth (cm)	Height (m)	Origin*	Representative (Yes/ No)	Remark

*Origin: 1. Root stock; 2. Coppice; 3. Seeds; 4. Planted 5. Others (Specify

Glossary of Local and Scientific Names

Common Name	Latin Nme
Ach	*Morinda tinctoria*
Achu	*Morinda tinctoria*
Ahsing	*Grewia tiliaefolia*
Ainta	*Helicteres isora*
Alcosi	*Mucuna purita*
Alkir	*Smilax parviflora* (Syn. *Smilax macrophylla*)
Am	*Mangifera indica*
Amboo	*Spondias mangifera*
Ambura	*Spondias mangifera*
Amla	*Emblica officinalis (*Syn. *Phyllanthus emblica)*
Amra	*Spondias mangifera*
Amti	*Antidesma diandrum*
Ankol or Akola	*Alangium lamarckii*
Ankula	
Aonla	*Emblica officinalis*
Arar	*Acacia pennata*
Arjun	*Terminalia arjuna*
Arrowroot	*Maranta arundinacea*
Asan	*Terminalia tomentosa*
Ashok	*Sarraca indica*
Asparagus	*Asparagus racemosus*
Aswagandha	*Withenia somnifera*
Baborang	*Embelia robusta* (Syn. *Antidesma ghaesembilla*)
Babul	*Acacia nilotia*
Ba-chom	*Eulaliopsis binata*
Baghanakhi	
Bahada	*Terminalia bellerica*
Bahera	*Terminalia bellerica*
Baibirang	*Emebelia trjeriam-cottam* (Syn. *Embelia robusta*)Baigoba
Bair	*Zizyphus jujuba*
Bakain	*Melia azadirachta*
Bamboo	*Dendrocalamus strictus*
Ban tulsi	*Erantemum pulchellum*Bans (salia bans), *Dendrocalamus strictus*Bar *Ficus bengalensis*
Bara bans	*Bambusa arundinacea*
Baranga	*Kydia calycina*
Barhar, Dahu	*Artocarpus lakoocha*
Barjono	*Thysanolaena agrostis*
Bel	*Aegla marmelos*

Belonjan	*Cordia macleodii*
Ber	*Zizyphus jujuba*
Bhant	*Clerodendron infortunatum*
Bhelwa	*Semecarpus anacardium*
Bhurkun	*Hymenodictyon excelsum*
Bhurkund	*Hymenodictyon excelsum*
Bia	*Pterocarpus marsupium*
Bija	*Pterocarpus marsupium*
Bis tendu	*Diospyros montana*
Bondarlauri	*Cassia fistula*
Broom grass	*Thysanolaena agrostis*
Buru-sanga	*Dioscorea sp*
Cashew nut	*Anacardium occidentale*
Champa	*Michelia champaca*
Chandra	*Rauwolfia serpentina*
Char	*Buchanania latifolia*
Chatavan	*Alstonia scholaris*
Chatni	*Alstonia scholaris*
Chilbil	*Holoptelia integrifolia*
Chilla or Reri	*Casearia graveolens*
Chiraita	*Swertia pulchella*
Chireita	*Casia tora*
Chironzi	*Buchanania latifolia* (Syn. *B. lanzan*)
Churanth	*Heteropogon contortus*
Churchu or Beri	*Casearia tomentosa*
Dadki	*Woodfordia fruticosa*
Dahu	*Artocarpus lakoocha*
Dathora	*Zizyphus oenoplea*
Dau	*Artocarpus lakoocha*
Dekamali	*Gardenia gummefera*
Detranga	*Ehretia leavis*
Dhadhki	*Woodfordia fruticosa* (Syn. *W. floribunda*)
Dhak	*Butea frondosa* (Syn. *B. monopserma)*
Dhaman	*Grewia tiliaefolia*
Dhanta	*Anogeissus latifolia*
Dhao	*Anogeissus latifolia*
Dhatki	*Woodfordia fruticosa*
Dhaura	*Anogeissus latifolia*
Dhawai	*Woodfordia fruticosa*
Doka	*Lannea grandis*
Edel	*Salmalia malabaricum*
Eri	

Gaj	*Milletia auriculata*
Galgal	*Cochlospermum gossypium*
Galphuli	*Flemingia chappar*
Gamhar	*Gmelina arborea*
Gara-hatna	*Terminalia arjuna*
Gende	*Type of mushroom*
Genthi-kand	*Dioscorea wallichii*
Ghanto	*Schrebera swietenioides*
Giliri	*Indigofera cassioides*
Gilla	*Caesalpinea crista*
Ginjan	*Lannea grandis*
Harida	*Terminalia chebula*
Harra,	*Terminalia chebula*
Harsinghar	*Nyctanthes arbortristis*
Hathipanjan	*Oroxylum indicum*
Hatna	*Terminalia tomentosa*
Hutar	*Indigofera pulchella*
Hutid	*Lagerstroemia flosreginas*
Icha	*Woodfordia fruticosa*
Imli	*Tamarindus indica*
Indrajab	*Holarhena antidysentrica*
Jackfruit	*Artocarpus integra*
Jamun	*Syzygium cuminii*
Janumjan	*Zizyphus jujuba*
Jarul	*Lagerstroemia flosreginas*
Jharu	*Thysanolaena agrostis*
Jhingan	*Lannea grandis*
Jirhul	*Indigofera pulchella*
Jojo	*Tamarindus indica*
Kachnar	*Bauhinia variegata*
Kadam	*Anthocephalus cadamba*
Kadamba	*Anthocephalus cadamba*
Kahua	*Terminalia arjuna*
Kaim	*Mitragyna parviflora*
Kala shisham	*Dalbergia latifolia*
Kalmegh	*Andragaphis paniculata*
Kalminkeram	*Mitragyna parviflora*
Kamini	*Murraya exotica*
Kamala	*Mallotus philippinensis*
Kanla	*Bauhinia retusa*
Kantar	*Artocarpus integrfolia*
Karam	*Adina cordifolia*

Karanj	*Pongamia glabra, P pinnata*
Karaya	*Sterculia ureus*
Karhhai	*Bauhinia variegata*
Kari	*Miluta velutina*
Karkatta	*Zizipyus xylopyra*
Karunda	*Carissa spinrum*
Kasmar	*Gmelina arborea*
Katahi	*Flacourtia ramontichii*
Katai	*Vangueria pubescens*
Katangai	*Cedrela toona*
Kathal	*Artocarpus integrfolia*
Kathber	*Zizipyus xylopyra*
Kekar	*Garuga pinnata*
Kend	*Diospyros melanoxylon*
Kendu	*Diospyros melanoxylon*
Keonjhi	*Sterculia urens*
Kessai	*Bridelia retusa*
Khaira	*Acacia catechu*
Khajur	*Phoenix acaulis*
Khejur	*Phoenix acaulis*
Khukri	*mushrooms*
Kia-chalon	*Albizzia odoratissima*
Kiri	*Dalbergia latifolia*
Kishkochali	*Bridelia retusa*
Koinar	*Bauhinia purpurea*
Koingata-mata	*Embelia robusta*
Koraia	*Hollarhena antidysenterica*
Koreya	*Hollarhena antidysenterica*
Koronjo	*Pongamia pinnata*
Kotor	*Symplocos racemosa*
Kudmi	*Polyalthia cerasiooides*
Kujri	*Celastrus pamiculata*
Kula-marasal	*Clerodendron infortunatum*
Kumbhui	*Careya arborea*
Kumumung	*Alstonia scholaris*
Kurchi	*Hollarhena antidysenterica*
Kusum	*Schleichera trijuga* (Syn. *S. oleorosa*)
Kuti	*Croton oblongifolius*
Lasarura	*Cordia myxa*
Lodh	*Symplocos racemosa*
Lodha	*Symplocos racemosa*
Lohagasi	*Aegla marmelos*

Lohajangia	*Ixora parviflora*
Ludam	*Symplocos racemosa*
Lupung	*Terminalia bellerica*
Madhbilata	*Combretum decandrum*
Madhcom	*Madhuca latifolia*
Mahua	*Madhuca latifolia* (Syn. *Basia latifolia*)
Mahul	*Madhuca latifolia*
Mahulan	*Bauhinia vahlii*
Mainphal	*Randia dumetorum*
Makar tendu	*Diospyios embryopteris*
Maljhan	*Bauhinia vahlii*
Malkamini	*Celastrus paniculata*
Mango	*Mangifera indica*
Marking nut	*Semecarpus anacardium*
Masia kanda	*Dioscorea spp.*
Matasura	*Antidesma diandrum*
Maula	*Butea parviflora* (Syn. *Spatholobus roxburghii*)
Maulana	*Bauhinia vahlii*
Medha	*Litsea glutinosa*
Meral	*Emblica officinalis*
Moraba	*Agave spp*
Moraphal	*Helicteres isora*
Morud	*Butea frondosa* (Syn. *B. monopserma*)Muga
Mulberry	*Morus nigra*
Murabba	*Agave spp*
Murur	*Butea frondosa* (Syn *B. monopserma*)
Nanam	*Lannea grandis*
Neem	*Azadirachita indica*
Nux vomica	*Strychnos nuxvomica*
Oal	
Pader	*Stereospermum suaveolens*
Paiman	*Eugenia operculata*
Palas	*Butea frondosa* (Syn *B. monopserma*)
Pani-alu	*Diosorea oppositifolia*
Panjan	*Ougenia dalbergioides*
Papda	*Gardenia latifolia*
Patal garuda	*Rawolfia serpentina*
Patalkohra	*Rawolfia serpentina*
Pendi	
Perar	*Randia uliginosa*
Pesar	*Pterocarpus marsupium*
Phalandu	*Combretum decandrum*

Phansi	*Anogeissus acuminata*
Phenphena	*Oroxylon indicum*
Phuljhanu	*Thysanolaena agrostis*
Piar	*Buchania latifolia* (Syn. *B. lanzan*)
Piasal	*Pterocarpus marsupium*
Pipal	*Ficus religiosa*
Pipali	*Piper longum*
Pitalu	*Dioscorea wallichii*
Porho	*Ficus cunia*
Poroso	*Artocarpus integra*
Puffballs	*Lycoperdon spp*
Pula	*Kydia calycina*
Putri	*Croton oblongifolius*
Putus	*Lantana camara*
Ramdatwan	*Smilax parviflora* (Syn. *S. macrophylla*)
Ranu	*Rice beer herbs*
Ratangaura	*Elaeodendron glaucum*
Reri	*Caseara graveolens*
Ritha	*Sapindus mukorossy*
Rohini	*Mallotus philippinensis*
Rola	*Terminalia chebula*
Roli	*Mallotus philippinensis*
Rori	*Mallotus philippinensis*
Ruga	*Lycoperdon spp.*
Rurungnani	*Bauhinia vahlii*
Sabai	*Eulaliopsis binata*
Sakhua	*Shorea robusta*
Sal	*Shorea robusta*
Salai	*Boswellia serrata*
Salga (buru)	*Boswellia serrata*
Sandan	*Ougeinia dalbergioides*
Sanko	*Anthocephalus cadamba*
Saparom	*Nyctanthes arbortristis*
Sarjom	*Shorea robusta*
Sarpgandha	*Rauwolfia serpentina*
Satawar	*Asparagus racemosus*
Sauna	*Oroxylum indicum*
Sauri	*Heteropogon contortus*
Semal	*Bombax ceiba*
Semul	*Salmalia malabaricum*
Sharifa	*Annona squamosa*
Shekoky	*Acacia concina*

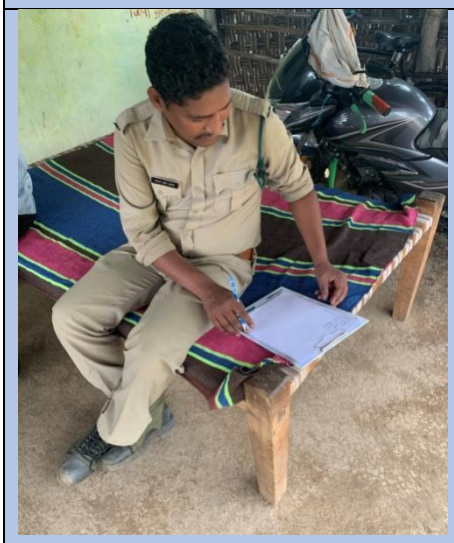
Shisum	*Dalbergia latifolia*
Siali	*Bauhinia valii*
Sidha	*Lagerstroemia parviflora*
Simuli cotton	*Bombax ceiba*
Sindhuri	*Mallotus philippinensis*
Sindwar	*Vitex negundo*
Singa	*Bauhinia purpurea*
Siris	*Albizzia odoratissima*
Siru	*Impereta arundinacea*
Sissoo	*Dalbergia sisoo*
Sona-chaal	*Oroxylum indicum*
Sonari	*Cassia fistula*
Soso	*Semecarpus anacardium*
Sunari	*Cassia fistula*
Tamarind	*Tamarindus indica*
Tamarind	*Tamarindus indica*
Tarob	*Buchanania latifolia* (Syn. *B. lanzan*)
Tassar	*Silk moth cocoons*
Tend	*Diospyros melanoxylon*
Tendu	*Diospyros melanoxylon*
Tewar	*Bauhinia retusa*
Thatch grass	*Heteropogon contortus*
Thingon	*Lannea grandis*
Tilia	*Wendlandia exsreta*
Tiril	*Diospyros melanoxylon*
Toon	*Cedrela toona*
Toot	
Turai-sing	*Cordia macleodii*
Uli	*Mangifera indica*
Ulu	*Impereta arundinacea*
Usangid-bo	*Sarraca indica*

Photo Gallery of Odisha

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>PI of Fire-Fighter, Vill.- Pahadpur, Rairangpur Div.</td><td>PI of Forest Dweller, Vill.- Chinasari, Rayagada Div.</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Interaction with VSS Members, Vill.- Raghunatpur, Rairangpur Div.</td><td>Awareness by Baliguda Forest Division, Vill.- Landgoan, Rayagada Div.</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>FGD, Vill.- Jambani, Rairangpur Div.</td><td>Interaction with Female VSS Members, Vill.- Bandhaguda</td></tr>
</table>

	
SCSTRTI research team with OUAT interns field visit, Beat –Tiring, Rairangpur Div.	Ecological Enumeration, Beat- Anagul, Baliguda Div.
	
Initiative taken during forest-fire, Vill.-Jambani, Rairangpur Div.	Fire watcher during forest fire, Vill.- Gambharia, Rairangpur Div.
	
Sal leaf Dona (Plate) Making, Vill.-Hantikhambha, Rayagada DIv	Ecological Enumeration, Beat- Daka, Rairangpur Div.

Photo Gallery Of Madhya Pradesh

	
PI of Forest Dweller, Vill.- Richikhedha, Khalwa Range	PI of a fire-Fighter, Mendhakheda, E Mandala
	
PI of a fire-Victim, Vill.- Hanumandol, N Betul	PI of Forest Dweller, Vill.- Bichiya, E Mandala
	
Questionnaire fill up, Vill.- Hanumandol, N	Interaction with Ranger, Vill.- Aanjania,

	
Forest Dweller with collected Summer-NTFP, Vill.- Semeria, E Mandala	Forest Dweller selling NTFP at village Hatt, Vill.- Bichhiya, E Mandala
	
FGD, Vill.- Jhilpa, N Betul	FGD, Vill.- Mendhakheda, N Betul
	
Post-Fire , Vill.- Darbara, E Mandala	Artificial fire to prevent forest-fire, Vill.-Rathipur, N Betul

Table 2.2 Forest Range/Beat selected for studies in, M.P.

Sr. No.	Division	Ranges	Frequency of Fire	Compartment No.	Fire Year	Fire incidence
1.	Khandwa	Khalwa	Low	836	2016, 2018	2
				827		
				833		
				831		
			Medium	814	2012, 2016, 2017, 2018, 2019,	5
				815		
				818		
				819		
			High	786	2011, 2012, 2013, 2014, 2016, 2017, 2018, 2019, 2020-21	9
				787		
				788		
				797		
2.	North Betul	Shahpur	Low	414	2012,2017, 2020-21	3
				413		
				194		
				225		
		Betul	Medium	274	2011, 2016, 2017, 2018, 2020-21	5
				275		
				276		
				285		
		Shahpur	High	210	2010, 2011, 2012, 2016, 2017, 2018, 2020-21	7
				211		
				213		
				240		
3	East Mandla	Jagmandal	Low	1494	2010, 2018, 2020-21	3
				1495		
				1496		
				1497		

		Motinala	Medium	1292 1295 1296 1297	2010, 2016, 2017, 2020-21	4
		Jagmandal And Bichhiya	High	1503 1512 1513 1522	2010, 2011, 2016, 2017, 2018, 2020-21	6
4	Control Khandwa	Khalwa	No fire	831 830B	NIL	0
5	Control North Betul	Shahpur	No Fire	241 239	NIL	0
6	Control East Mandla	Bichhiya	No Fire	1523 1524	NIL	0

Table 2.3 Forest Range/Beat selected for studies in Odisha

Sr. No	Division/District	Ranges	Frequency of Fire	Beat	Fire Year	Fire incidence
1.	Baliguda/ Khandmal	Baliguda	Low	Anagul	2010-11, 2017,2020-21	3
			Medium	Landagaon	2009-10,2011-12,2017,2018,2020-21	5
			High	Daka	200910,2011-12,2013,2014,2016,2017,2018,2020-21	8
2.	Rairangpur/ Mayurbhanj	Bahalda	Low	Tiring	2017,2020-21	2
			Medium	Bahalda	2013,2018,2020-21	3
			High	Manbir	2009-10,2016,2017,2018,2020-21	5
3	Raygada/ Raygada	Gunpur	Low	Hatikhamba	2017,2020-21	2
			Medium	Sikabadi	2011-12,2018,2020-21	3
			High	Chinasari	2009-10,2011-12,2013,2017,2020-21	5
4	Control Baliguda	NIL	NIL	NIL	NIL	0
5	Control Rairangpur	Rairangpur	No Fire	Ichinda	NIL	0
6	Control Raygada	Munguda	No Fire	Pokhari	NIL	0

GIS and Remote sensing - Parameters and Indicators

The parameters used for these studies are broadly classified into 3 categories, which are Remotely sensed data to know the frequency and extent of forest fire, Ecological parameters for biodiversity analysis and social parameters to know the causes, social structure and economical losses of forest-dependent communities, residing around the forest fringes, who are totally or partially dependent on Forest for their direct and indirect needs.

1) Remote Sensing Parameters

The remote Sensing technique is widely used in the field of research and other development programs. It provides an effective tool for analysis and systematic survey for the better management of natural resources (land, soil, water. Forest etc.). This technology is used in our study for selecting the area based on fire incidences over the years (10 years) and analysing several parameters based on our objectives to identify the pattern and extent of forest fire in the study area. The MODIS data provides the fire incidents, and MSS data provides information on the extent of a forest fire. The satellite data has been downloaded from the website and processed to generate land use/ land cover, NDVI (Normalized Difference Vegetation Index), SMI (Soil Moisture Index) and LST (Land Surface Temperature) of the study area.

a) **Normalised Differential Vegetation Index (NDVI):**

Multispectral remote sensing data techniques are used to find the vegetation index. The study used Landsat 8 satellite imagery, which is having 30m spatial resolution. For vegetation monitoring, NDVI layers have been used to perform multi-source classification. NDVI has been consistently used as an index to indicate vegetation health or the impacts of disturbances on vegetation. The higher value of NDVI signifies the integrity of vegetation cover, while the lower values denote the opposite trend (Kumar et al., 2018).

NDVI can be quantified by the following formula:

$$NDVI = NIR - R / NIR + R$$

Where NIR – Near Infra-Red; R – Red region of the spectral band.

Downloaded both season satellite images (Landsat 8) from the USGS site, for pre-fire, i.e., the second week of February data and for post-fire, downloaded the last week of May 2020 data. In Landsat 8, two bands

were used i.e., band 5 (NIR) and band 4 (Red). For computing the NDVI landsat8 satellite image following
the formula was used- **NDVI = (Band 5 – Band 4) / (Band 5 + Band 4)**

b) Land use land cover:

In the present study, a maximum likelihood classifier (MLC) algorithm was applied to satellite images (Landsat 8) for the period of pre and post-fire during the classification analysis. Based on MLC, this area was considered into ten pre-defined classes including agricultural land, barren land, a tree outside forest area, very dense forest, moderately dense forest, open canopy forest, scrubland, forest blank and water body (including lakes, pond, reservoir and rivers). The overall accuracy of the classification achieved is 8o% to 90%.

c) Land Surface Temperature (LST):

LST is the radiative temperature, which is calculated using the top of atmosphere brightness temperature, the wavelength of emitted radiance, and land surface emissivity. Land surface emissivity (LSE) is the average emissivity of an element of the surface of the Earth calculated from NDVI values. To analyse the land surface temperature (LST) using multi-temporal Landsat 8 Operational Land Imager OLI and Thermal Infrared Sensor (TIRS).

LST extraction from the thermal band:

Conversion of the digital number (DN) to spectral radiance (Lk) Every object emits thermal electromagnetic energy as its temperature is above absolute zero (K). Following this principle, the signals received by the thermal sensors can be converted to at-sensor radiance. The spectral radiance (Lk) is calculated using the following equation (Landsat Project Science Office, 2002).

(00003342* satellite image band 10 and 11+0.1)

Conversion of spectral radiance (Lk) to At-satellite brightness temperatures (TB): Corrections for emissivity (e) have been applied to the radiant temperatures according to the nature of the land cover. In general, vegetated areas have given a value of 0.95 and non-vegetated areas 0.92 (Nichol, 1994). The emissivity corrected surface temperature has been computed following Artis and Carnahan (1982).

Tb $=1321.0789/\ln(774.8853/radience+1)273.15$

Where: Tb = At-satellite brightness temperature

After the calculation of atmospheric brightness temperature, the next step will calculate the proportion of vegetation using NDVI values. The following formula will use to calculate the proportion of vegetation:

$$\boldsymbol{\rho_v = \left(\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right)^2}$$

After that, land surface emissivity will compute with the following formula $\mathbf{0.004}\times(\boldsymbol{Proportion\ of\ vegetation})+\mathbf{0.986}$

Land surface temperature (LST): The corrections for spectral emissivity (e) become necessary. These can be done according to the nature of land cover (Snyder et al., 1998) or by deriving corresponding emissivity values from the Normalized Differences Vegetation Index (NDVI) values for each pixel. The emissivity corrected land surface temperatures (St) will have been computed following Artis and Carnahan (1982).

$$\boldsymbol{LST = TB = ½1 + \{\left(\lambda * \frac{TB}{p}\right) * ln}\ €$$

Whereas, P= h*C/S = 1.438*10-2 mk
= 1438μm
“h” is plank const = 6.626*10-34
“C” is velocity of light = 2.998*108m/s
“S” is Boltzman const. = 1.38*10-23

λ Wavelength = 10.895

Table No. 1. List of Sampled Villages in Baliguda Forest Division of Odisha State

Division	SL. No	Village Name	Section	Category			Grand Total
			Category	ST	SC	OBC/GEN	
Baliguda Division	1	Anagula	Male	133	11	0	301
			Female	119	12	0	300
			Total population	252	23	0	601
			Household	149	4	0	153
	2	Muthiabali	Male	47	57	0	225
			Female	59	75	0	266
			Total population	106	132	0	491
			Household	51	85	0	136
	3	Daka	Male	148	7	188	343
			Female	163	10	127	300
			Total population	311	17	315	643
			Household	60	4	65	129
	4	Dampanga	Male	20	0	19	39
			Female	19	0	10	29
			Total population	39	0	29	68
			Household	9	0	5	14
	5	Mudiatundi	Male	162	69	369	600
			Female	142	72	361	575
			Total population	304	141	712	1157
			Household	100	80	115	295
	6	Salmapada	Male	88	14	7	109
			Female	92	11	8	111
			Total population	180	25	15	220
			Household	53	5	5	63

Table No. 2. List of Sampled Villages in Rairangpur Forest Division of Odisha State

Division	SL. No	Village Name	Section	Category			Grand Total
			Category	ST	SC	OBC/GEN	
Rairangpur Division	1	Raghunathpur	Male	209	14	19	242
			Female	224	13	22	259
			Total population	433	27	41	501
			Household	100	10	13	123
	2	Jambani	Male	213	12	1	226
			Female	182	14	3	199
			Total population	395	26	4	425
			Household	75	8	2	85
	3	Manbir	Male	616	42	293	951
			Female	699	42	314	1055
			Total population	1315	84	607	2006
			Household	300	17	130	447
	4	Jaganathpur	Male	248	0	30	278
			Female	278	0	31	309
			Total population	526	0	61	587
			Household	118	0	12	130
	5	Gambharia	Male	93	92	755	940
			Female	54	87	670	811
			Total population	147	179	1425	1751
			Household	36	48	385	469
	6	Pahadpur	Male	181	2	7	190
			Female	176	2	5	183
			Total population	357	4	12	373
			Household	74	2	3	79

Table No. 3. List of Sampled Villages in Rayagada Forest Division of Odisha State

Division	SL. No	Village Name	Section	Category			Grand Total
			Category	ST	SC	OBC/GEN	
Rayagada Division	1	Hatikhamba	Male	18	99	92	209
			Female	27	102	96	225
			Total population	45	201	188	434
			Household	6	61	45	112
	2	Chinasari	Male	31	48	40	119
			Female	23	44	68	135
			Total population	54	92	108	254
			Household	18	25	29	72
	3	Bandhaguda	Male	51	0	0	51
			Female	46	0	0	46
			Total population	97	0	0	97
			Household	23	0	0	23
	4	Gogupadu	Male	185	3	19	207
			Female	216	10	24	250
			Total population	401	13	43	457
			Household	99	3	12	114
	5	Sikabadi	Male	172	2	2	176
			Female	206	0	6	212
			Total population	378	2	8	388
			Household	88	1	2	91
	6	Bada Redhapal	Male	56	4	0	60
			Female	74	4	0	78
			Total population	130	2	0	132
			Household	35	1	0	36

Source – Aanganwadi Kendra, Odisha, 2022

Table No. 4. List of Sampled Villages of Betul division of Madhya Pradesh

Division	SL No	Village Name	Section	Category			Grand Total
			Category	ST	SC	OBC/GEN	
Betul	1	Khamalpur	Male	365	6	5	376
			Female	324	6	6	336
			Total population	689	12	11	712
			Household	135	3	3	141
	2	Teremal	Male	250	0	20	270
			Female	286	0	26	312
			Total population	536	0	46	582
			Household	91	0	9	100
	3	Pawawadi	Male	373	0	33	406
			Female	365	0	32	397
			Total population	738	0	65	803
			Household	135	0	5	140
	4	Jhilipa	Male	273	114	95	482
			Female	257	110	82	449
			Total population	530	224	177	931
			Household	160	44	20	224
	5	Mendhakhada	Male	273	114	95	482
			Female	257	110	82	449
			Total population	530	224	177	931
			Household	110	80	34	224
	6	Rathipur	Male	142	88	286	516
			Female	152	76	248	476
			Total population	294	164	534	992
			Household	60	44	110	214

Table No. 5. List of Sampled Villages of Khandawa division of Madhya Pradesh

Division	SL No	Village Name	Section	Category			Grand Total
			Category	ST	SC	OBC/GEN	
Khandwa	1	Khari	Male	365	401	0	766
			Female	355	380	0	735
			Total population	720	781	0	1501
			Household	130	100	0	230
	2	Karawani	Male	402	6	0	408
			Female	480	3	0	483
			Total population	882	9	0	891
			Household	167	3	0	170
	3	Sundardev	Male	579	2	19	600
			Female	632	3	18	653
			Total population	1211	5	37	1253
			Household	113	2	7	122
	4	Nagotar	Male	547	0	0	547
			Female	522	0	0	522
			Total population	1069	0	0	1069
			Household	162	0	0	162
	5	Kumarkheda	Male	372	0	7	379
			Female	360	0	5	365
			Total population	732	0	12	744
			Household	217	0	4	221
	6	Adakheda	Male	248	0	30	278
			Female	278	0	31	309
			Total population	526	0	61	587
			Household	118	0	12	130

Table No. 6. List of Sampled Villages of Mandla division of Madhya Pradesh

Division	SL No	Village Name	Section	Category			Grand Total
			Category	ST	SC	OBC/GEN	
Mandala	1	Julup	Male	95	0	100	195
			Female	100	0	80	180
			Total population	195	0	180	375
			Household	95	0	50	145
	2	Bariha	Male	105	0	435	540
			Female	141	0	449	590
			Total population	246	0	884	1130
			Household	76	0	180	256
	3	Darabara	Male	130	0	0	130
			Female	139	0	0	139
			Total population	269	0	0	269
			Household	59	0	0	59
	4	Semeria	Male	239	0	0	239
			Female	265	0	0	265
			Total population	504	0	0	504
			Household	113	0	0	113
	5	Sahajpani	Male	177	0	0	297
			Female	167	0	0	282
			Total population	344	0	0	579
			Household	0	0	0	157
	6	Dalakagopangi	Male	305	5	178	488
			Female	349	9	172	530
			Total population	654	14	350	1018
			Household	190	4	76	270

Source – Aanganwadi Kendra, Madhya Pradesh, 2022

Socio-economic Tables

Table no.1 Age classification of Forest Dwellers

SL.No	States	Divisions	Forest Dweller	Age below 18	Age Between 19-30	Age Between 31-60	Age Above 60	Total Participants
1	Odisha	Rairangpur	Number	4	50	5	1	60
		%	%	6.7%	83.3%	8.3%	1.7%	100%
		Baliguda	Number	4	54	2	0	60
		%	%	6.7%	90.0%	3.3%	0.0%	100%
		Rayagada	Number	3	43	13	1	60
		%	%	5.0%	71.7%	21.7%	1.7%	100%
		Grand Total Odisha	Number	**11**	**147**	**20**	**2**	180
			%	**6.1%**	**81.7%**	**11.1%**	**1.1%**	50%
			Number	**180**	**180**	**180**	**180**	360
			%	**100%**	**100%**	**100%**	**100%**	100%
2	Madhya Pradesh	Betul	Number	1	50	8	1	60
		%	%	1.7%	83.3%	13.3%	1.7%	100%
		Khandwa	Number	4	33	21	2	60
		%	%	6.7%	55.0%	35.0%	3.3%	100%
		Mandla	Number	4	11	44	1	60
		%	%	6.7%	18.3%	73.3%	1.7%	100%
		Grand Total Madhya Pradesh	Number	**9**	**94**	**73**	**4**	180
			%	**5.0%**	**52.2%**	**40.6%**	**2.2%**	50%
			Number	180	180	180	180	360
			%	100%	100%	100%	100%	100%
3	**Participants**		**Grand Total**	**20**	**241**	**93**	**6**	360
			%	**5.6%**	**66.9%**	**25.8%**	**1.7%**	100%
	Total Study Sample		**Grand Total**	360	360	360	360	360
			%	100%	100%	100%	100%	100%

Source – Field Survey, SCSTRTI, 2022

Table No- .2. caste classification of forest dwellers

SL.No	States	Divisions	Forest Dweller	SC	ST	General	OBC	Total Participants
1	Odisha	Baliguda	Number	2	22	27	9	60
		%	%	3.3%	36.7%	45.0%	15.0%	100%
		Rairangpur	Number	1	51	3	5	60
		%	%	1.7%	85.0%	5.0%	8.3%	100%
		Rayagada	Number	0	54	6	0	60
		%	%	0.0%	90.0%	10.0%	0.0%	100%
		Grand Total Odisha	Number	3	**127**	**36**	14	180
			%	1.7%	**70.6%**	**20.0%**	7.8%	50%
			Number	180	180	180	180	360
			%	100%	100%	100%	100%	100%
2	Madhya Pradesh	Betul	Number	3	49	8	0	60
		%	%	5.0%	81.7%	13.3%	0.0%	100%
		Khandwa	Number	0	56	3	1	60
		%	%	0.0%	93.3%	5.0%	1.7%	100%
		Mandla	Number	0	43	17	0	60
		%	%	0.0%	71.7%	28.3%	0.0%	100%
		Grand Total Madhya Pradesh	Number	**3**	**148**	**28**	**1**	180
			%	**1.7%**	**82.2%**	**15.6%**	**0.6%**	50%
			Number	180	180	180	180	360
			%	100%	100%	100%	100%	100%
3	**Participants**		**Grand Total**	**6**	**275**	**64**	15	360
			%	**1.7%**	**76.4%**	**17.8%**	4.2%	100%
	Total Study Sample		**Grand Total**	360	360	360	360	360
			%	100%	100%	100%	100%	100%

Source- Field Survey, SCSTRTI, 2022

Table No-3. Tribal classification of forest dwellers

SL.No	States	Divisions	Tribal Forest Dweller	Bhunjia	Hoo	Kandha	Kolha	Munda	Saora (PVTG)	Santal	Paraja	Dongria Kondh (PVTG)	Total participants
1	Odisha	Baliguda	Number	0	0	22	0	0	0	0	0	0	60
		%	%	0.0%	0.0%	36.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
		Rairangpur	Number	1	6	0	21	2	0	21	21	21	60
		%	%	1.7%	10.0%	0.0%	35.0%	3.3%	0.0%	35.0%	35.0%	35.0%	100%
		Rayagada	Number	0	0	34	0	0	12	2	0	0	60
		%	%	0.0%	0.0%	56.7%	0.0%	0.0%	20.0%	3.3%	0.0%	0.0%	100%
		Grand Total Odisha	Number	1	6	**56**	**21**	2	12	23	21	21	180
			%	0.6%	3.3%	**31.1%**	**11.7%**	1.1%	6.7%	12.8%	11.7%	11.7%	50%
			Number	180	180	180	180	180	180	180	180	180	180
			%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SL.No	**States**	**Divisions**	**Tribal Forest Dweller**	**Barela**	**Bhilala**	**Gond**	**Gual**	**Korku**	**Panika**	**Tatia**	**Bhil**	**Baiga (PVTG)**	
1	Madhya Pradesh	Betul	Number	0	0	39	1	12	0	0	0	0	60
		%	%	0.0%	0.0%	65.0%	1.7%	20.0%	0.0%	0.0%	0.0%	0.0%	100%
		Khandwa	Number	0	13	3	0	38	0	1	1	0	60
		%	%	0.0%	21.7%	5.0%	0.0%	63.3%	0.0%	1.7%	1.7%	0.0%	100%
		Mandla	Number	1	0	41	0	0	2	0	0	2	180
		%	%	1.7%	0.0%	68.3%	0.0%	0.0%	3.3%	0.0%	0.0%	3.3%	100%
		Grand Total Madhya Pradesh	Number	1	13	**83**	1	**50**	2	1	1	2	180
			%	0.6%	7.2%	**46.1%**	0.6%	**27.8%**	1.1%	0.6%	0.6%	1.1%	50%
			Number	180	180	180	180	180	180	180	180	180	360
			%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source- Field Survey, SCSTRTI, 2022

Table No – 4. Family types and economic classification

SL. No	States	Divisions	Forest Dweller	Type of family					Economic cetagory				
				Joint	Nuclear	Extended	Total participants		BPL	APL	Antordaya	Total participants	
1	Odisha	Rairangpur	Number	19	36	5	60	Odisha	50	9	0	60	
		%	%	31.7 %	60.0%	8.3%	100%		83.3 %	15.0 %	0.0%	100%	
		Baliguda	Number	29	27	4	60		53	6	1	60	
		%	%	48.3 %	45.0%	6.7%	100%		88.3 %	10.0 %	1.7%	100%	
		Rayagada	Number	22	30	8	60		44	16	1	60	
		%	%	36.7 %	50.0%	13.3%	100%		73.3 %	26.7 %	1.7%	100%	
		Grand Total Odisha	Number	70	**93**	17	180		**147**	31	2	180	
			%	38.9 %	**51.7%**	9.4%	100%		**81.7 %**	17.2 %	3.3%	50%	
			Number	180	180	180	360		180	180	180	360	
			%	100%	100%	100%	100%		100%	100%	300.0%	100%	
2	Madhya Pradesh	Betul	Number	30	30	0	60	Madhya Pradesh	54	5	0	60	
		%	%	50.0 %	50.0%	0.0%	100%		90.0 %	8.3%	0.0%	100%	
		Khandwa	Number	36	19	5	60		56	4	0	60	
		%	%	60.0 %	31.7%	8.3%	100%		93.3 %	6.7%	0.0%	100%	
		Mandla	Number	24	27	9	60		47	12	1	60	
		%	%	40.0 %	45.0%	15.0%	100%		78.3 %	20.0 %	1.7%	100%	
		Grand Total Madhya Pradesh	Number	**90**	**76**	14	180		**157**	21	2	180	
			%	**50.0 %**	**42.2%**	7.8%	100%		**87.2 %**	11.7 %	3.3%	50%	
			Number	180	180	180	360		180	180	180	360	
			%	100%	100%	100%	100%		100%	100%	300.0%	100%	
3	**Total VSS Participants**		**Grand Total**	**160**	**169**	31	360	Total	**304**	52	4	360	
			%	**44.4 %**	**46.9%**	8.6%	100%		**84.4 %**	14.4 %	6.7%	100%	
	Total Study Sample		**Grand Total**	360	360	360	360		360	360	360	360	
			%	100%	100%	100%	100%		100%	100%	600.0%	100%	

Source- Field Survey, SCSTRTI, 2022

Table no – 5. Occupational classification of the Participants

SL.No	States	Divisions	Forest Dweller	Primary Occupation			Secondary Occupation		
				Forest Dweller	Agricultural Labour/Farmer	Wage Labour / Self Employed	Forest Dweller	Agricultural Labour/Farmer	Wage Labour / Self Employed
1	Odisha	Rairangpur	Number	32	27	1	16	35	9
		%	%	53.3%	45.0%	1.7%	26.7%	58.3%	15.0%
		Baliguda	Number	26	33	1	9	44	7
		%	%	43.3%	55.0%	1.7%	15.0%	73.3%	11.7%
		Rayagada	Number	33	18	9	23	28	9
		%	%	55.0%	30.0%	15.0%	38.3%	46.7%	15.0%
		Grand Total Odisha	Number	**91**	**78**	11	**48**	**107**	25
			%	**50.6%**	**43.3%**	6.1%	**26.7%**	**59.4%**	13.9%
			Number	180	180	180	180	180	180
			%	100%	100%	100%	100%	100%	50%
2	Madhya Pradesh	Betul	Number	15	30	15	16	35	9
		%	%	25.0%	50.0%	25.0%	26.7%	58.3%	15.0%
		Khandwa	Number	16	28	16	16	38	6
		%	%	26.7%	46.7%	26.7%	26.7%	63.3%	10.0%
		Mandla	Number	17	30	13	19	32	7
		%	%	28.3%	50.0%	21.7%	31.7%	53.3%	11.7%
		Grand Total Madhya Pradesh	Number	**48**	**88**	44	**51**	**105**	22
			%	**26.7%**	**48.9%**	24.4%	**28.3%**	**58.3%**	12.2%
			Number	180	180	180	180	180	180
			%	100%	100%	100%	100%	100%	50%
3	**Total VSS Participants**		**Grand Total**	**139**	**166**	**55**	**99**	**212**	**47**
			%	**39%**	**46.1%**	**15.3%**	**27.5%**	**58.9%**	**13.1%**
	Total Study Sample		**Grand Total**	360	360	360	361	362	363
			%	100%	100%	100%	100%	100%	100%

Source – Field survey, SCSTRTI, 2022

Table No 6. Reasons behind visiting the forest

SL.No	States	Divisions	Forest Dweller	Reasons behind Visiting the forest					
				Grazing	NTFP collection	Fodder	Sand & Soil	Stones	Total participants
1	Odisha	Rairangpur	Number	44	60	47	19	15	60
		%	%	73.3%	100.0%	78.3%	31.7%	25.0%	100%
		Baliguda	Number	30	55	18	10	9	60
		%	%	50.0%	91.7%	30.0%	16.7%	15.0%	100%
		Rayagada	Number	45	60	55	21	20	60
		%	%	75.0%	100.0%	91.7%	35.0%	33.3%	100%
		Grand Total Odisha	Number	119	**175**	120	50	44	180
			%	66.1%	**97.2%**	66.7%	27.8%	24.4%	100%
			Number	180	180	180	180	180	180
			%	100%	100%	100%	100%	100%	50%
2	Madhya Pradesh	Betul	Number	53	60	59	52	28	60
		%	%	88.3%	100.0%	98.3%	86.7%	46.7%	100%
		Khandwa	Number	51	60	53	47	34	60
		%	%	85.0%	100.0%	88.3%	78.3%	56.7%	100%
		Mandla	Number	59	60	54	45	36	60
		%	%	98.3%	100.0%	90.0%	75.0%	60.0%	100%
		Grand Total Madhya Pradesh	Number	**163**	**180**	**166**	144	98	180
			%	**90.6%**	**100.0%**	**92.2%**	80.0%	54.4%	50%
			Number	180	180	180	180	180	180
			%	100%	100%	100%	100%	100%	100%
3	**Total VSS Participants**		**Grand Total**	**282**	**355**	**286**	194	142	360
			%	**78.3%**	**98.6%**	**79.4%**	53.9%	39.4%	100%
	Total Study Sample		**Grand Total**	360	360	360	361	362	360
			%	100%	100%	100%	100%	101%	100%

Source- Field Survey, SCSTRTI, 2022

Table No 7. Consumption and Income from the Forest

SL.No	States	Divisions	Forest Dweller	NTFP Purpose Ratio (Yearly)			Income from NTFP (Yearly)				
				Own Consumption volume %	Selling volume %		Below 5000	Between 5000-10000	Between 10000-20000	Above 20000	Total participants
1	Odisha	Baliguda				Odisha	40	18	1	1	60
		%	%	75.0%	25.0%		66.7 %	30.0 %	1.7%	1.7%	100%
		Rairangpur					30	25	3	2	60
		%	%	78.0%	23.0%		50.0 %	41.7 %	5.0%	3.3%	100%
		Rayagada					27	28	3	2	60
		%	%	67.0%	33.0%		45.0 %	46.7 %	5.0%	3.3%	100%
		Grand Total Odisha					**97**	**71**	7	**5**	180
			%	**73.3%**	**26.7%**		**53.9%**	**39.4%**	3.9%	**2.8%**	100%
							180	180	180	180	180
			%	**100%**	**100%**		100%	100%	100%	100%	50%
2	Madhya Pradesh	Betul				Madhya Pradesh	40	19	1	0	60
		%	%	60.0%	40.0%		66.7 %	31.7 %	1.7%	0.0%	100%
		Khandwa					37	22	1	0	60
		%	%	57.0%	43.0%		61.7 %	36.7 %	1.7%	0.0%	100%
		Mandla					29	30	0	1	60
		%	%	48.3%	41.7%		48.3 %	50.0 %	0.0%	1.7%	100%
		Grand Total Madhya Pradesh					**106**	71	2	**1**	180
			%	**55.1%**	**44.9%**		**58.9%**	39.4 %	1.1%	**0.6%**	100%
							180	180	180	180	180
			%	**100%**	**100%**		100%	100%	100%	100%	50%
3	**Forest dwellers NTFP Purpose & Income**					**Total**	**203**	**142**	**9**	**6**	**360**
			%	**64.2%**	**35.8%**		**56.4%**	**39.4%**	**2.5%**	**1.7%**	**100%**
	Total Study Sample						360	361	362	363	360
			%	**100%**	**100%**		100%	100%	101%	101%	100%

Source- Field Survey, SCSTRTI, 2022

Importance Value Index

A. Odisha

4. Rairangpur Division

We have selected tiring beat, manbir beat and Bahalda beat as low, medium and high forest fire categories respectively.

Table 1.1.1 Tiring beat (Low fire category), IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
Sal	*Shorea robusta*	87.32	19.50	27.81	17.14	21.54	55.27	93.95
Char	*Buchanania lanzon*	47.61	10.48	15.16	20.00	18.46	14.08	52.54
Kendu	*Diospyros melanoxylon*	27.13	6.60	8.64	14.29	13.85	3.43	31.56
Bela	*Aegle marmelos*	37.00	10.00	11.78	2.86	1.54	0.71	5.10
Arjuna	*Terminalia arjuna*	62.50	12.00	19.90	5.71	3.08	4.04	12.84
Karada	Bambusa bamboos	27.14	5.75	8.64	11.43	12.31	3.05	26.79
Sida	Lagerstroemia parviflora	44.50	6.25	14.17	5.71	4.62	3.08	13.41
Sirisa	*Albizzia odorettissima*	96.00	12.00	30.57	2.86	1.54	4.77	9.17
Kusa phala		51.50	10.00	16.40	2.86	3.08	2.75	8.68
Haramu		45.00	8.00	14.33	2.86	1.54	1.05	5.44
Mahuala	*Madhuca indica*	29.00	10.00	9.24	2.86	1.54	0.44	4.83
Papad	Gardenia latifolia	21.00	4.00	6.69	2.86	1.54	0.23	4.62
Teak	*Tectona grandis*	27.20	9.00	8.66	2.86	12.31	3.06	18.23
Arjuna	Terminalia arjuna	62.50	11.50	19.90	5.71	3.08	4.04	12.84
					100.00	**100.00**	**100.00**	**300.00**

(Source: SCSTRTI, Field work)

Table 1.1.2 Tiring beat (Low Fire category), Established Regeneration & Unestablished Regeneration

Local Name	Botanical Name	Total Sampled	Established Reg/Ha	Local Name	Botanical Name	Total sampled area	Unestablished Rege/ha
Sal	*Shorea robusta*	0.36	288.89	Karada	Bambusa bamboos	0.012	216.67
Karada	*Bambusa bamboos*	0.28	275.00	Kendu	*Diospyros melanoxylon*	0.01	160.00
Kendu	*Diospyros melanoxylon*	0.36	327.78	Sal	*Shorea robusta*	0.008	200.00
Sida	*Lagerstroemia parviflora*	0.2	70.00	Hatta phula		0.004	100.00
Chara	*Buchanania lanzon*	0.16	75.00	Neem	Azadirachita indica	0.006	166.67
Piasal	*Pterocarpus marsupium*	0.16	87.50	Palandu	Combretum decandrum	0.006	266.67
Bela	*Aegle marmelos*	0.2	135.00	Khaira	Acacia catechu	0.008	225.00
Patali		0.08	112.50	Khajuri	Phoenix acaulis	0.004	150.00
Mahula	*Madhuca latifolia*	0.2	75.00	Sida	Lagerstroemia parviflora	0.004	100.00
Sunari	*Cassia fistula*	0.12	91.67	Arjuna	Terminalia arjuna	0.006	300.00
Neem	*Azadirachita indica*	0.16	31.25	Badu		0.008	175.00
Harida	*Terminalia chebula*	0.28	89.29	Papada	Gardenia latifolia	0.006	233.33
Jamun	*Syzygium cuminii*	0.2	145.00	Karada	Bambusa bamboos	0.01	100.00
Mankada kendu		0.16	100.00	Chara	*Buchanania lanzon*	0.004	150.00
Acacia		0.16	156.25	Acacia		0.01	180.00
Teak	*Tectona grandis*	0.04	575.00	Palash	Butea monosperma	0.008	100.00
Mangium		0.08	137.50	Jamun	Syzygium cuminii	0.008	150.00
Mahatila		0.04	75.00	Teak	Tectona grandis	0.006	133.33

Palasha	*Butea monosperma*	0.08	50.00	Bahada	Terminalia bellerica	0.004	150.00
Karanja	*Pongamia glabra*	0.2	90.00	Bhalia		0.006	166.67
Dhala		0.12	133.33	Tamarind	Tamarindus indica	0.008	200.00
Bhalia		0.12	108.33	Dhala		0.006	166.67
Kusum	*Schleichera trijuga*	0.2	110.00	Harida	Terminalia chebula	0.004	100.00
Asana	*Terminalia tomentosa*	0.12	100.00	Sirisa	Albizzia odoratissima	0.004	100.00
Bahada	*Terminalia bellerica*	0.16	62.50	**Total**		**0.16**	**166.25 avg/ha**
Total		**4.24**	**140.07 avg/ha**				

Table: A.1.2.1 Bahalada beat, (Medium Fire Category), IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
Sal	*Shorea robusta*	67.60	16.43	21.52	15.25	12.86	28.42	56.53
Char	*Buchanania lanzon*	33.38	9.00	10.63	3.39	2.86	1.54	7.79
Kendu	*Diospyros melanoxylon*	36.71	8.63	11.68	13.56	20.71	13.50	47.77
Arjuna	Terminalia arjuna	43.33	12.78	13.79	5.08	2.14	1.95	9.17
Karada	Bambusa bamboos	32.17	7.25	10.24	6.78	6.43	3.22	16.43
Sida	Lagerstroemia parviflora	31.58	10.00	10.05	3.39	3.57	1.72	8.68
Kusa phala		21.00	4.00	6.68	1.69	0.71	0.15	2.56
Asana	Terminalia tomentosa	42.50	13.00	13.53	1.69	1.43	1.25	4.37
Acacia		35.18	8.00	11.20	3.39	10.00	5.98	19.37
Bahada	Terminalia bellerica	58.50	11.50	18.62	3.39	1.43	2.36	7.18
Bhalia		34.33	10.00	10.93	5.08	2.14	1.22	8.45
Dhala		60.00	15.00	19.10	1.69	0.71	1.24	3.65

Doka	Lannea grandis	28.25	6.00	8.99	3.39	2.14	0.83	6.36
Kusuma	Schleichera trijuga (Syn. S. oleorosa)	27.00	12.00	8.59	1.69	0.71	0.25	2.66
Mahatila		31.33	8.00	9.97	1.69	2.14	1.02	4.86
Mahuala	Madhuca indica	39.16	11.00	12.47	11.86	21.43	15.90	49.19
Mankada Kendu		28.00	10.00	8.91	1.69	0.71	0.27	2.68
Mirgi		24.00	7.00	7.64	1.69	0.71	0.20	2.61
Panchjana	Ougenia dalbergioides	71.00	10.00	22.60	1.69	0.71	1.74	4.15
Piasal	Pterocarpus marsupium	62.33	16.67	19.84	1.69	2.14	4.03	7.86
Snadhusikre		62.00	17.00	19.74	1.69	0.71	1.33	3.74
Sikre		39.00	13.00	12.41	1.69	0.71	0.53	2.93
Simli		165.00	33.00	52.52	1.69	0.71	9.41	11.82
Arjuna	Terminalia arjuna	43.33	12.67	13.79	5.08	2.14	1.95	9.17
					100.00	**100.00**	**100.00**	**300.00**

Table: A.1.2.2 Bahalada beat, (Medium Fire Category), Established & Unestablished Regeneration

Local Name	**Botanical Name**	**Total Sampled**	**No of Individuals/Ha**	**Local Name**	**Botanical Name**	**Total sampled area**	**Rege/ha**
Sal	*Shorea robusta*	0.4	255.00	Karada		0.006	133.33
karada	Bambusa bamboos	0.4	192.50	Kendu		0.006	233.33
Kendu		0.4	335.00	Sal		0.006	200
Sida		0.24	150.00	Hatta phula		0.004	150
Chara		0.32	96.88	Neem		0.008	175
Piasal		0.28	107.14	Palandu		0.004	200
Bela		0.24	104.17	Khaira		0.006	200
Patali		0.04	225.00	Khajuri		0.006	233.33
Mahula		0.36	133.33	Sida		0.008	100
Neem		0.2	90.00	Arjuna		0.004	150

Harida		0.04	200.00	Badu		0.004	250
Jamun		0.28	192.86	Papada		0.004	300
Mankada kendu		0.28	71.43	Karada		0.004	300
Acacia		0.16	112.50	Chara		0.004	150
Teak		0.08	187.50	Acacia		0.006	233.33
Mangium		0.12	125.00	Palash		0.004	100
Palasha		0.2	95.00	jamun		0.004	150
karanja		0.16	93.75	Teak		0.002	100
Dhala		0.2	70.00	Bhada		0.004	250
Bhalia		0.16	68.75	Bhalia		0.002	100
Kusum		0.28	96.43	Tamarind		0.002	100
Asana		0.08	112.50	Dhala		0.002	100
Arjuna		0.24	87.50	Harida		0.004	150
Bahada		0.24	79.17	Sirisa		0.004	100
		5.16	**136.72**			**0.108**	**176.4493**

Table 1.3.1 Manbir beat (High Fire Category), IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
Sal		92.17	28.17	29.337	11.111	7.576	29.872	48.559
Kendu		40.93	12.67	13.029	16.667	21.212	16.498	54.377
Karada		35.28	10.67	11.231	16.667	15.152	8.756	40.574
Asana		68.33	20.00	21.750	5.556	4.545	9.852	19.953
Acacia		37.63	13.60	11.978	27.778	45.455	29.878	103.110
Bahada		42.00	13.00	13.369	5.556	1.515	1.241	8.311
Hasel		47.00	13.00	14.961	5.556	1.515	1.554	8.624
mahuala		46.00	18.00	14.642	5.556	1.515	1.488	8.559
Nehuri		35.00	17.00	11.141	5.556	1.515	0.862	7.932
					100	**100**	**100**	**300**

The Highest IVI in above table is Acacia with 103.110 and least is Nehuri with 7.932.

Table 1.3.2 Manbir beat (High Fire Category), Established and Unestablished Regeneration

Local Name	Botanical Name	Total Sampled	Established Reg/Ha	Local Name	Botanical Name	Total sampled area	Established Rege/ha
Sal		0.24	341.67	Karada		0.008	150.0
Karada		0.24	262.50	Kendu		0.006	200.0
Kendu		0.24	287.50	Sal		0.004	150.0
Sida		0.12	150.00	Hatta phula		0.006	100.0
Chara		0.24	175.00	Neem		0.01	140.0
Piasal		0.28	92.86	Palandu		0.004	100.0
Bela		0.16	93.75	Khajuri		0.002	100.0
Ptali		0.12	141.67	Sida		0.002	200.0
Mahula		0.2	115.00	Arjuna		0.002	300.0
Sunari		0.08	62.50	Badu		0.004	150.0
Neem		0.12	58.33	Papada		0.004	150.0
Harida		0.16	118.75	Karada		0.002	100.0
Jamun		0.16	93.75	Chara		0.004	150.0
Mankada kendu		0.16	106.25	Acacia		0.006	166.7
Acacia		0.24	270.83	Papash		0.006	100.0
Mangium		0.2	240.00	Jamun		0.006	100.0
Palasha		0.04	25.00	Teak		0.002	200.0
karanja		0.12	108.33	Bahada		0.004	100.0
Dhala		0.12	66.67	Bhalia		0.004	100.0
Bhalia		0.08	87.50	Tamarind		0.004	100.0
Kusum		0.16	50.00	Dhala		0.004	200.0
Asana		0.12	50.00	Harida		0.004	200.0
Arjuna		0.16	75.00	Sirisa		0.004	200.0
Bahada		0.12	75.00	Total		**0.102**	**150.3 avg/ha**
Total		**3.88**	**131.16 avg/ha**				

Table 2.1.1 Hatikhamba beat (Low Fire Category), IVI

Common Name	Botanical Name	CBH	Avg Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominace	IVI
Limbur		49.000	7.620	15.605	2.941	0.980	0.523	4.445
Chara		39.000	12.192	12.420	2.941	0.980	0.332	4.253
Kendu		32.633	8.585	10.393	8.824	7.843	1.857	18.524
Piasal		66.000	13.716	21.019	2.941	0.980	0.949	4.871
Sida		35.500	12.192	11.306	2.941	1.961	0.549	5.451
Teak		64.557	19.677	20.560	23.529	62.745	58.137	144.411
Mahula		206.000	21.336	65.605	2.941	0.980	9.250	13.171
Bahada		47.167	14.224	15.021	8.824	3.922	1.940	14.685
Dhaura		74.000	25.908	23.567	2.941	1.961	2.387	7.289
Sana Chakunda		67.000	18.288	21.338	2.941	1.961	1.957	6.859
Bhalia		37.167	9.906	11.837	8.824	3.922	1.204	13.949
Asana		123.000	17.526	39.172	5.882	1.961	6.595	14.438
Bheru		75.500	15.240	24.045	5.882	1.961	2.485	10.328
Bada mai		63.500	17.907	20.223	11.765	4.902	4.394	21.061
Haldu		156.000	7.620	49.682	2.941	0.980	5.304	9.226
Rana bela		70.000	8.200	22.293	2.941	1.961	2.136	7.038
					100.000	**100.000**	**100.000**	**300.000**

Table 2.1.2 Hatilhmaba beat (Low Fire Category), Established and Unestablished Regeneration

Local Name	Botanical Name	Total Sampled	No of Individuals/Ha	Local Name	Botanical Name	Total Sampled Area	Reg/Ha
Asana		0.08	187.5	Kendu		0.012	916.67
Sida		0.04	125	Sunari		0.002	600.00
Kendu		0.24	187.5	Sal		0.008	675.00
L.mai		0.16	112.5	Jamunu		0.004	400.00
Haldu		0.04	250	Bana khajuri		0.01	400.00
Acacia		0.16	118.75	Salpani		0.006	966.67
Sal pani		0.12	100	Bhuineem		0.01	580.00
Sal		0.2	100	Teak		0.008	700.00
Jamunu		0.12	100	gangasiuli		0.004	400.00

Chara		0.04	250	Kanteikoli		0.004	350.00
Piasal		0.04	125	Kurui		0.002	400.00
Mahula		0.04	150	poka sungha		0.016	925.00
Teak		0.32	256.25	Chara		0.002	400.00
Dhaura		0.04	300	Antia		0.002	200.00
Bela		0.24	83.33333	Mahula		0.002	500.00
Sana Chakunda		0.04	175	Bhalia		0.002	300.00
Bhalia		0.2	125	Sirisa		0.006	833.33
Sirisa		0.08	100	Modimodika		0.014	557.14
Gangasiuli		0.16	93.75	Palasha		0.002	300.00
Bahada		0.24	95.83333	Bela		0.014	657.14
Total		**2.6**	**151.7708**	Dhatki		0.004	750.00
				Lunilunia koli		0.002	400
				Acacia Pinata		0.008	575.00
				Sata Karadia		0.002	300.00
				Bahada		0.002	400.00
				Kanchana		0.002	400.00
				Bheru		0.008	350.00
				Kapacia		0.002	300.00
				Ankula		0.002	300.00
				Ran bela		0.006	600.00
				Chilli Kanta		0.006	333.33
				Mango		0.002	300.00
				Sana chak		0.004	350.00
				Total		**0.182**	**491.7437**

Table 2.2.1 Sikabadi (Medium Fire Category), IVI

Local Name	**Botanical Name**	**Avg CBH**	**Avg Height**	**GBH (CM)**	**Relative Frequency**	**Relative Density**	**Relative Dominance**	**IVI**
Karada		33.20	7.43	10.57	14	18.45	7.92	40.36
Kasi		23.66	7.62	7.54	2	2.91	0.63	5.55
Sal		99.00	11.05	31.53	4	2.91	11.11	18.03
Chara		52.00	14.22	16.56	4	2.91	3.07	9.98

Jamun		27.00	9.91	8.60	2	1.94	0.55	4.49
Sahaj		56.00	15.20	17.83	2	1.94	2.37	6.31
Kendu		26.00	6.10	8.28	4	1.94	0.51	6.45
Piasal		23.00	6.10	7.32	2	0.97	0.20	3.17
Teak		31.00	9.45	9.87	2	0.97	0.36	3.33
Mahula		31.42	9.02	10.01	6	5.83	2.24	14.06
Bahada		32.67	10.67	10.40	6	2.91	1.21	10.12
Bhalia		63.08	14.34	20.09	12	10.68	16.55	39.23
Asana		83.00	18.29	26.43	2	0.97	2.60	5.57
Bada mai		61.27	14.01	19.51	14	22.33	32.64	68.97
Sirisa		54.75	15.62	17.44	8	9.71	11.33	29.04
Kochila		45.00	7.62	14.33	2	0.97	0.77	3.74
Char koli		26.33	8.13	8.39	2	2.91	0.79	5.70
Cashew		29.50	4.57	9.39	2	1.94	0.66	4.60
Katak		23.00	6.10	7.32	2	0.97	0.20	3.17
Phaura		31.00	6.10	9.87	2	0.97	0.36	3.33
Karanja		48.00	18.29	15.29	2	0.97	0.87	3.84
Bana kaith		22.00	4.57	7.01	2	0.97	0.18	3.15
Sarvapatri mai		50.33	9.65	16.03	2	2.91	2.87	7.79
					100	**100**	**100**	**300**

Table 2.2.2. Sikabadi (Medium Fire Category), Established and Unestablished Regeneration

Local Name	**Botanical Name**	**Sampled Area**	**Individuals/ha**	**Local Name**	**Botanical Name**	**Sampled Area**	**Reg/Ha**
Karada		0.28	189.29	Kendu	Diospyros melanoxylon	0.02	870.00
Kendu		0.2	145.00	Bajramuli		0.006	500.00
L. mai		0.28	171.43	Sunari		0.002	800.00
kasi		0.04	175.00	Sal	Shorea robusta	0.012	950.00
Acacia		0.08	112.50	Jammu		0.008	775.00
Sal		0.16	162.50	Bana Khajuri		0.012	483.33
Jamunu		0.08	137.50	Salpani		0.004	700.00
Chara		0.04	150.00	Bhuineem		0.012	950.00
Piasal		0.08	125.00	Gangasiuli		0.006	500.00
Mahula		0.12	133.33	Karda		0.018	577.78
Sahaj		0.04	175.00	Kanteikoli		0.006	733.33
Teak		0.04	125.00	poka sungi		0.02	880.00

Bela		0.24	75.00	Mahula		0.008	450.00
Sana Chakunda		0.12	83.33	Bhalia		0.006	500.00
Bhalia		0.2	165.00	Sirisa		0.006	400.00
Dhatki		0.08	87.50	modimodika		0.01	740.00
Sirisa		0.2	185.00	Bela		0.002	900.00
Cashew		0.08	137.50	Dhatki		0.01	700.00
Gangasiuli		0.28	85.71	Acacia Pinata		0.004	400.00
Tangana		0.04	75.00	Bahada		0.002	500.00
Total		**2.68**	**134.78**	Bheru		0.002	600.00
				Ran bela		0.002	500.00
				Bamboo		0.006	366.67
				Kochila		0.004	450.00
				Char koli		0.004	450.00
				Achu		0.008	475.00
				Muchkunda		0.008	450.00
				Total		**0.208**	**614.86**

Table 2.3.1 Chinsari beat (High Fire Category), IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominace	IVI
Karada	*Cleistanthus collinus*	34.00	6.86	10.828	2.941	1.342	0.785	5.069
limbur mai	*Protium serratum*	50.33	12.95	16.030	4.412	2.685	3.442	10.538
Kasi	*Bridelia retusa*	38.33	7.87	12.208	4.412	2.013	1.497	7.922
Pahadi Sisu	*Dalbergia sisoo*	41.50	8.38	13.217	5.882	2.685	2.340	10.907
Sal	*Shorea robusta*	39.10	10.10	12.451	5.882	20.134	15.574	41.591
Chara	*Buchnania lanzan*	37.41	7.68	11.913	13.235	23.490	16.634	53.360
Jamunu	*Syzygium cumini*	44.13	10.48	14.053	5.882	5.369	5.291	16.542
Kendu	*Diospyros melanoxylon*	27.67	6.26	8.811	4.412	4.027	1.560	9.999
Piasal	*Pterocarpus marsupium*	64.25	15.08	20.461	11.765	10.067	21.031	42.863

Ghanta koli	*Ziziphus xylopyrus*	44.00	9.14	14.013	1.471	2.013	1.973	5.457
Mahula	*Madhuca indica*	41.00	9.14	13.057	1.471	0.671	0.571	2.713
Bahada	*Terminalia bellirica*	38.00	9.91	12.102	2.941	2.013	1.471	6.426
Bela	*Aegle marmelos*	26.22	6.43	8.350	4.412	3.356	1.168	8.935
Dhaura	*Anogeissus latifolia*	144.00	13.72	45.860	1.471	0.671	7.043	9.185
Sana Chakhunda	*Cassia siamea*	43.00	9.14	13.694	2.941	2.013	1.884	6.839
Bhalia	*Semecarpus anacardium*	38.20	8.99	12.166	7.353	4.698	3.469	15.520
Karanja	*Pongamia pinnata*	28.00	9.14	8.917	1.471	0.671	0.266	2.408
Asana	*Terminalia alata*	55.25	11.05	17.596	2.941	2.013	3.110	8.065
Sirisa	*Albizia lebbeck*	58.13	14.67	18.511	5.882	4.027	6.885	16.794
Sunari	*Cassia fistula*	26.67	8.60	8.493	4.412	2.013	0.725	7.150
Masinia		24.00	6.10	7.643	1.471	0.671	0.196	2.337
Bandhana	*Desmodium oojenesis*	49.50	9.91	15.764	1.471	1.342	1.664	4.477
Kuruma	*Haldina cordifolia*	37.33	5.59	11.889	1.471	2.013	1.420	4.904
					100	**100**	**100**	**300**

Table 2.3.2 Chinsari beat (High Fire Category), Established and Unestablished Regeneration

Local Name	Botanical Name	Total Sampled Area	Established Reg /Ha	Local Name	Botanical Name	total sampled	regeneration/ha
Karada		0.2	160.00	Kendu	Diospyros melanoxylon	0.014	1271.43
Asana		0.16	125.00	Sunari		0.002	800.00
Kendu		0.28	214.29	Sida		0.002	800.00
Bamboo		0.04	75.00	Sal	Shorea robusta	0.01	1540.00
L. mai		0.12	50.00	Jamunu		0.006	666.67
Sunari		0.16	112.50	Meramine		0.012	1550.00
Sal		0.24	354.17	Bana khajuri		0.018	922.22
Anala		0.12	75.00	Salpanni		0.012	950.00
Jamunu		0.16	87.50	bhuineem		0.01	780.00

Chara		0.28	210.71	Piasal		0.008	550.00
Piasal		0.16	100.00	gangasiuli		0.012	600.00
Palasha		0.08	237.50	Karada	Bambusa bamboos	0.016	1475.00
Mahula		0.12	75.00	Kanteikoli		0.004	550.00
sahaj		0.04	250.00	Kurei		0.004	850.00
Dhaura		0.08	225.00	poka sunghal		0.014	1228.57
Bela		0.24	95.83	Chara		0.01	780.00
Pahadi sisu		0.04	125.00	Antia		0.002	800.00
Sana Chakunda		0.04	225.00	Dhaura		0.002	600.00
Bhalia		0.32	93.75	Bhalia		0.014	685.71
Sirisa		0.2	135.00	Modimodi ka		0.012	666.67
Ghantu		0.2	125.00	Palasha		0.002	500.00
Gangasiuli		0.08	112.50	Bela		0.012	616.67
Total			**148.35 avg/ha**	Anala		0.008	375.00
				Acchu		0.008	750.00
				Mango		0.004	600.00
						0.218	**836.32 avg/ha**

Table 3.1.1 Angul Beat (Low Fire Category), IVI

S. No	Species	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
1	Ghambari	14.331	1.639	0.680	0.272	2.591
2	Bansula	9.554	1.639	0.680	0.121	2.440
3	karada	19.130	9.836	19.048	13.550	42.434
4	Limbur	23.089	6.557	6.122	6.345	19.025
5	Kasi	15.446	3.279	1.361	0.631	5.270
6	Pahadi Sisu	25.318	3.279	1.361	1.695	6.335
7	Sal	18.617	6.557	8.163	5.500	20.221
8	Palash	15.287	1.639	1.361	0.618	3.618
9	Chara	19.214	4.918	2.721	1.953	9.592
10	Jamunu	23.035	1.639	2.041	2.105	5.785

11	Saja	30.533	6.557	7.483	13.562	27.602
12	Tendu	12.845	6.557	4.082	1.309	11.948
13	Piscal	19.639	4.918	2.721	2.040	9.679
14	Mundi	29.723	1.639	2.041	3.505	7.185
15	Achu	12.261	1.639	1.361	0.398	3.398
16	Ghanta koli	15.764	1.639	1.361	0.657	3.657
17	Sida	27.389	1.639	0.680	0.992	3.312
18	Salai	45.143	8.197	7.483	29.646	45.32
19	Teak	9.777	9.836	19.048	3.540	32.423
20	kalchua	27.548	3.279	1.361	2.007	6.646
21	Mahula	7.325	1.639	0.680	0.071	2.391
22	Rohini	7.643	1.639	0.680	0.077	2.397
23	Bahada	63.694	1.639	0.680	5.365	7.685
24	Bela	41.720	1.639	0.680	2.302	4.621
25	Kusumu	19.427	1.639	0.680	0.499	2.819
26	Dhaura	10.191	1.639	0.680	0.137	2.457
27	K.mai	11.624	1.639	2.721	0.715	5.075
28	Sana Chakhunda	9.873	1.639	2.041	0.387	4.067
			100.00	**100.00**	**100.00**	**300.000**

Table: 3.1.2 Angul Beat (Low Fire Category), Established and Unestablished Regeneration

S. No	Spp	Total Sampled Area	Sapling /Ha	S.No.	Spp	Total Sampled Area	Regeneration/Ha
1	Karada	0.36	283.33	1	Tendu	0.02	870.00
2	Asana	0.04	100.00	2	Sahaj	0.014	457.14
3	Sida	0.2	90.00	3	Pahadi Sissoo	0.004	300.00
4	Kusuma	0.08	125.00	4	Sunari	0.004	600.00
5	Tendu	0.36	227.78	5	Buduli	0.002	400.00
6	Bamboo	0.04	250.00	6	Tangan	0.002	500.00
7	Budel	0.04	100.00	7	Kusum	0.002	500.00
8	L. mai	0.16	75.00	8	Sal	0.008	1000.00

9	Haldu	0.04	75.00	9	Jamun	0.002	500.00
10	Kasi	0.08	112.50	10	Meramine	0.006	1033.33
11	Acacia	0.04	125.00	11	Bana Khajuri	0.004	650.00
12	Sunari	0.12	141.67	12	Teak	0.002	300.00
13	Sal Pani	0.04	100.00	13	Kumbhi	0.002	300.00
14	Sal	0.28	264.29	14	Piscal	0.006	200.00
15	Anala	0.08	62.50	15	gangasiuli	0.004	550.00
16	Jamunu	0.08	262.50	16	Karada	0.01	640.00
17	Chara	0.16	131.25	17	Khaira	0.008	500.00
18	Banakhajuri	0.08	125.00	18	Kurei	0.002	700.00
19	Diospyros malabarica	0.04	75.00	19	Dumkurudu	0.004	200.00
20	Piasal	0.16	100.00	20	Baranga	0.004	300.00
21	Palasha	0.08	62.50	21	Dhauda	0.004	500.00
22	Mahula	0.24	162.50	22	Chara	0.004	350.00
23	Sahaj	0.16	256.25	23	Kasi	0.002	300.00
24	Teak	0.24	304.17	24	Antia	0.004	550.00
25	Salai	0.08	150.00				**508.35**
26	Dhaura	0.16	143.75				
27	Bela	0.12	66.67				
28	Pahadi Sisu	0.04	150.00				
29	Sissoo	0.04	75.00				
30	Khira	0.04	75.00				
31	Rohini	0.04	75.00				
32	Sana Chakhunda	0.04	75.00				
33	Holarrhenaantidy senterica	0.04	125.00				
34	Mannja	0.04	75.00				
35	Bhalia	0.04	25.00				
			132.76				

Table 3.2.1 Landgaon (Medium Fire category), IVI

S. No	Species	CBH (cm)	Hight (m)	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
1	Ghambari (*Gmelina arborea*)	45.000	13.716	14.331	1.538	0.581	0.253	2.372
2	Bansula	30.000	7.620	9.554	1.538	0.581	0.112	2.232
3	Karada (*Cleistanthus collinus*)	60.067	9.468	19.130	9.231	16.279	12.599	38.109
4	limbur mai (*Protium serratum*)	72.500	17.271	23.089	6.154	5.233	5.900	17.286
5	Kasi (*Bridelia retusa*)	48.500	14.478	15.446	3.077	1.163	0.587	4.826
6	Pahadi Sisu (*Dalbergia sissoo*)	79.500	15.240	25.318	3.077	1.163	1.576	5.816
7	Sal (*Shorea robusta*)	58.458	14.668	18.617	6.154	6.977	5.114	18.245
8	Palash (*Butea monosperma*)	48.000	12.954	15.287	1.538	1.163	0.575	3.276
9	Chara (*Buchnania lanzan*)	60.333	11.684	19.214	4.615	2.326	1.816	8.757
10	Jamun (*Syzygium cumini*)	72.330	15.240	23.035	1.538	1.744	1.957	5.240
11	Saja (*Terminalia tomentosa*)	95.875	14.383	30.533	6.154	6.395	12.610	25.159
12	Tendu (*Dyspyrous melonoxylon*)	40.333	8.813	12.845	6.154	3.488	1.217	10.859
13	Piscal (*Pterocarpus marsupium*)	61.667	16.510	19.639	4.615	2.326	1.897	8.838
14	Mundi	93.330	19.303	29.723	1.538	1.744	3.259	6.542
15	Achu (*Morinda tinctoria*)	38.500	6.858	12.261	1.538	1.163	0.370	3.071
16	Ghanta koli (*Ziziphus xylopyrus*)	49.500	9.906	15.764	9.231	16.279	8.556	34.066
17	Salai (*Bowellia Serrata*)	141.750	25.247	45.143	7.692	6.395	27.564	41.652
18	Teak (*Tectona grandis*)	30.700	10.848	9.777	9.231	16.279	3.291	28.801

19	Kalchua (*Diospyros sylvatica*)	86.500	22.098	27.548	3.077	1.163	1.866	6.106
20	Mahula (*Madhuca indica*)	23.000	7.620	7.325	1.538	0.581	0.066	2.186
21	Rohini (*Mallotus philippensis*)	24.000	7.620	7.643	1.538	0.581	0.072	2.192
22	Bahada (*Terminalia bellirica*)	200.000	28.956	63.694	1.538	0.581	4.988	7.108
23	Bela (*Aegle marmelos*)	131.000	25.908	41.720	1.538	0.581	2.140	4.260
24	Kusumu (*Schleicherao oleosa*)	61.000	9.144	19.427	1.538	0.581	0.464	2.584
25	Dhawra (*Anogeissus latifolia*)	32.000	9.144	10.191	1.538	0.581	0.128	2.248
26	K.mai (*Lannea coromandelica*)	36.500	11.430	11.624	1.538	2.326	0.665	4.529
27	Sana Chakhunda (*Cassia siamea*)	31.000	14.222	9.873	1.538	1.744	0.360	3.642
					98.462	**100.000**	**99.640**	**300.00**

Table 3.2.2 Landagaon (Medium Fire Category), Established and Unestablished regeneration

S. No	**Spp**	**Total Sampled Area**	**Established /Ha**	**S.No.**	**Spp**	**Total Sampled Area**	**Unestablished/Ha**
1	Karada	0.28	282.14	1	Tendu	0.018	1366.67
2	Sida	0.24	108.33	2	Sahaj	0.014	742.86
3	Kusum	0.08	50.00	3	Sunari	0.004	700.00
4	Tendu	0.40	305.00	4	buduli	0.012	750.00
5	Kusuma	0.20	100.00	5	Tangan	0.002	800.00
6	Tendu	0.40	220.00	6	Kusuma	0.006	700.00
7	L. Mai	0.16	37.50	7	Sal	0.016	1162.50
8	Kasi	0.16	75.00	8	jamunu	0.002	400.00
9	Sunari	0.20	110.00	9	Bana khajuri	0.012	700.00

10	Sal	0.40	245.00	10	Piasal	0.004	450.00
11	Anala	0.08	100.00	11	Karada	0.002	900.00
12	Jamun	0.04	200.00	12	Ziziphus oenoplia	0.002	400.00
13	Chara	0.16	237.50	13	Kurei	0.008	700.00
14	Banakhajuri	0.04	125.00	14	Baranga	0.006	633.33
15	Piasal	0.20	200.00	15	Dhaura	0.01	620.00
16	Palasha	0.32	128.13	16	poka sungha	0.01	1340.00
17	Mahula	0.24	187.50	17	Chara	0.008	600.00
18	Sahaj	0.32	165.63	18	Kasi	0.01	360.00
19	Teak	0.04	450.00	19	Dhaura	0.006	1000.00
20	Salai	0.08	112.50	20	Mahula	0.006	466.67
21	Dhaura	0.24	129.17	21	Bhalia	0.004	250.00
22	Pahadi Sisu	0.12	58.33	22	Bandhan	0.004	300.00
23	Rohini	0.08	112.50	23	Rohini	0.002	300.00
24	Holarrhenaantidysenterica	0.12	191.67	24	Sirisa	0.002	500.00
25	Mannja	0.08	112.50				**672.58**
26	Dhatki	0.04	50.00				
27	Sirisa	0.04	50.00				
28	Banatula	0.04	175.00				
29	Ghantu	0.04	100.00				
30	Nyctathes arbortristis	0.04	125.00				
31	Tangana	0.04	150.00				
			151.40				

Table:3.3.1 Dhaka (Hire Fire Category), IVI

S. No	Species	CBH (cm)	Hight (m)	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
1	Karada (Cleistanthus collinus)	38.03	10.68	12.11	16.33	25.93	15.79	58.04
2	Limbur (Protium serratum)	55.00	16.01	17.52	4.08	1.23	1.57	6.89
3	Kasi (Bridelia retusa)	61.00	19.83	19.43	2.04	1.23	1.94	5.21

4	Sal (Shorea robusta)	46.20	17.75	14.71	10.20	14.81	13.32	38.34
5	Chara (Buchnania lanzan)	26.92	11.31	8.57	6.12	4.32	1.32	11.76
6	Saja (Terminalia tomentosa)	61.17	12.33	19.48	8.16	4.94	7.78	20.88
7	Tendu (Diospyros melanoxylon)	47.33	9.30	15.07	8.16	13.58	12.81	34.55
8	Sida	37.04	13.07	11.79	14.29	8.64	4.99	27.92
9	Mahula (Madhuka indica)	71.50	13.73	22.77	4.08	1.23	2.66	7.97
10	Dhavdha (Anogeissus latifolia)	42.00	15.76	13.38	2.04	1.85	1.38	5.27
11	K. Mai (Lannea coromandelica)	43.00	16.01	13.69	4.08	1.85	1.44	7.38
12	Tangana (Xylia xylocarpa)	59.59	18.21	18.98	14.29	16.05	24.01	54.34
13	Bhalia (Terminalia bellirica)	77.00	16.39	24.52	4.08	2.47	6.17	12.72
14	Kumbhi (Careya arboria)	78.66	11.22	25.05	2.04	1.85	4.83	8.72
					100.00	100.00	100.00	300.00

Table 3.3.2 Dhaka Beat (High Fire Category), Established Regeneration & Unestablished Regeneration

S. No	Spp	Total Sampled Area	Sapling /Ha	S.No.	Spp	Total Sampled Area	Regeneration/Ha
1	Karada	0.4	307.50	1	Tendu	0.02	1210.00
2	Asana	0.04	75.00	2	sahaj	0.002	700.00
3	Sida	0.08	187.50	3	Pahadi Sissoo	0.004	350.00
4	Kusum	0.08	50.00	4	Sunari	0.006	466.67
5	Tendu	0.4	305.00	5	Tangan	0.014	614.29
6	Bamboo	0.16	125.00	6	Kusuma	0.004	400.00
7	L. Mai	0.2	45.00	7	Sida	0.006	433.33
8	Haldu	0.04	100.00	8	Sal	0.008	1050.00
9	Kasi	0.04	75.00	9	Bana khajuri	0.004	300.00
10	Sal	0.32	156.25	10	Karada	0.012	583.33
11	Anala	0.08	37.50	11	Kanteikoli	0.002	300.00
12	Chara	0.12	166.67	12	Kurei	0.012	700.00
13	Piasal	0.08	50.00	13	Chara	0.004	600.00
14	Palash	0.04	25.00	14	Kasi	0.002	400.00
15	Mahula	0.08	112.50	15	Dhaura	0.002	400.00
16	Sahaj	0.24	100.00	16	Palash	0.006	333.33
17	Dhawra	0.2	21.00	17	Bael	0.002	400.00
18	Pahadi Sisu	0.12	100.00			**0.11**	**543.59**
19	Sissoo	0.04	50.00				
20	Sana Chakhunda	0.04	25.00				
21	Holarrhenaantidy senterica	0.16	106.25				
22	Bhalia	0.16	100.00				
23	Gangasiuli	0.04	125.00				
24	Tangana	0.24	237.50				
		3.4	**111.78**				

Khandwa Forest Division

Table B.1.1.1 Compartments (836, 827, 833, 831), Low Fire Categoty, IVI

Species	CBH (cm)	Hight (m)	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
Teak	61.33514	13.84372	19.53349	27.52294	66.07495	59.60252	153.2004
Tendu	42.37778	11.23333	13.49611	8.256881	2.366864	1.019198	11.64294
Dhavdha	58.8	74.25	18.72611	1.834863	0.591716	0.490543	2.917121
Lendia	41.57143	10.74286	13.23931	6.422019	1.775148	0.735586	8.932753
Saja	90.61359	15.99697	28.85783	15.59633	8.87574	17.47432	41.94639
Aonla	72	13.4	22.92994	1.834863	0.394477	0.490339	2.719678
Achar	52.65844	17.35515	16.7702	10.09174	10.84813	7.212731	28.1526
Palash	48.47	8.358	15.43631	9.174313	3.944773	2.222169	15.34126
Kalam	114	16.3	36.30573	1.834863	0.394477	1.229252	3.458591
Salai	142	17.2	45.22293	0.917431	0.197239	0.953625	2.068295
Mahua	82	13	26.11465	3.669725	0.788955	1.272005	5.730685
Bael	77	13.9	24.52229	0.917431	0.394477	0.560806	1.872714
Amaltash	23	8.8	7.324841	1.834863	0.394477	0.050036	2.279376
Moyan	127.6	15.46	40.63694	4.587156	1.380671	5.390145	11.35797
Karanj	48	11.475	15.28662	1.834863	0.591716	0.326892	2.753471
Reonjha	75	9.85	23.88535	1.834863	0.394477	0.532051	2.761391
Piparia	88	16.8	28.02548	0.917431	0.197239	0.366241	1.48091
Kari	27.5	11.4	8.757962	0.917431	0.394477	0.071531	1.38344
				100	**100**	**99.99999**	**300**

Table B.1.1.2 (Compartments (836, 827, 833, 831), Low Fire Categoty, Established and Unestablished Regeneration

S. No.	Spp	Total Sampled Area	Sapling /Ha	S.No	Species	Total Sampled Area	Regeneration /Ha
1	Teak	0.96	362.50	1	Lendia	0.01	416.67
2	Tendu	0.44	281.82	2	Dhavdha	0.01	625.00
3	Achar	0.04	175.00	3	Tendu	0.04	1126.32
4	Lendia	0.36	63.89	4	Amaltash	0.02	344.44

5	Amaltash	0.32	100.00	5	Teak	0.04	315.79
6	Palash	0.12	33.33	6	Saja	0.05	808.70
7	Saja	0.08	37.50	7	Gathber	0.01	100.00
8	Aonla	0.04	25.00	8	Shisham	0.01	150.00
9	Kari	0.04	50.00	9	Bael	0.00	100.00
10	Reonjha	0.16	50.00	10	Tinsa	0.01	200.00
	Total	2.56	117.90	11	Astara	0.00	100.00
				12	Achar	0.01	185.71
				13	Maikadh	0.03	284.62
				14	Neem	0.00	100.00
				15	Babool	0.00	100.00
				16	Kala Siris	0.00	100.00
				17	Kari	0.00	300.00
				18	Khamar	0.00	100.00
				19	Palash	0.00	100.00
					Total	0.25	292.49

Table B.1.2.1 Compartments (814, 815, 818, 819), Medium Fire Category, IVI

Local Name	CBH (cm)	Hight (m)	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
Teak	59.005	14.022	18.791	19.512	71.965	65.444	156.921
Tendu	33.750	8.012	10.748	3.902	2.012	0.599	6.513
Dhavdha	75.539	15.859	24.057	18.537	2.131	3.175	23.843
Lendia	43.780	11.376	13.943	9.756	4.971	2.489	17.216
Saja	103.702	27.007	33.026	7.317	2.722	7.647	17.686
Aonla	59.000	12.163	18.790	3.902	1.420	1.291	6.614
Achar	26.000	8.667	8.280	1.463	0.355	0.063	1.881
Palash	53.733	8.413	17.113	2.439	1.184	0.893	4.515
Salai	107.500	18.080	34.236	2.439	0.710	2.144	5.293
Mahua	132.000	15.900	42.038	0.976	0.237	1.077	2.290
Bael	40.000	13.000	12.739	0.488	0.355	0.148	0.991
Gathber	38.000	9.500	12.102	0.976	0.237	0.089	1.302
Astara	43.667	9.367	13.907	2.927	0.710	0.354	3.991
Amaltash	43.250	10.350	13.774	1.951	0.710	0.347	3.008

Tinsa	48.000	11.417	15.287	1.463	0.710	0.427	2.601
Moyan	109.833	16.333	34.979	2.927	0.947	2.984	6.857
Dudhi	39.952	9.034	12.723	4.878	4.616	1.925	11.419
Om	90.000	17.800	28.662	0.488	0.118	0.250	0.857
Bhelwa	66.000	11.400	21.019	0.488	0.118	0.135	0.741
Phansi	64.744	65.356	20.619	1.463	0.710	0.778	2.951
Bahedha	44.500	11.575	14.172	1.951	0.592	0.306	2.849
Umba	59.500	14.125	18.949	0.976	0.355	0.328	1.659
Chillore	56.000	14.200	17.834	0.488	0.118	0.097	0.703
Gurgutti	40.500	11.700	12.898	0.976	0.355	0.152	1.483
Mokha	90.000	15.400	28.662	0.488	0.118	0.250	0.857
Kadhka	138.333	18.900	44.055	1.463	0.473	2.366	4.303
Rohan	54.000	9.400	17.197	0.488	0.118	0.090	0.696
Kedha	95.000	14.150	30.255	1.463	0.355	0.837	2.656
Kalam	114.000	20.500	36.306	0.976	0.237	0.804	2.016
Kumbhi	136.000	14.600	43.312	0.488	0.118	0.572	1.178
Shisham	52.000	13.800	16.561	0.488	0.118	0.084	0.690
Haldu	220.000	18.600	70.064	0.488	0.118	1.496	2.103
Dhaman	40.000	12.400	12.739	0.488	0.118	0.049	0.656
Agan	100.000	14.600	31.847	0.488	0.118	0.309	0.915
				100.000	**100.000**	**100.000**	**300.000**

Table B.1.2.2 Compartments (814, 815, 818, 819), Medium Fire Category, Established & Unestablished Regeneration

S.No	Spp	Total Sampled Area	Sapling /Ha	S.No	Species	Total Sampled Area	Regeneration/Ha
1	Teak	1.44	152.08	1	Lendia	0.024	300.00
2	Tendu	0.76	248.68	2	Dhavdha	0.03	213.33
3	Lendia	0.64	90.62	3	Tendu	0.038	605.26
4	Amaltash	0.12	25	4	Amaltash	0.01	160.00
5	Saja	0.08	75	5	Teak	0.04	280.00
6	Bahedha	0.04	25	6	Aonla	0.002	100.00
7	Gurgutti	0.04	25	7	Saja	0.048	541.67
8	Phnasi	0.04	50	8	Gathber	0.016	125.00

9	Dudhi	0.04	25	9	Dhaman	0.002	100.00
		3.2	**79.59**	10	Shisham	0.028	257.14
				11	Dudhi	0.016	150.00
				12	Bahedha	0.014	242.86
				13	Bija	0.004	100.00
				14	Phansi	0.004	100.00
				15	Bael	0.014	128.57
				16	Tinsa	0.002	200.00
				17	Gurgutti	0.016	212.50
				18	Astara	0.002	400.00
				19	Moyan	0.002	100.00
				20	Chillore	0.006	266.67
				21	Palash	0.006	400.00
				22	Kalam	0.002	600.00
				23	Maikadh	0.006	200.00
				24	Bamboo	0.002	100.00
				25	Booti	0.002	200.00
				26	Kakdha	0.002	100.00
				27	Umba	0.002	100.00
				28	Maha	0.002	100.00
				29	Neem	0.002	100.00
						0.344	**223.55**

Table B.1.3.1 Compartments (786, 787, 788, 797), High Fire Category, IVI

Jkl

Species	**CBH (cm)**	**Hight (m)**	**GBH (CM)**	**Relative Frequency**	**Relative Density**	**Relative Dominace**	**IVI**
Teak	55.939	12.975	17.815	25.850	73.862	61.595	161.308
Tendu	50.499	9.325	16.082	8.844	4.551	3.093	16.488
Dhavdha	62.279	14.309	19.834	9.524	2.991	3.092	15.606
Lendia	42.803	10.978	13.631	8.163	3.121	1.524	12.808
Saja	91.238	15.530	29.057	12.245	5.592	12.405	30.241
Aonla	58.333	11.752	18.577	4.762	0.910	0.825	6.498
Sirali	25.000	7.725	7.962	1.361	0.390	0.065	1.816

Achar	54.125	11.275	17.237	5.442	1.430	1.117	7.989
Palash	64.258	9.570	20.464	5.442	1.951	2.146	9.539
Khair	38.500	10.600	12.261	1.361	0.260	0.103	1.723
Kalam	195.500	16.275	62.261	1.361	0.390	3.974	5.724
Salai	100.548	14.405	32.022	4.762	1.560	4.204	10.527
Mahua	68.500	12.300	21.815	1.361	0.260	0.325	1.946
Bael	73.000	12.900	23.248	0.680	0.260	0.369	1.310
Gathber	47.000	10.200	14.968	0.680	0.130	0.077	0.887
Astara	77.000	6.200	24.522	0.680	0.130	0.205	1.016
Amaltash	31.500	11.200	10.032	1.361	0.260	0.069	1.689
Tinsa	43.000	11.400	13.694	0.680	0.130	0.064	0.874
Moyan	132.000	16.800	42.038	1.361	0.260	1.208	2.828
Bhelwa	32.000	9.400	10.191	0.680	0.130	0.035	0.846
Phansi	81.167	13.733	25.849	0.680	0.910	1.598	3.189
Kumbhi	150.000	14.800	47.771	0.680	0.130	0.780	1.590
Vidyanath	165.000	12.400	52.548	0.680	0.130	0.943	1.754
Kekdha	38.000	15.400	12.102	0.680	0.130	0.050	0.860
Mokha	62.000	13.600	19.745	0.680	0.130	0.133	0.944
				100.000	**100.000**	**100.000**	**300.000**

Table B.1.3.2 Compartments (786, 787, 788, 797), High Fire Category, Established and Unestablished Regeneration

S.No.	Spp	Sample Size	Total Sampled Area	Sapling /Ha	S.No.	Species	Total Sampled Area (Ha.)	Regeneration/Ha
1	Teak	0.04	1.48	497.97	1	Lendia	0.02	140.00
2	Tendu	0.04	1.08	226.85	2	Dhavdha	0.032	206.25
3	Achar	0.04	0.08	75	3	Tendu	0.04	495.00
4	Lendia	0.04	0.92	73.91	4	Chiras	0.006	100.00
5	Sirali	0.04	0.08	162.5	5	Gadhaka	0.002	100.00
6	Ber	0.04	0.04	25	6	Amaltash	0.01	100.00
7	Khair	0.04	0.04	25	7	Teak	0.024	150.00
8	Gathber	0.04	0.16	50	8	Aonla	0.002	100.00
9	Dhavdha	0.04	0.08	25	9	Saja	0.042	466.67

10	Amaltash	0.04	0.36	50	10	Gathber	0.018	166.67
11	Palash	0.04	0.12	33.33	11	Jamla	0.006	100.00
12	Saja	0.04	0.12	133.33	12	Dhaman	0.064	21.88
13	Nehru	0.04	0.04	25	13	Shisham	0.026	161.54
14	Dhaman	0.04	0.04	25	14	Rohan	0.014	142.86
			4.64	101.99	15	Dudhi	0.006	200.00
					16	Sirali	0.004	300.00
					17	Bahedha	0.006	100.00
					18	Rekhali	0.008	175.00
					19	Bija	0.004	100.00
					20	phansi	0.004	100.00
					21	powder	0.004	100.00
					22	Bael	0.008	175.00
					23	Astara	0.002	100.00
					24	Palash	0.002	100.00
					25	Garudh	0.002	100.00
					26	Kalam	0.004	100.00
					27	Achar	0.004	100.00
					28	Mokha	0.004	200.00
					29	Khair	0.002	100.00
							0.37	155.20

Betul Table B.2.1.1 Betul Compartments (414, 413, 194, 225), Low Fire Category, IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominace	IVI
Sal		142.8	13.22	45.47771	2.649006693	0.978792822	5.116916759	8.744716274
Saaj		86.275	11.725	27.47611	2.649006693	1.957585644	3.735526905	8.342119242
Lendia		48.63846	5.115385	15.48996	8.609271751	11.908646	7.222427748	27.7403455
Dhawda		60.75	4.75	19.34713	1.324503346	0.652528548	0.617380976	2.59441287
Amaltash		30.21429	7.1	9.622384	4.635761712	1.63132137	0.381790704	6.648873787
Dhaman		64.6	12	20.57325	0.662251673	0.489396411	0.523584736	1.675232821
kari		55.63333	10.10667	17.71762	9.933775098	4.567699837	3.624339582	18.12581452
Teak		55.38269	9.265385	17.6378	17.2185435	36.21533442	28.47749535	81.91137327
Mahua		141.92	14.84	45.19745	3.311258366	1.794453507	9.265749971	14.37146184
Tendu		55.86667	8.358333	17.79193	7.947020078	5.872756933	4.699035291	18.5188123
Palash		47.25	8.2	15.04777	1.324503346	0.489396411	0.280108035	2.094007793
kusum		180	18	57.32484	0.662251673	0.163132137	1.355019974	2.180403784
Astra		29.5	10.2	9.394904	0.662251673	0.326264274	0.072790502	1.061306449
Moyan		109.4636	11.82727	34.86103	7.284768405	3.752039152	11.52572532	22.56253288
Ghiriya		49.94286	7.485714	15.90537	13.90728514	23.3278956	14.91706878	52.15224951
phansi		148	17	47.13376	1.98675502	0.489396411	2.74818125	5.224332681
Kuku		35.5	8.1	11.30573	1.324503346	0.326264274	0.105411353	1.756178974
jamrasi		26	6.4	8.280255	0.662251673	0.326264274	0.056542809	1.045058756
Achar		73	11.18	23.24841	3.311258366	0.978792822	1.33720397	5.627255158
Rohini		127	10	40.44586	1.324503346	0.326264274	1.349081306	2.999848926
Tondru		29.66667	6.9	9.447983	3.973510039	1.305057096	0.294461268	5.573028403
Gilchi		21	8.2	6.687898	0.662251673	0.163132137	0.018443327	0.843827138
Padar		25	3	7.961783	0.662251673	0.163132137	0.026138503	0.851522313
Bel		77.75	12.1	24.76115	1.324503346	1.305057096	2.022513686	4.652074129
Jamun		28	3	8.917197	0.662251673	0.163132137	0.032788138	0.858171948
Tondri		26	3	8.280255	0.662251673	0.163132137	0.028271404	0.853655215
Maharukh		63	6	20.06369	0.662251673	0.163132137	0.165989947	0.991373757
					100.00	**100.00**	**100.00**	**300.00**

Table B.2.1.2 Compartments (414, 413, 194, 225), Low Fire Category, Established and Unestablished Regeneration

Name	Botanical Name	Total Sampled	No of Individuals/Ha	Local Name	Botanical Name	Total Sampled Area	Individuals/ha
Lendia		0.76	394.74	Dudhi		0.014	171.43
Haldu		0.04	250.00	Achar		0.004	150.00
Tendu		0.96	416.67	Kari		0.016	562.50
Amaltash		0.36	97.22	Saaj		0.016	162.50
kari		0.56	187.50	Tendu		0.018	377.78
Palash		0.08	87.50	Ghatol		0.01	260.00
Teak		1.04	365.38	Kari		0.008	125.00
Jamūn		0.04	150.00	Jamun		0.004	600.00
bael		0.12	125.00	Dhaman		0.006	300.00
bamboo		0.12	25.00	Teak		0.01	180.00
Astara		0.04	25.00	dhawan		0.002	100.00
Ghiriya		0.84	386.90	Mahua		0.002	400.00
kuku		0.04	250.00	bael		0.014	242.86
kasai		0.04	100.00	Amaltash		0.006	100.00
Tondaru		0.32	175.00	kasai		0.004	100.00
Paddar		0.04	125.00	dhawdha		0.006	200.00
Sinduri		0.04	50.00	Ghiriya		0.042	742.86
			181.162	kusum		0.002	100.00
				aaita		0.002	300.00
				kuku		0.004	100.00
				Khareta		0.004	300.00
				jamrasi		0.002	100.00
				gilchi		0.004	300.00
				papad		0.004	300.00
				tondru		0.002	100.00
				kalmegh		0.008	575.00
				barmasia		0.002	300.00
				Sinduri		0.002	100.00
				Phansi		0.002	300.00
						0.232	**260.55**

Table B.2.2.1 Compartments (274, 275, 276, 285), Medium Fire Category, IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominace	IVI
Teak		56.2	11.551979	17.89809	23.8806	57.89474	27.09111	108.8664
Tendu		29.5	5.6833333	9.394904	2.985075	1.503759	0.193882	4.682716
Haldu		68.0	12.4	21.65605	1.492537	0.37594	0.257544	2.126021
Palash		32.1	9.8206667	10.21231	7.462687	4.135338	0.62999	12.22801
Lendia		74.5	12.75	23.72611	5.970149	2.255639	1.8548	10.08059
Amalatash		52.0	10.3	16.56051	1.492537	0.75188	0.30121	2.545627
Saja		171.8	19.244	54.70064	7.462687	6.390977	27.93356	41.78722
Podder		57.5	12.05	18.3121	2.985075	1.12782	0.552447	4.665341
Palash		41.7	7.8	13.26752	1.492537	1.12782	0.289997	2.910354
Lendia		74.5	12.75	23.72611	5.970149	2.255639	1.8548	10.08059
Amalatash		52.0	10.3	16.56051	1.492537	0.75188	0.30121	2.545627
Saja		171.8	19.244	54.70064	7.462687	6.390977	27.93356	41.78722
Podder		57.5	12.05	18.3121	2.985075	1.12782	0.552447	4.665341
Palash		41.7	7.8	13.26752	1.492537	1.12782	0.289997	2.910354
Kari		90.0	12.2	28.66242	1.492537	0.37594	0.451147	2.319624
Salai		94.4	15.08	30.06369	7.462687	2.631579	3.474364	13.56863
Bela		73.0	12.9	23.24841	1.492537	0.75188	0.593621	2.838038
Gathber		47.0	10.2	14.96815	1.492537	0.37594	0.123035	1.991512
Astara		77.0	6.2	24.52229	1.492537	0.37594	0.330229	2.198706
Aonla		67.3	11.633333	21.44374	4.477612	1.503759	1.010075	6.991446
Tinsa		44.5	11.325	14.17197	2.985075	1.879699	0.551472	5.416246
Achar		44.0	8.6	14.01274	1.492537	3.007519	0.862638	5.362694
Kusum		82.0	13.2	26.11465	1.492537	0.37594	0.374508	2.242985
Dhawda		99.2	24	31.59236	1.492537	1.503759	2.192384	5.188681
					100	**100**	**100**	**300**

Table B.2.2.2 Compartments (274, 275, 276, 285), Medium Fire Category, Established and Unestablished Regeneration

Name	Botanical Name	Total Sampled	No of Individuals/Ha	Local Name	Botanical Name	Sampled Area	individuals/ha
Teak		0.68	476.47	Bel		0.01	300
Lendia		0.56	214.29	Ghiriya		0.014	214.2857
Ghiriya		0.2	200.00	Teak		0.02	280
Tendu		0.36	80.56	Saja		0.02	780
Dhaoura		0.16	125.00	lendia		0.014	328.5714
Kari		0.24	108.33	Amaltash		0.006	100
kusum		0.04	25.00	Dhaman		0.016	125
Dudhi		0.16	187.50	Kari		0.022	463.6364
Bel		0.08	112.50	Kasai		0.022	572.7273
Tondaru		0.24	108.33	Tendu		0.012	366.6667
kumin		0.04	75.00	peeepal		0.002	100
kuku		0.28	239.29	Kusum		0.002	100
Saja		0.04	625.00	Dhaoura		0.012	333.3333
Amaltash		0.24	45.83	Jamun		0.002	100
Palash		0.16	75.00	Tondaru		0.004	150
Ghator		0.04	25.00	Kachnar		0.002	100
			170.19	Kulu		0.002	100
				Karanj		0.002	100
				Kakai		0.004	200
				Kharsali		0.004	150
				Tinsa		0.008	150
				Ashta		0.002	100
				Baranga		0.002	100
				Dudhi		0.006	266.6667
				Palash		0.006	233.3333
				Phansi		0.002	100
				Sheesham		0.004	100
				kuku		0.012	416.6667
				Gular		0.006	400
						0.24	**235.5478**

Species	Botanical Name	CBH (cm)	Hight (m)	GBH (CM)	Relative Frequency	Relative Density	Relative Dominance	IVI
Teak		72.21	11.52	22.99681529	23.25581395	37.96761586	48.14732831	109.3707581
Saja		137.5	20.50	43.78980892	2.325581395	1.116694584	5.134568859	8.576844838
Lendia		42.1	7.42	13.40764331	16.27906977	31.26744835	13.47785591	61.02437403
Tendu		31.8	4.40	10.12738854	4.651162791	2.79173646	0.686582666	8.129481917
Achar		112.5	11.80	35.82802548	4.651162791	1.116694584	3.437190724	9.205048098
Kari		67.7	11.04	21.56050955	18.60465116	6.700167504	7.468393184	32.77321185
Mahua		145	16.60	46.17834395	2.325581395	2.233389168	11.41996009	15.97893066
Ghiriya		3	153.50	0.955414013	4.651162791	10.66443328	0.023342344	15.33893841
Amaltash		28	5.77	8.917197452	6.976744186	1.675041876	0.31937867	8.971164732
Dhaman		39	9.20	12.42038217	4.651162791	1.116694584	0.413073943	6.180931318
Ghator		33.5	4.30	10.66878981	2.325581395	1.116694584	0.304781218	3.747057197
Baranga		100	14.20	31.84713376	2.325581395	0.558347292	1.357902508	4.241831196
Chichola		142.5	14.50	45.38216561	4.651162791	1.116694584	5.514781561	11.28263894
Bija		130	20.20	41.40127389	2.325581395	0.558347292	2.294855239	5.178783926
					100	**100**	**100.00**	**300.00**

Table B.2.3.1 Compartments (210, 211, 213, 240), High Fire Category, IVI

Table B.2.3.2 Compartments (210, 211, 213, 240), High Fire Category, Established and Unestablished regeneration

Local Name	Botanical Name	Samples area	individual/ha	Local Name	Botanical Name	Total Sampled area	Reg/ ha
Teak		0.32	375	Bael		0.002	100
Lendia		0.28	321.4286	Ghiryan		0.014	228.5714
Ghiriya		0.04	50	Lendia		0.01	140
Tendu		0.36	338.8889	Amaltash		0.002	100
Kari		0.08	150	Dhaman		0.008	125
Bael		0.04	125	Kari		0.004	100
Amaltash		0.24	66.66667	Kasai		0.002	200
Ghator		0.04	75	Tendu		0.012	400
Tinsa		0.04	50	Dhaora		0.008	125
Harra		0.2	35	kakai		0.004	100
			158.698	Tinsa		0.004	100
				Ghatol		0.01	180
				Ashta		0.004	100

				Baranga		0.002	100
				Dudhi		0.004	150
				Baheda		0.002	100
				Jamrasi		0.002	100
				Phendra		0.006	100
						0.094	**141.59**

Mandla

Table B.3.1.1 Compartments (1494, 1495, 1496, 1497), Low Fire Category, IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominace	IVI
Teak		84.24	14.77	26.83	23.21	48.39	45.13	116.73
Tendu		39.92	7.35	12.71	10.71	7.74	1.62	20.08
Haldu		57.00	10.38	18.15	7.14	3.23	1.38	11.75
Palash		70.67	8.77	22.51	5.36	2.58	1.69	9.63
Lendia		75.57	9.29	24.07	12.50	8.39	6.29	27.18
Amaltash		22.00	5.40	7.01	1.79	0.65	0.04	2.47
Saja		167.93	19.49	53.48	5.36	7.10	26.30	38.75
Podder		120.00	20.20	38.22	1.79	0.65	1.22	3.65
Kari		64.67	9.60	20.59	5.36	1.94	1.06	8.36
Salai		84.00	13.80	26.75	1.79	0.65	0.60	3.03
Gular		120.00	15.40	38.22	1.79	0.65	1.22	3.65
Bela		75.00	3.50	23.89	1.79	0.65	0.48	2.91
Aonla		71.50	12.65	22.77	3.57	1.94	1.30	6.81
Tinsa		46.00	11.25	14.65	3.57	2.58	0.72	6.87
Achar		44.00	8.60	14.01	1.79	0.65	0.16	2.60
Bahedha		180.00	20.20	57.32	1.79	0.65	2.75	5.18
Kusum		82.00	13.20	26.11	1.79	0.65	0.57	3.00
Dhawdha		63.48	14.20	20.22	5.36	9.68	5.13	20.16
Jamun		117.50	16.80	37.42	3.57	1.29	2.34	7.20
					100.00	**100.00**	**100.00**	**300.00**

Table B.3.1.2 Compartments (1494, 1495, 1496, 1497), Low Fire Category, Established and Unestablished Regeneration

Local Name	**Botanical Name**	**Total Sampled area**	**individulas/ha**	**Local Name**	**Botanical Name**	**Total Sampled Area**	Reg/ha
Teak		0.36	286.1111	Lendia		0.01	300.00
Tendu		0.36	202.7778	Dhawdha		0.014	357.14
Haldu		0.04	150	Tendu		0.014	457.14
Jamun		0.08	25	Chirash		0.004	400.00
Khisalu		0.04	25	Amaltash		0.008	375.00
Lendia		0.32	325	Teak		0.014	500.00
Saaj		0.04	100	Aonla		0.004	250.00
Palash		0.16	81.25	Saja		0.014	428.57
Amaltash		0.08	75	Gathber		0.006	333.33
Patto		0.12	58.33333	Jamun		0.008	250.00
Kari		0.04	25	Dhaman		0.002	200.00
		1.64	**123.0429**	Dudhi		0.002	100.00
				Bahedha		0.002	400.00
				Podder		0.002	400.00
				bael		0.006	266.67
				Tinsa		0.002	400.00
				Mundhi		0.002	400.00
				Achar		0.002	300.00
				Gilchi		0.006	133.33
				Kari		0.006	600.00
				Papadi		0.002	700.00
				Jamarasi		0.004	100.00
						0.134	**347.78**

Table B.3.2.1 Compartments (1292, 1295, 1296, 1297), Medium Category Fire Category, IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominace	IVI
Sal		74.50	15.81	23.73	9.71	29.61	38.01	77.33
Bija		255.00	25.00	81.21	1.94	0.43	6.45	8.82
Kumbhi		44.55	12.95	14.19	3.88	1.07	0.49	5.45
Saaj		72.58	14.49	23.11	10.68	10.94	13.33	34.95
Vedi		29.93	6.73	9.53	3.88	1.93	0.40	6.21
Lendia		40.80	11.85	12.99	12.62	28.33	10.90	51.85
Dhawda		63.86	15.20	20.34	4.85	1.50	1.42	7.77
kakai		26.50	7.00	8.44	1.94	0.43	0.07	2.44
Kari		40.00	8.95	12.74	1.94	0.64	0.24	2.82
Kundru		59.17	13.07	18.84	2.91	0.86	0.69	4.47
Amaltash		34.25	8.20	10.91	1.94	0.64	0.17	2.76
Aonla		51.38	10.50	16.36	3.88	2.15	1.31	7.34
Kurmi		60.00	7.00	19.11	0.97	0.21	0.18	1.36
Ghari		100.00	18.00	31.85	0.97	0.21	0.50	1.68
Dhaman		73.33	15.00	23.35	2.91	0.86	1.07	4.84
Karai		31.50	7.10	10.03	1.94	0.64	0.15	2.73
Chironji		45.79	8.19	14.58	6.80	2.36	1.14	10.30
Gunja		81.67	11.23	26.01	2.91	1.72	2.65	7.28
Saruta		27.00	3.00	8.60	0.97	0.21	0.04	1.22
Haldu		115.67	13.77	36.84	2.91	1.07	3.32	7.31
Teak		60.55	10.50	19.28	1.94	4.51	3.82	10.27
Dhaman		99.60	13.18	31.72	3.88	1.50	3.45	8.83
mudhi		70.80	9.70	22.55	0.97	1.93	2.24	5.14
mudhi		70.80	9.70	22.55	0.97	1.93	2.24	5.14
Mahua		83.38	12.85	26.56	5.83	2.58	4.14	12.54
Tendu		51.25	9.35	16.32	1.94	0.64	0.39	2.98
Bhelwa		72.00	10.00	22.93	0.97	0.21	0.26	1.44
guma		100.00	10.00	31.85	0.97	0.21	0.50	1.68
Palash		84.00	10.00	26.75	0.97	0.21	0.35	1.54
Paton		30.00	8.80	9.55	0.97	0.43	0.09	1.49
					100.00	**100.00**	**100.00**	**300.00**

Table B.3.2.2 Compartments (1292, 1295, 1296, 1297), Medium Category Fire Category, Established and Unestablished Regeneration

Local Name	Botanical Name	Total Sampled area	Individual/ha	Local Name	Total Sampled Area	Reg/Ha
Lendia		0.64	251.56	dudhi	0.022	863.64
Sal		0.32	490.63	Achar	0.002	200.00
Haldu		0.04	25.00	Sal	0.02	2840.00
Tendu		0.4	135.00	Ara-angur	0.006	133.33
Chironji		0.12	41.67	karai	0.012	300.00
Kundru		0.24	162.50	bai ber	0.006	166.67
amaltash		0.32	71.88	Fitkari	0.004	600.00
Karai		0.32	296.88	charthia	0.002	100.00
Vedi		0.2	140.00	saaj	0.022	400.00
bhelwa		0.04	25.00	pandri	0.002	100.00
palash		0.16	68.75	badhi	0.002	100.00
Saaj		0.12	183.33	kakai	0.012	216.67
redhi		0.04	200.00	Tendu	0.012	300.00
Dhawadha		0.04	25.00	Ghatol	0.02	120.00
Aonla		0.04	25.00	Kari	0.006	133.33
Teak		0.08	487.50	Chidiya	0.004	150.00
kumbhi		0.04	50.00	Jamun	0.012	566.67
jamun		0.08	62.50	Bija	0.006	100.00
Bael		0.04	125.00	Vedia	0.002	100.00
Mahua		0.04	25.00	Papdi	0.006	300.00
Konda		0.04	50.00	palash	0.004	100.00
Kannja		0.04	25.00	redhi	0.002	100.00
pathon		0.08	87.50	baigania	0.002	100.00
Dhaman		0.04	50.00	surabadhi	0.002	100.00
kakai		0.04	75.00	dhaman	0.02	450.00
ghatol		0.04	25.00	lendia	0.014	128.57
ledhi		0.04	75.00	baheda	0.002	100.00
mahua		0.04	25.00	teak	0.002	100.00
papdi		0.04	100.00	khasi	0.002	100.00
jamarasi		0.04	25.00	mahua	0.002	100.00
		3.76	**114.32**	kuku	0.002	1000.00
					0.234	**328.03**

Table B.3.3.1 Compartments (1503, 1512, 1513, 1522), High Category Fire Category, IVI

Name	Botanical Name	CBH	Height	GBH (CM)	Relative Frequency	Relative Density	Relative Dominace	IVI
Teak		48.43	9.67	15.42	16.67	39.82	24.00	80.49
Tendu		42.64	4.06	13.58	10.00	8.85	4.13	22.98
Haldu		119.75	10.00	38.14	3.33	1.77	6.52	11.62
Palash		127.00	6.00	40.45	1.67	0.44	1.83	3.94
Lendia		121.66	24.41	38.75	6.67	6.64	25.24	38.54
Amaltash		23.17	6.00	7.38	5.00	1.77	0.24	7.01
Saja		72.39	12.08	23.06	10.00	5.75	7.75	23.50
podder		130.00	12.00	41.40	1.67	0.44	1.92	4.03
Palash		127.00	6.00	40.45	1.67	0.44	1.83	3.94
Kari		53.25	9.80	16.96	3.33	1.33	0.97	5.63
Aonla		85.25	9.00	27.15	1.67	1.33	2.48	5.47
kusum		67.17	7.50	21.39	3.33	1.77	2.05	7.15
Dhawadha		50.92	9.20	16.22	11.67	20.80	13.85	46.31
Gilchi		35.50	7.50	11.31	3.33	0.88	0.29	4.50
Khasi		80.00	12.00	25.48	1.67	0.44	0.73	2.84
Gyrujha		107.00	10.00	34.08	3.33	0.88	2.60	6.82
Ghatia		31.50	4.50	10.03	1.67	0.88	0.23	2.78
Kosam		35.00	6.40	11.15	1.67	0.44	0.14	2.25
Patoh		30.00	5.20	9.55	1.67	0.44	0.10	2.21
Jamun		62.25	7.08	19.82	3.33	2.21	2.20	7.75
Jamarasi		31.00	6.20	9.87	1.67	0.44	0.11	2.22
Parada		40.00	5.50	12.74	3.33	0.88	0.36	4.58
Harra		35.00	8.33	11.15	1.67	1.33	0.42	3.41
					100.00	**100.00**	**100.00**	**300.00**

Table B.3.3.2 Compartments (1503, 1512, 1513, 1522), High Category Fire Category, Established and Unestablished Regeneration

Local Name	Botanical Name	Total Sampled Area	Individual/Ha	Local Name	Botanical Name	Total Sampled Area	Reg/Ha
Teak		0.4	457.50	Lendia		0.008	250.00
Tendu		0.4	175.00	Dhawda		0.006	166.67
haldu		0.04	50.00	Tendu		0.008	250.00
Jamun		0.08	87.50	Amaltash		0.004	150.00
Lendia		0.32	115.63	Teak		0.006	233.33
Saja		0.12	41.67	Saja		0.004	150.00
Palash		0.04	25.00	Gathber		0.004	150.00
Amaltash		0.36	108.33	jamun		0.002	100.00
Patto		0.08	112.50	Dhaman		0.004	2100.00
Saja		0.12	41.67	Shisham		0.002	100.00
Dhaman		0.08	125.00	Dudhi		0.002	100.00
Dhawda		0.2	160.00	khansi		0.002	200.00
Gilchi		0.12	75.00	bael		0.004	300.00
Jamarashi		0.16	75.00	Gilchi		0.004	400.00
Bela		0.04	25.00	papadi		0.01	360.00
Podder		0.04	100.00	kari		0.002	100.00
Papada		0.04	25.00	ptoh		0.01	480.00
Harra		0.08	237.50	kusum		0.004	150.00
Vadra		0.04	100.00			**0.086**	**318.89**
		2.76	**112.49**				