

ANALYSING THE OCCURRENCE AND DISTRIBUTION OF FOREST FIRE

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INTRODUCTION

1.1. Background

Throughout history, fire has been an essential part of human life. In the book, „The Descent of Man“, Charles Darwin describes the discovery of fire as „probably the greatest thing ever made by man, excepting language (Darwin, 1882). Fire has been closely associated with mankind from the beginnings of civilization. Humans have long used fire as a forest management tool, whether for hunting, to clear land for agriculture, to promote the growth of fodder for grazing livestock, or to facilitate their collection of non-timber forest products (NTFP). Forests are a major natural resource, which play crucial role in maintaining environmental balance. The health of forest in any given area is a true indicator of the ecological condition prevailing in that area. Forest fires are harmful to the ecological environment, which have induced global attention. Forest fire destroy many more trees than all other natural calamities, parasite attacks, insects, frost, etc. (Alexanderian *et al.* 1999). Frequent occurrence of forest fires has been one of the major reasons for the depletion and extinction of most of our valuable plant and animal species. Even human beings are adversely affected either directly or indirectly by these killer fires. Many argue that fires also contribute to global warming through the emission of carbon dioxide (CO₂). Thus forest fires are considered to be a potential hazard with physical, biological, ecological & environmental consequences.

Every year million hectares of forested land are burned either naturally or manmade, intentional or unintentional. There are many factors that contribute the fire risk such as: Fuels (leaves, needles, grass, branches and logs) (Sam et al. 2021; Sam et al. 2022), Climatic factor including (temperature, humidity, precipitation and wind), Topography or landscape of the area, as steep slopes offer greater potential for increased fire intensity and more obstacles for fire fighting. Natural factors (e.g. Thunderstorms) of fire are not reported. Climatic regime determines the region's vegetation and hence, plays a dominant role in creating fire prone areas. An increase in temperature increases the chances of fire, whereas rainfall and humidity have the opposite effect (M.G.R. Cannel, 1999). Globally, 1997 and 1998 were the worst years for wildlife and forest fire in the recent times. Although forest fire occur every year in the arid and semi-arid zones of the world, nearly all types of forest burnt in 1997-1998, even some

tropical rain forests which had not burned in recent memory. In 1997, wildfires ranged in Indonesia, Papua New Guinea, Australia, The Russian Federation, Mongolia, Kenya, Rwanda Columbia, Peru and other part of Africa. By mid-1998, were reported in Indonesia, The Amazon, Mexico and Central America, USA, Western Canada, Russian Far East and parts of Europe as a Nation Disasters in many of these places and national and international resources were mobilized to fight the fire. (FAO, 2001). This fire incident have stimulated various international effort related to fires. A global system of early warning to indicate the potential fire risk related to climatic condition is being investigated by several international organization including WHO, ICUN, UNEP and FAO.

Forest fires are one of the most important factors that threaten forest in Nepal. An increase in the trend of occurrence of extreme natural hazards and disasters directly or indirectly related to forest fires has been observed and fatal accidents resulted in human casualties have occurred in the events for the past several years. The extent of biomass burning has increased significantly over the past 100 years due to anthropogenic disturbances and has become much more frequent and widespread. The burning of the world's living and dead biomass for land clearing and land-use change is a significant global source of atmospheric gases and particulates that impact the chemistry of the troposphere and stratosphere and the climate of our planet (Beringer *et al.* 2003).

Although fire under control may be a beneficial (Thapa 2018), uncontrolled fire is always harmful. Therefore, fire is neither destructive nor constructive; it simply causes changes. Whether these changes are viewed as desirable or not depends upon their compatibility with overall objectives (Wade & Lundsford, 1990, Thapa 2022). The most fires today are likely to be human-caused, the reasons could be manifold. By and large, forest fires are linked to the benefits that people obtain from forests. To a lesser extent, forest fires are linked to people's religious beliefs or cultural practices. People have also been known to use fires as a form of protest against restrictive forest policies. In addition, forest managers use fire as a habitat management tool for instance, to maintain grasslands for herbivores. People set about 64% of fires intentionally; about 32% of fires are due to accidental/carelessness, and about 4% by unknown causes (Sharma, 1996).

The widespread occurrence of fires in forests is still lack precise information regarding fire occurrence, fire frequency, fire intensity, and the exact causes of fire. Due to the fact that objective tools are required in pre-fire planning in order to monitor when and where a fire is more likely to occur, or when it will have more negative effects, the most and critical part of fire prevention is the evaluation of fire risk (Chuvieco *et al.* 2000). A detailed understanding of the spatial patterns of natural and human-induced processes is important to be able to identify forest fire prone areas.

Active fire incidents and total burning days are increasing in Nepal from the recent past impacting huge loss of lives, properties and natural resources. Forest fire is considered one of the climate induced disasters in the National Adaptation Programs of Action (Nepal NAPA, 2010).

As mentioned, forest fire predominantly occurs within this Terai region, with districts such as Chitwan, Nawalparasi and Palpa particularly badly affected (ICIMOD, 2010). No data are reliable until and unless we have appropriate methods and techniques to measure and calculate the burnt area and burnt area products. To achieve this requirement, Satellite data have been used to monitor biomass burning at regional to global. As Forest fire research can be considered as one of the most appropriate areas, where Geographic Information System (GIS) approach can be effectively applied. GIS can take definite advantage of the computer's capability in processing, storage and retrieval of immense data. The use of the GIS approach facilitates in integrating several variables in order to establish and focus on the problem. At the same time, it makes it possible to update or retrieve spatial information in different ways included in the database, to develop various models. It has been stated that when it comes to spatial decision aid, the analytical capability of the GIS has to be enhanced in respect of semi-structured problems involving subjective judgments (Beedasyl *et al.* 1999). This can be strengthened by any GIS application, which is most appropriate for that site specific condition.

1.2. Statement of problem:

Whether natural or human caused, forest fire can be a catastrophic phenomenon responsible for burning millions of hectares globally every year, and causing billions of dollars of damage (Cochrane, 2002). Trans-boundary forest fire and haze pollution

is an emerging issue in south Asia. Moreover, fire is the most important disturbance agent in global vegetation cover worldwide, affecting between 3 and 4 million square kilometres annually (GFMC, 2009). In developing countries forest fire science is poorly developed (Tacconi *et al.* 2007). There is still a lack of understanding of the fire phenomenon, its impacts and what should be done to address these problems. There are no comprehensive data on different dimensions of fire, such as fire behaviour, loss of ecological and economic values and regeneration status. In addition, the contribution of forest fires to carbon emissions has not been included in the national inventories of greenhouse gas emissions of most developing countries (Fearnside, 2009). A study done by IFFN (2006) revealed that the number of forestfire occurrences in Nepal was increasing in relation to increased dryness in the forest, and the middle hills region was identified as one of the areas where forest fires are the major driver of forest degradation.

In 2009, the National Aeronautics and Space Administration (NASA) listed Nepal as a country "most vulnerable to wildfires" with the highest number of forest fires in a day-at 358 places on April 25. The Intergovernmental Panel on Climate Change (IPCC) also recently dubbed the Nepal region as a "white spot", as so few studies have been conducted, and little data is available (Khadka, 2009).

Every year wildfires destroy considerable forest resources in Nepal. Such destruction includes both timber and non-timber forest products. Although quantitative information is not available, forest fires are definitely degrading biological diversity in Nepal's forests. In addition, fires cause soil erosion and induce floods and landslides due to the destruction of the natural vegetation.

Occasionally, embers from forest fires also cause fires in nearby villages, especially in the Terai region where the roofs are made of thatched grass. Many villages are burned every year with loss of lives, cattle and other property (Bajracharya, 2001).

Thus, this research will focus on getting the answer of the following research questions; what is the frequency of forest fires and its distribution? What is the condition of forest cover that contributes to forest fire? Are nearby villages and roads responsible for forest fire? What are the causes and consequences of forest fire?

1.3. Rational of study:

Developing countries are often the most susceptible to the damaging impacts of fire which causes loss of human lives and property and destruction of natural resources annually. Government of Nepal does not have exact forest fire data, very less systematic and scientific studies regarding forest fire have been done in the past days. Attacking fire from the air is an effective way of controlling fires, but Nepal has few aircraft that can adequately achieve this. In order to reduce the number of fires, or to ensure their effective control, it is necessary to have an understanding of which areas are most prone to fire damage (Chen *et al.* 2001). Recognizing the above problems and lacking of fire related research in Nepal this study was proposed to overcome the data deficient on forest fire. This study was focused on identifying the frequency of forest fire, occurrence and distribution of forest fire, identifying the bio-physical attributes that are responsible for forest fire and its consequences. This study also utilized the data given by MODIS to search fire regions in forest so that effective ground verification was done on forest of Palpa district and data given by NASA is merged to obtain high accuracy and valid result.

1.4. Objective:

Management of forest fire is technological and resource problems in Palpa district.

The **general objective** of this research is to find out the distribution and occurrence of forest fire by means of using the MODIS data.

Specific objectives:

1. To find out the spatial distribution of forest fire.
2. To verify the fire detected data given by MODIS.
3. To assess the bio-physical attributes of fire occurrence.

1.5 Limitation of this study:

Earlier fire studies have found that MODIS fire products are suffering from commission and omission errors. Commission errors for MODIS fire products was caused by non-fire surfaces that are highly reflective or where sharp contrast exist, e.g. between desert and vegetation. MODIS fire products also suffer from high omission error due to persistent cloud cover; difference between the time of fire occurrence and satellite overpass and too coarse pixel size to detect small patchy fires (e.g. Roy *et al.* 2008). Therefore, it must be kept in mind that without ground truth accurate burned area cannot be detected and therefore burned area comparison results was interpreted somewhat cautiously. This study cannot measure the actual loss of forests, wildlife, and other biological diversity and

ecosystem of an area but can only answer the mentioned research questions. And at last this study has been carried out for the partial fulfillment of the requirement of the B.SC Forestry. Therefore, detailed research was not possible due to the lack of sufficient resources within such a short period.

CHAPTER TWO: LITERATURE REVIEW:

2.1. What is forest fire?

Technically, fire is a state, process, or instance of combustion in which fuel or other material is ignited and combined with oxygen, giving off light, heat, and flame. It is a rapid, persistent chemical change that releases heat and light and is accompanied by flame, especially by the exothermic oxidation of a combustion substance. There are three conditions that need to be present in order for a forest fire to burn, which refer to the fire triangle: fuel, oxygen, and a heat source. Fuel is any flammable material surrounding a fire, including trees, grasses, brush, even homes. The greater an area fuel load, the more intense the fire is. Air supplies the oxygen to the fire that needs to burn. Heat sources help spark the forest fire and bring fuel to temperatures hot enough to ignite. Crown fires, surface fires, and ground fires have different heat release and spread rate characteristics. Containing and extinguishing the fire poses a unique challenge because it burns in highly flammable peat land.

Uncontrolled blazes fueled by weather, wind, and dry underbrush, forest fires can burn acres of land and consume everything in their paths in mere minutes. Severe forest fires have occurred in many countries in Asia, Africa, Europe, North America, South America and Australia. Six million km² of forest have been lost around the world in less than 200 years mainly due to forest fire (Dimopoul & Giannikos). On average, more than 100,000 forest fires, clear 4 million to 5 million acres (1.6 million to 2 million hectares) of land in the U.S. every year. In recent years, forest fires have burned up to 9 million acres (3.6 million hectares) of land. A forest fire moves at speeds of up to 14 miles an hour (23 kilometres an hour), consuming everything trees, brush, homes, even humans in its path.

The Mediterranean basin is marked by a prevalence of human induced fires, i.e. about 95% of fires (FAO, 2007). Fires can be set voluntarily or involuntarily. In some cases they are initiated for criminal reasons, in many others they are related to agricultural and forestry activities (e.g. fires for agricultural clearing that go out of control). These factors are also exacerbated by climate conditions, as Southern Europe is usually characterized by hot and dry summers, associated with high levels of fire hazard. Furthermore, research on climate change indicates that increased fire hazard is likely to arise from global warming (FAO, 2007). Fires globally consume about 5% of net

annual terrestrial primary production per annum, and release about 2-4 billion metric tons of carbon (C) per year. Approximately 0.6 billion tons of carbon emitted to the atmosphere come from tropical deforestation and peat fires, the global figure is equivalent to about 20-30% of global emissions from fossil fuels (GFMC, 2009).

2.1.1 Types of Forest Fire:

Ground Fires: A ground fire consumes the organic materials beneath the surface litter of the forest floor. It may and often does follow a surface fire, depending on the moisture content of organic layer.

Surface fire: A surface fire is “a fire that burns surface litter, other loose debris of the forest floor and small vegetation”. This is the most common type of fire in timber stands of all species. It may and often does burn up into the later vegetation and tree crowns as it progresses.

Crown fire: A crown fire is “a fire that advances from top to top of trees or shrubs more or less independently of the surface risk” (Brown & Davis, 1973). This is the most spectacular kind of forest fire. Since it is the over heads of ground forces it is uncontrollable until it again drops to the ground. In timber, crown fires can spread 5 or more miles per hour so it is usually passes fast moving and poses great danger to the fire fighter and wildlife in its path.

2.1.2 Factor of forest fire;

There are various factors which affect the forest fire. Some of them are shortly describe below

Topography: By topography we generally refer to the landscape type that is slope, aspect and elevation

Slope: The slope is a gradient of land and is generally expressed in % or in degree. Highly sloping terrain accelerates the spread of fire. Among all factor slope is considered to be the most critical. A fire burning up to slope of +20 to +39% will spread twice as fast a fire on level terrain (Brown & Davis, 1973)

Aspect: This refers to the direction of the slope which in turns determines the intensity and amount of sunlight received by that face. Generally, the slope facing the north is

cooler while that facing the South is warmer. The direction of the slope (aspect) determines how much sunlight is received.

Elevation: Elevation is the height of the land from the sea-level, generally the higher the elevation, it is assumed that it will be cooler than the areas at lower elevation.

(A) Climatic factor:

Relative humidity: It is the expression of the amount of moisture in the air compared to the total amount that is capable of holding at that temperature and pressure. When RH falls below 30% the beginning is intense and the danger from fire is also present when the relative humidity is 60% a fire may cause (Brown & Davis 1973, Artsybashev 1983 & Antoninetti 1993)

Temperature: Temperature strongly affects the moisture content in forest fuels quickly. An area where the crown density is high will keep the ground cooler as it is less exposed to direct sunlight, cleared areas are often burned when the air temperature is high (Brown & Davis 1973, Artsybashev 1983 & Antoninetti 1993)

Precipitation: Rainfall has effect on both fuel moisture and soil moisture. It is thus, important to have an estimate of rainfall on an area in order to prevent fire during the long stretches of dry weather.

Wind Speed: Wind speed affects the burning rate of fuel density by influencing the rate of oxygen supply to burning fuel. Wind is one of the most important factors because of oxygen it can bring a fresh supply of oxygen and also put the blaze toward a new fuel source.

2.1.3 Causes of fire:

The cause of Forest fire can be classified into natural and manmade depending upon origin.

Natural made cause of forest fire: Climate and vegetation cover are the main reasons for natural forest fire. A typically tropical and sub-tropical type of climate with high temperature in the summer month with strong dry wind favours these types of forest fire. Along with this the dry vegetation covers or flammable vegetation like pine and other coniferous forests, which contain resiniferous chemical, are highly inflammable.

About 8% of bush fire occurs in Australia due to natural cause forest fire. But in Nepal natural cause of fire was not reported yet.

Manmade cause of forest fire: The forest fires are caused by both callous and intentional human actions. Burning forests for the purpose of cultivation is common all over the world (e.g. Sifting cultivation). Some of the other anthropogenic causes are grazer, hunter, campfires, cigarettes and matches, domestic ignition also a motor vehicle.

2.2 Status of Forest fire in Nepal:

Nepal is a small country of 14.7 million hectares and has a topographic variation from 150 meters above sea level at the southern border to the highest mountain in the world (Everest at 8 848 m) in the north. Due to the east-west orientation of the mountain ranges, the country has a tropical climate in the south and temperate and alpine climates in the north. Accordingly, there are many different forest types in Nepal. (Bajracharya, 2001)

In terai-bhabar region, the main forest type comprised of Sal (*Shorea robusta*) with smaller proportions of moist evergreen forest, dry deciduous forest, and Khair-sisoo (*Acacia catechu*/*Dalbergia sissoo*) forest. In this region, the accumulated glabrous Sal leaf litter is burned every year and during the process naturally regenerated Sal seedlings and other herbs and shrubs are burned. However, larger green trees are usually not damaged and neither are the root systems of the Sal seedlings, although the aerial parts are burned. Sal forests appear to be able to regenerate only when there are no surface fires.

The Siwaliks Hills and the Inner Terai Region, It is characterized by a subtropical climate. It consists of mixed forest type according to Siwalik hill to inner terai. In this region, the vegetation along the southern drier slopes is burned during the dry season starting in March. Occasionally, bamboo brakes and grassy areas are destroyed, but the larger trees are usually spared.

The middle Mountain Region, It has mostly lower temperate forests. Usually the pine forests and pine plantations, which are more susceptible to fire due to resin content, are frequently burned. As a result, the extensive Chir pine (*Pinus roxburghii*) forests, which grow in the main habitat zone between 1 000 to 2 000 m, have become greatly fragmented.

The High Mountain Region, it comprised coniferous forests are susceptible to extensive fire damage during the dry season, especially on windy days.

High Himal Region, the fire problems are acute for three to four months during the dry period between March and June every year. In most cases fires are caused by negligence. Sometimes grazers burn dry grassy areas purposely in order to get young shoots immediately after the first few pre-monsoon showers.

In Nepal, forests cover 25.36% of total land area of the country (2010; World Bank); and the data from the Food and Agriculture Organization of the United Nations (FAO) shows that Nepal's forest area has decreased from 4.8 million hectares to 3.6 million hectares over twenty years from 1990 – 2010 (FAO, 2011). Forest fires occur throughout Nepal during the dry season from February to May large numbers of incident of fire are reported and results the deforestation of around 1.7 per cent of the total forest area annually. It is estimated that more than 400,000 ha of forest area in Nepal are burnt annually (IFFN). According to a report by NBS (2002), there is no systematic and complete record of the occurrence of forest fires and affected areas in Nepal.

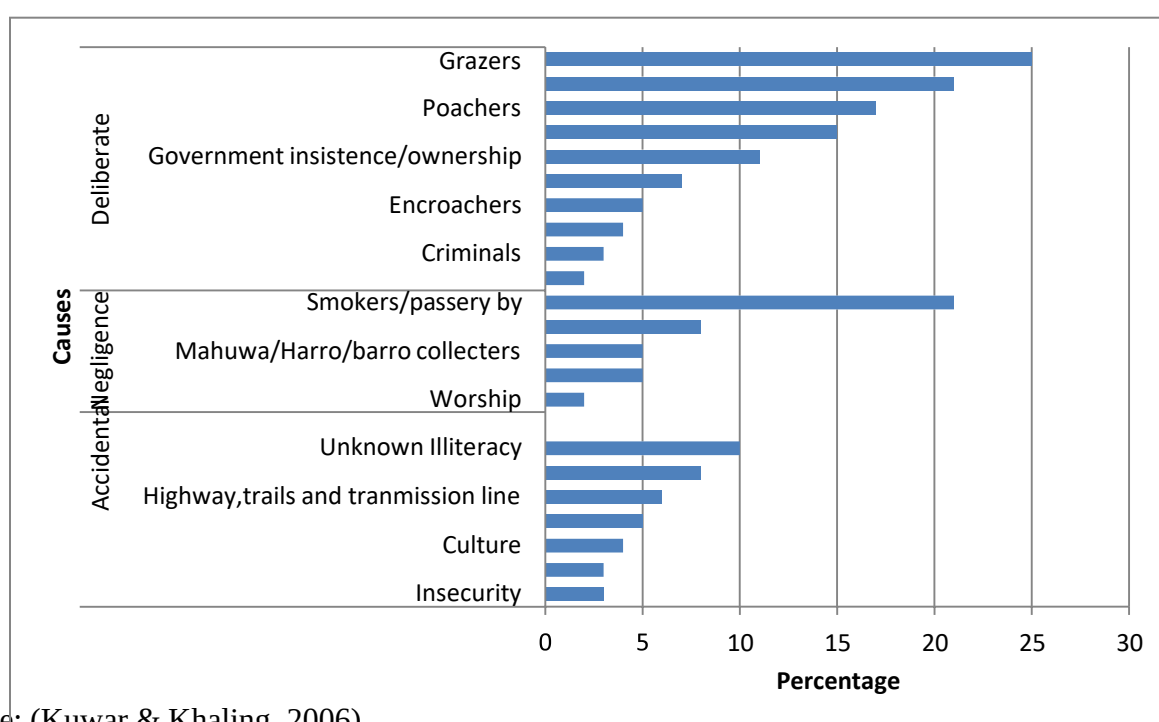
2.2.1 Wildfire database:

A wildfire database or other wild land fire statistics are not available. However, the magnitude of the forest area annually affected by fire is known. Sharma (1996) observed that in 1995 about 90 % of the Terai forests were burned. Earlier observations by Goldammer (1993) confirmed this statement. Accordingly, the forest area burned annually must be in the order of more than 400 000 ha. (Bajracharya, 2001)

2.2.2 Causes of forest fire in Nepal:

The causes of forest fires vary and the outcomes are always unique, all forest fires can be characterized in terms of their physical properties, their fuel type, and the effect that weather has on the fire. Forest fire behaviour and severity result from the combination of factors such as available fuels, physical setting, and weather. The majority of forest fires are caused by human activities and very few fires are naturally caused in Nepal (NBS, 2002). Most of the forest fires are intentional for land conversion, timber harvesting, and socio-economic conflicts over question of property and land use right, deforestation activities (conversion of forest to other land uses; e.g.

agriculture land, pasture) grazing land management (fire set by grazers), use of non- wood forest product (use of forest fire to facilitate harvest or improve yield of plant, fruit and other forest product), settlement fire (fire from settlement, e.g. from cooking, torches, campfires“ etc.) and other traditional fire uses (in the wake of religious ethic and folk tradition, tribal warfare) and also by discarded cigarette butts of illegal loggers, passer- by, cattle herders and grazer. Karkee (1991) observed that 40% of forest fires in the mid-hills are caused by accidents while 60% are started deliberately. Cattle grazing for new grass and smokers alone share about 45% of fires among all known causes of forest fires.



Source: (Kuwar & Khaling, 2006)

CHAPTER THREE: MATERIAL AND METHODOLOGY:

3.1 Overview of study Area:

This research will be carried out in some places (Municipality and VDC) of Palpa District which is located on the Western Region of Nepal with geographical coordinate 27°52'N and 83°33'E and total area of 1,373 km² supporting total population of 268,558 (NBS, 2001). Palpa is situated in at the southern slope of the Mahabharata range, and the Himalayas. This district ranges between 300m to 6000m. The area is covered with thick green forest, mainly Sal, Pine and other varieties of forest along with grass and shrubs. These forests are divided into three types according to the geographical region. They are Chure (cover 25.7 %), Mahabharata (47%) and Kaligandaki.

This study was conducted in some places of Palpa district which was prone of forest fire.

Fig shown in the below is the study area.

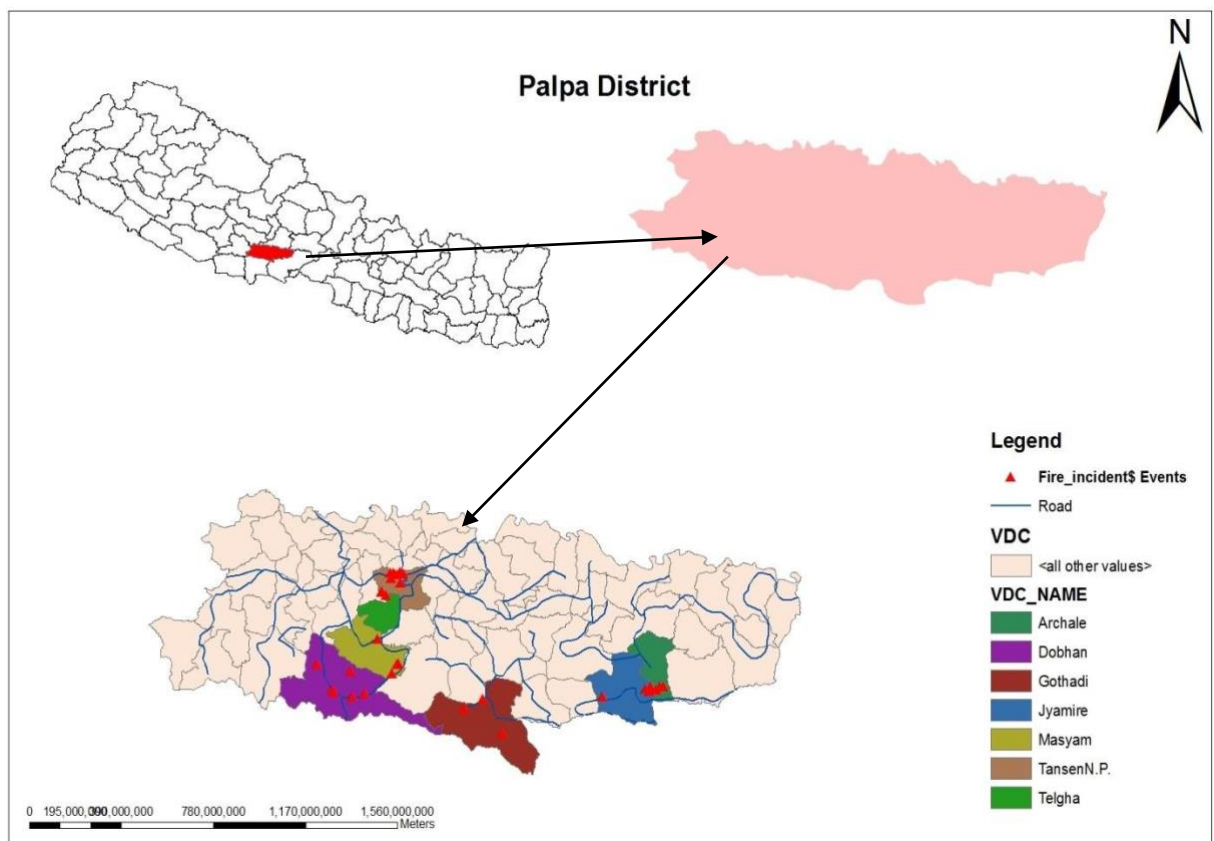


Figure 1 Study Area

3.2 Methodology:

This study was carried out by analysing the primary data and review complied and collected the existing literatures. Field visit, group discussion, informal interview, meeting, survey, checklist and scaling and ranking were employed as tools for primary data collection. Secondary data was collected from NASA.

3.2.1 Data Collection:

(A) Primary Data: The seven place of Palpa District; Municipality (Tansen) and VDC (Telgha, Dobhan, Masyam, Gothadi, Jamire, and Archale) where the study was conducted. Field visit, group discussion, informal interview, survey, was conducted in those places and also bio-physical data was collected as well as ground verification was done with the data given by the NASA.

Also semi-structured questionnaire survey was conducted with the group members of community forest and other related authority to know the actual condition of the forest fire.

(B) Secondary Data:

Data acquisition: As it was based on GIS interpretation data which downloaded from NASA's official website. Fire Information for Resource Management System (FIRMS) provides the information of active fires using the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on board NASA's Aqua and Terra Satellite. With the help of data provided by NASA, the main place that was prone of forest fire was identified. After that the cross check ground truth verification was done.

Data analysis: Occurrence of forest fire was analyzed according forest types, crown cover, ground litter, slope aspect, time etc.

Ground Verification: Data given by NASA was verified by doing random verification in certain areas of the district for the valid result. GPS point obtained from NASA and from the field was overlaid.

Burnt area Detection: ARC GIS 10.1 was used to identify all the burnt area of Palpa district.

Research Design:

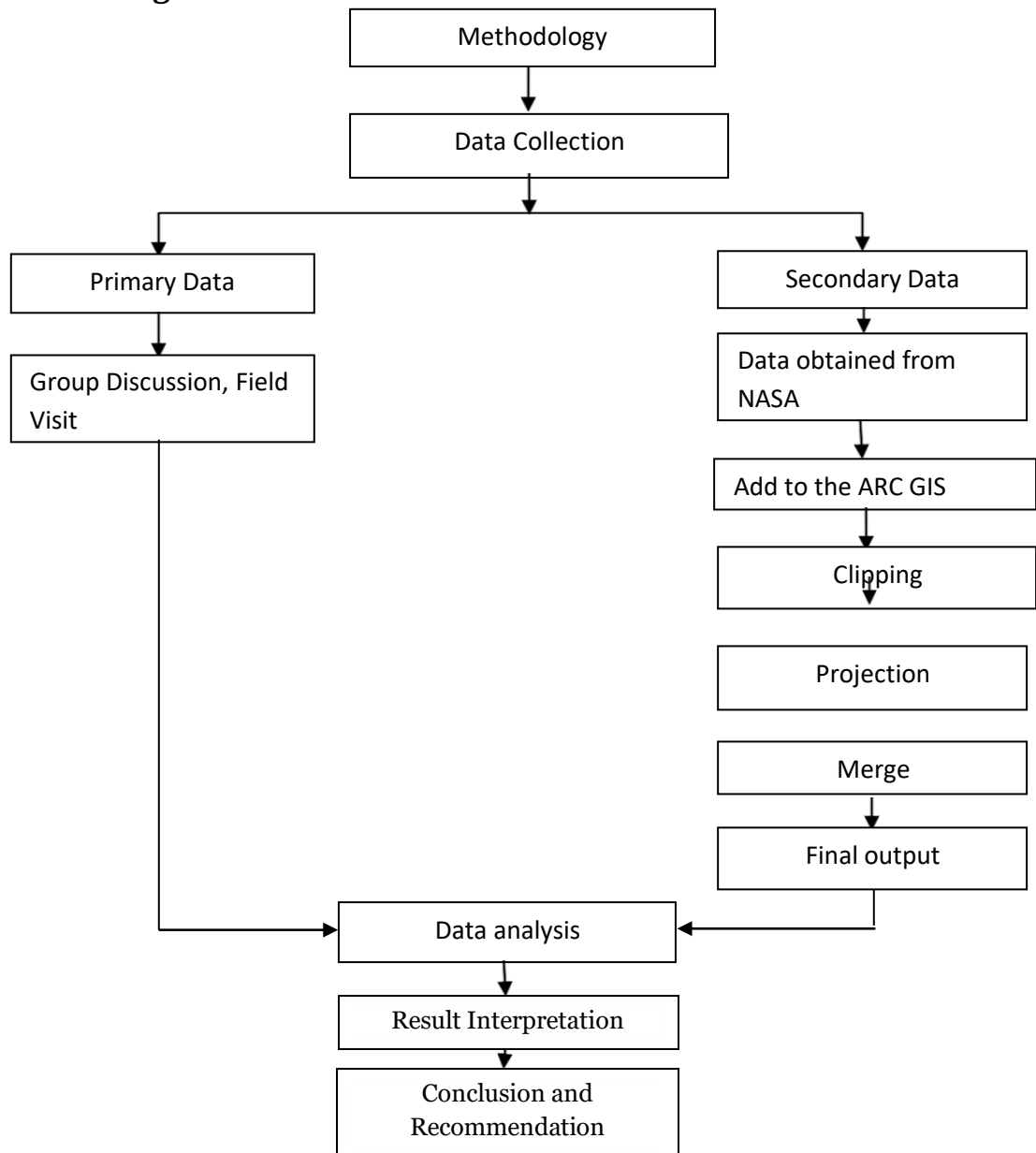


Figure 2 Flow chart of the Research Design

3.2.2 Development of fire Burnt area model:

Digital elevation model, longitude, latitude, slope and aspect were used to find out the regression. Slope and aspect image were generated using the DEM data. Aspect and slope plays a vital role in spreading of the fire. Bio-physical attributes are also used to identify the burnt area.

CHAPTER FOUR: RESULTS AND DISCUSSIONS:

4.1 Results:

4.1.1 Distribution of Forest Fire:

According to the finding, the distributions of forest fire in this District with their respective VDC and Ward as well as the name of community forest are as given below table:

Table 1: Distribution of Forest Fire in Palpa District

VCD/Municipality	Ward No.	Name of Community Forest(CF)	No. of fire incidents
Dobhan	3,4,5,6	Arghachhap CF, Shinary CF, Satpatera CF, Ranibash CF	4
Gothadi	5,7	Alichhi CF, Hattilungh CF	2
Masyam	4,7	National forest, Kalsebasbari CF	1
Tansen	4,5,6,7,8,10,11,12	Deurali CF, Kailash Basanta CF, Shreenagar Ganesh CF, Bhusaldada CF, Bandevi CF	5
Telgha	9	Belautichaur CF	1
Jyamire	1,2,7,8	Dhaunepakha CF,Dhupdada CFRukshepakha CF	4
Archela	4,6,7,	Chhatiban Salghari CF, Chaurdada CF, Lakuribhanjhan CF	3

It was observed that most of the fire was occurred in Tansen and Dobhan i.e. (n=5) and (n=4) respectively.

4.1.2 MODIS data verification:

As per MODIS fire data the number of fire incidence within the different VDC/ municipality of Palpa District are identify and field verification was done on those areas and the result was as given below:

Table 2: No. of fire incidents with respect to their VDC

VDC/Municipality	No. of fire incident (By MODIS)	Verified Results
Archale	3	Yes
Dobhan	1	Yes
Tansen	0	Yes
Gothadi	1	Yes
Jyameri	4	Yes
Masyam	1	Yes
Telgha	0	Yes

From the field verified data about 80% was found accurate and 20% was not detected as the data given by the MODIS.

4.1.3 Fire occurrence location characteristic:

Almost all the study area has a different feature which has a significant role in forest fire. The study area was overviewed on the basis of slope, aspect, distance and human interference.

Slope Index:

Most of the study area was steep in nature. As the GPS point of those area as well as MODIS data was over-layed on DEM (Digital Elevation Model) and derived the slope of the area. The fire occurrence on the basis of slope was as given in the figure below:

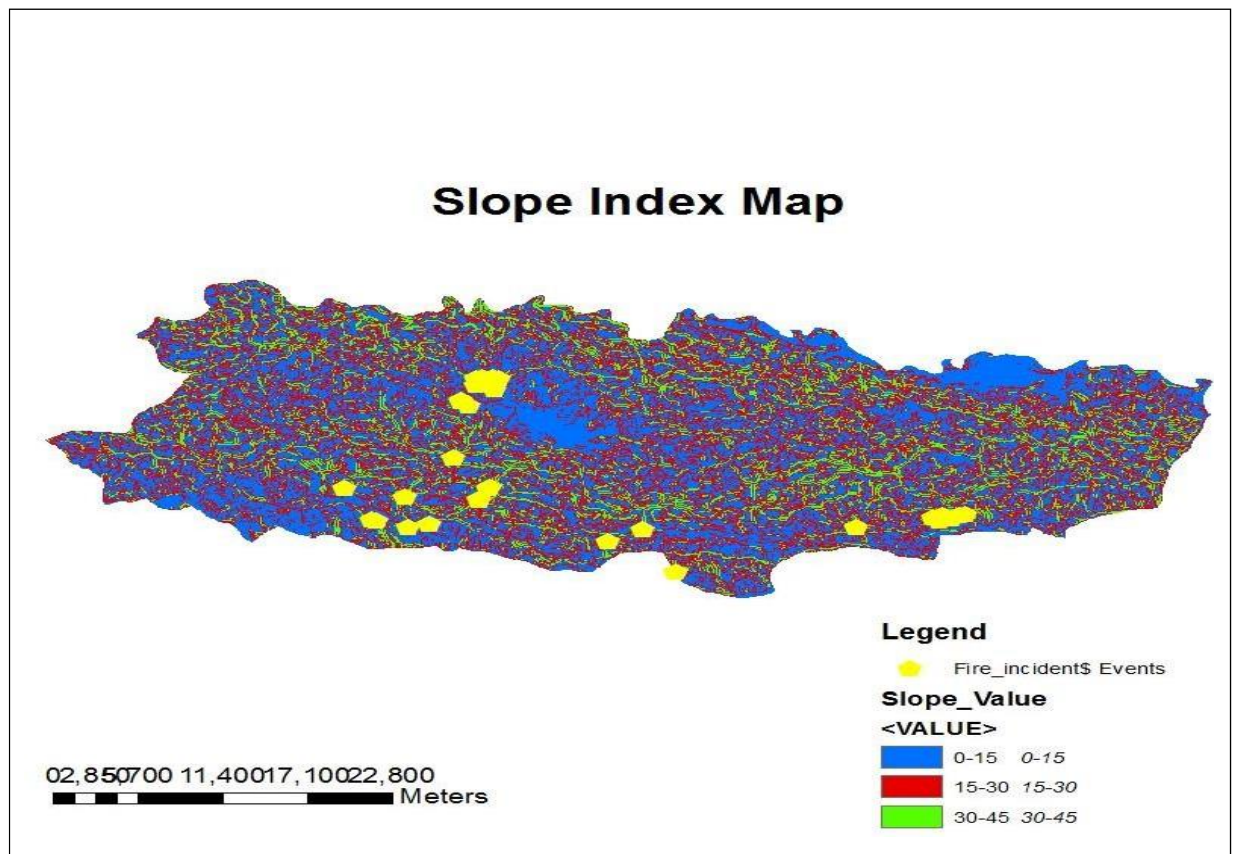


Figure 3 Slope Index Map

According to the analysed results the more occurrence of forest fire was on the following categories of slope.

Table 3 Categories of Slope

S. No.	Slope in Degree	No. of fire incident
1	0-15	11
2	15-30	17
3	30-45	5

Table 4 shows the distribution of fire in the study area having the slope with 15-30% is more i.e. (n=17) and least slope ranging 30-45% i.e. (n=5)

Aspect Index:

Aspect is the direction in which slope faces. Similar to the slope, aspect was derived from the DEM (Digital Elevation Model).

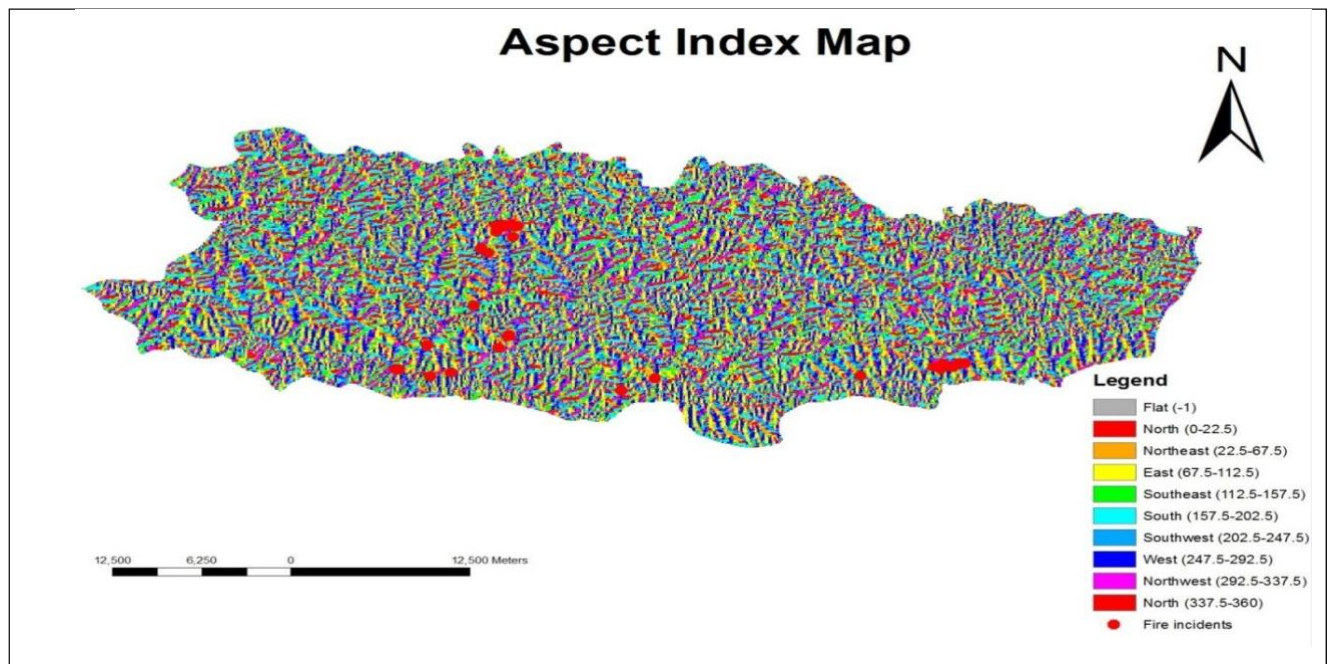


Figure 4 Aspect Index Map

Accordingly, the data was analysed and the result was given in the following table:

Table 4 Categories of Aspect

Sn. No.	Aspect	No. of fire-incidents
1	North	0
2	North East	2
3	East	0
4	Southeast	17
5	South	1
6	Southwest	11
7	West	0
8	Northwest	2

Table 4 indicates that slope facing the southeast and southwest are more prone to the fire in which more fire was occurred i.e. (n=17 and n=11) respectively.

Human Interference:

Almost all the study area had a great influence of human which was the main cause of forest fire. Below figure show the result:

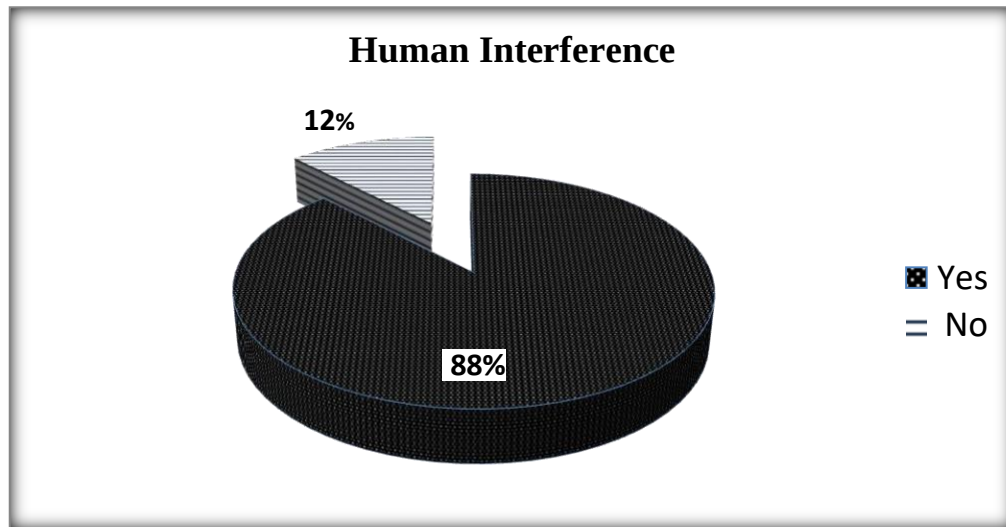


Figure 5 Human interference

From the above figure about 88% had a human disturbance in the forest as a result the fire was occurred frequently.

Distance:

It is observed that forest close to the road and settlement area is more prone to the forest fire. Below chart show the result of this:

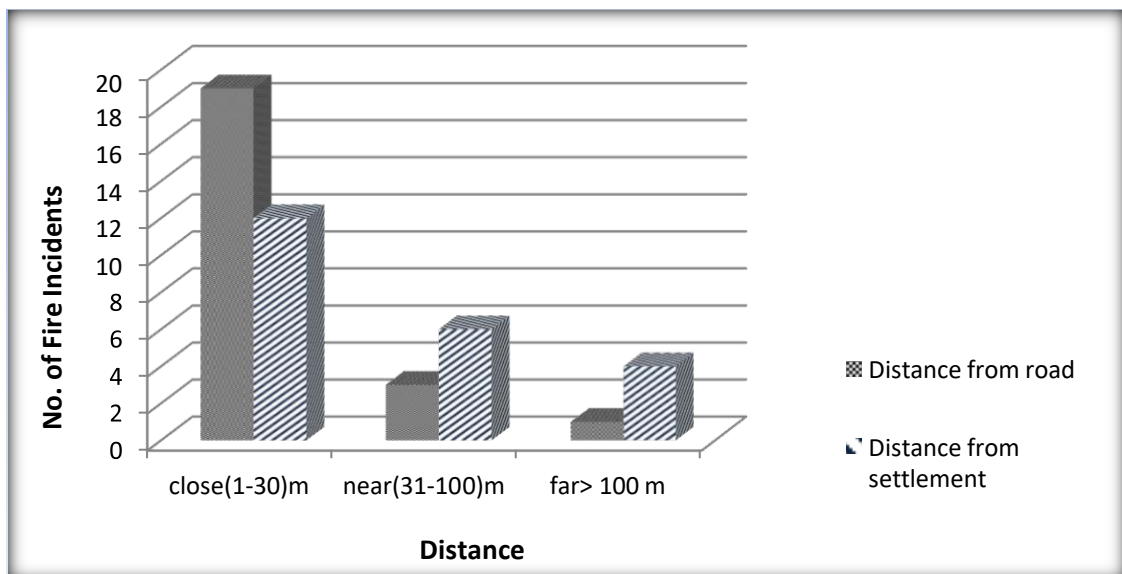


Figure 6 Distance from the road and settlement area to the FireIncident

The study area close (1-30) m from the road and settlement consist the more fire incidents than the area far (more than 100 m).

4.1.4 Influence of vegetation types on fire occurrence:

From figure 7 shows, the distribution of fire occurrence according to the forest type and it is easy to observe that most of the fire was detected mainly in the Sal (26%) and pine (20%) forest frequently. Figure given below shows the types of forest.

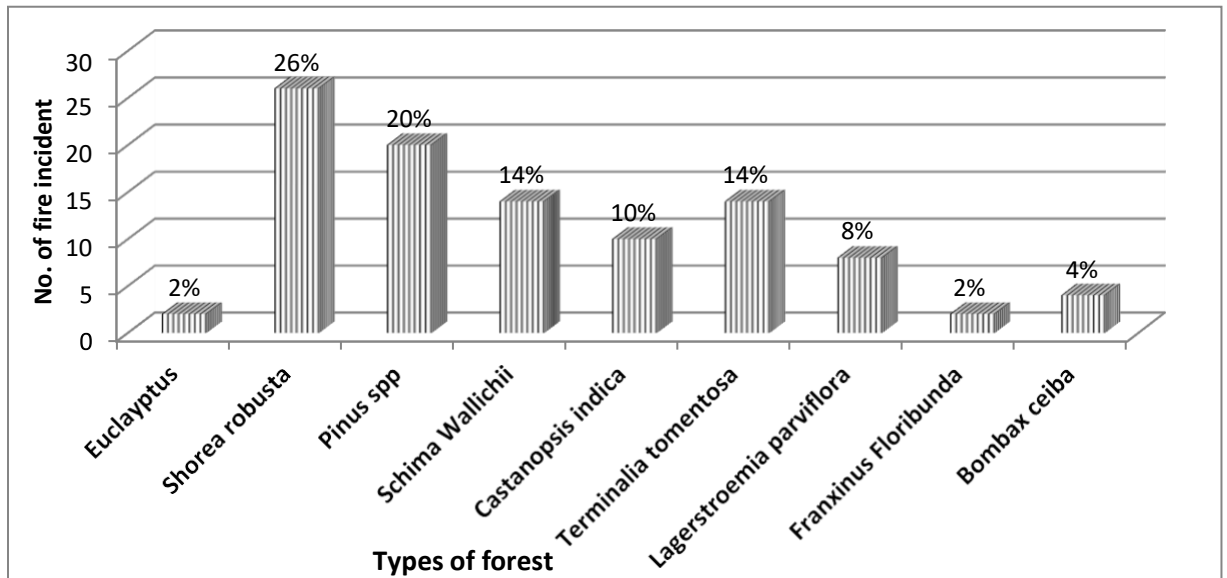


Figure 7 Number of fire detection according to forest types

According to finding, there was a positive influence of bio-physical attributes on forest fire. Following chart shows the condition of forest in which frequent forest fire occurred.

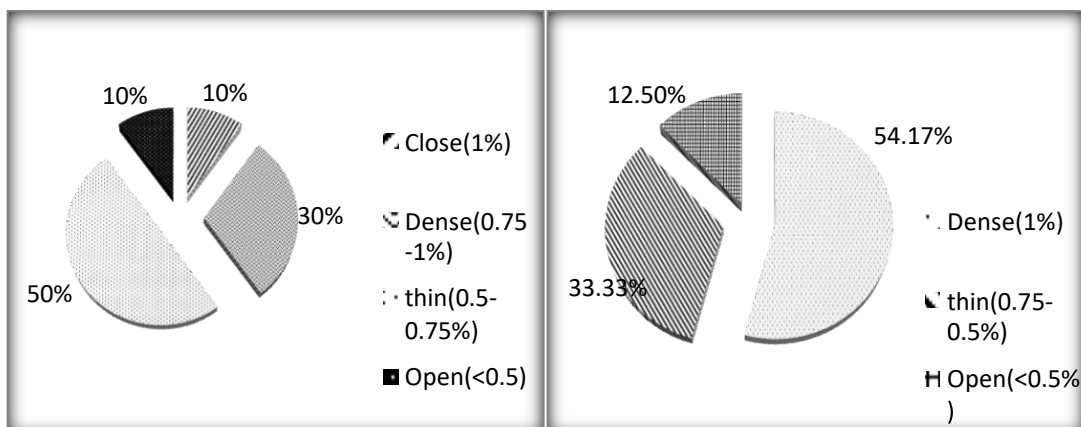


Figure 8 Crown Cover

Figure 9 Ground litter

From the figure it is known that most of the fire incident was occurred in the forest having a thin crown cover and dense ground little i.e. (50% and 54.17%) respectively.

4.1.5 Distribution of forest fire in relation to monthly patterns:

There was a large variation in average monthly patterns of fire occurrence. Following figure shows the result of fire occurrence.

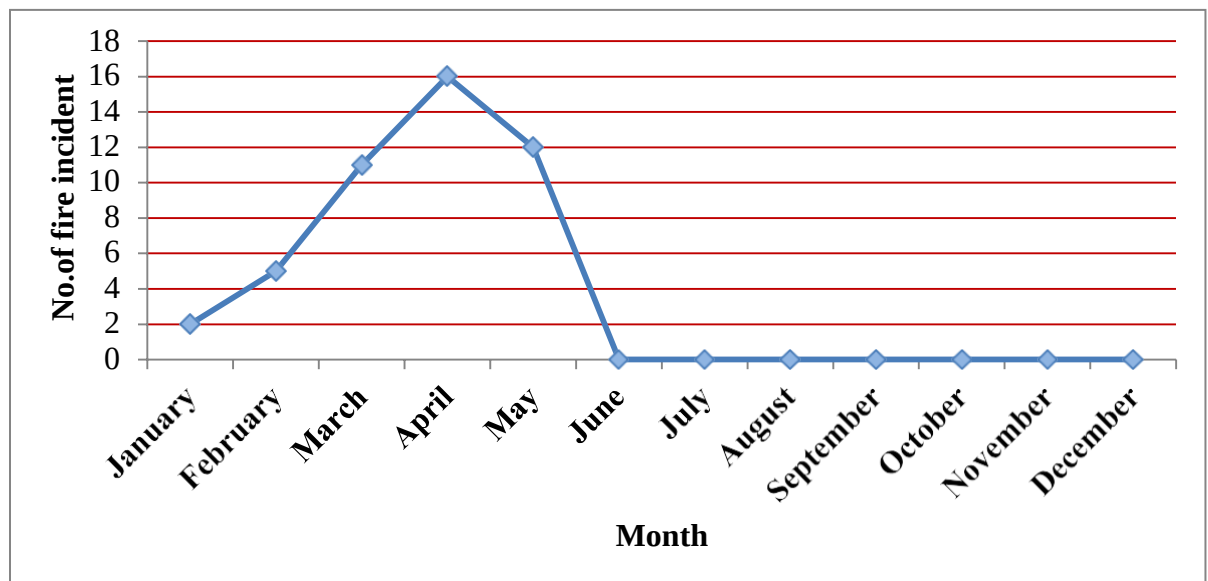


Figure 10 Number of fire incident as per month

From Fig 10 it is possible to determine the month with the highest fire incidence. In Palpa District, forest fire was noticed mainly in three months March, April and May but no fires in September, October and November.

4.1.6 Major Causes and Consequences of forest fire:

From the key informants and focus group interview the overall perception of the respondents about the causes and consequences of forest fire were quite interesting.

People's perception towards the causes of forest fire:

The cause of fire are various, but as a matter of fact was marked by a strong prevalence of human induced fire.

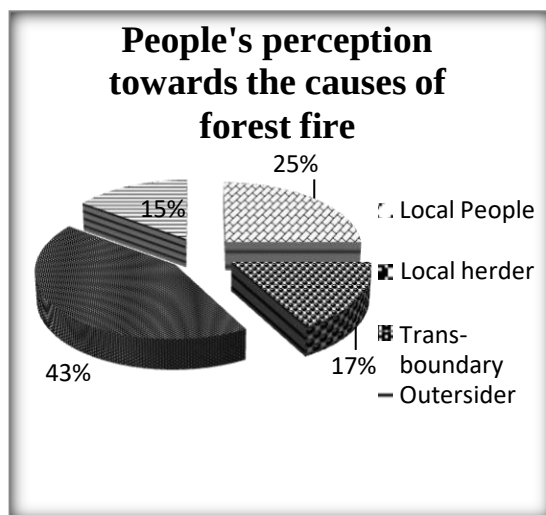


Figure 11 *People's perception towards the causes Of forest fire*

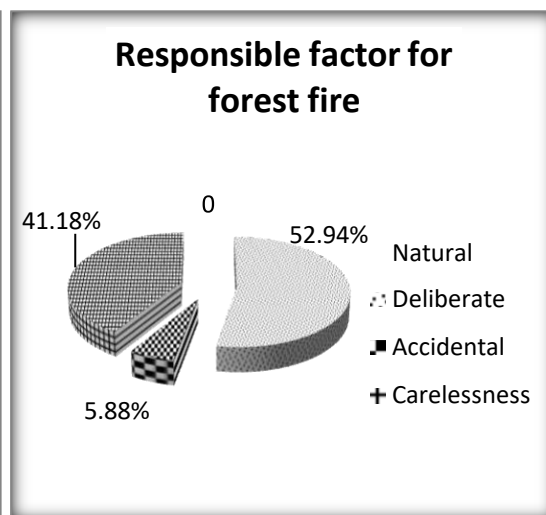


Figure 12 *Responsible factor for forest fire*

People's perception regarding the consequences of forest fire:

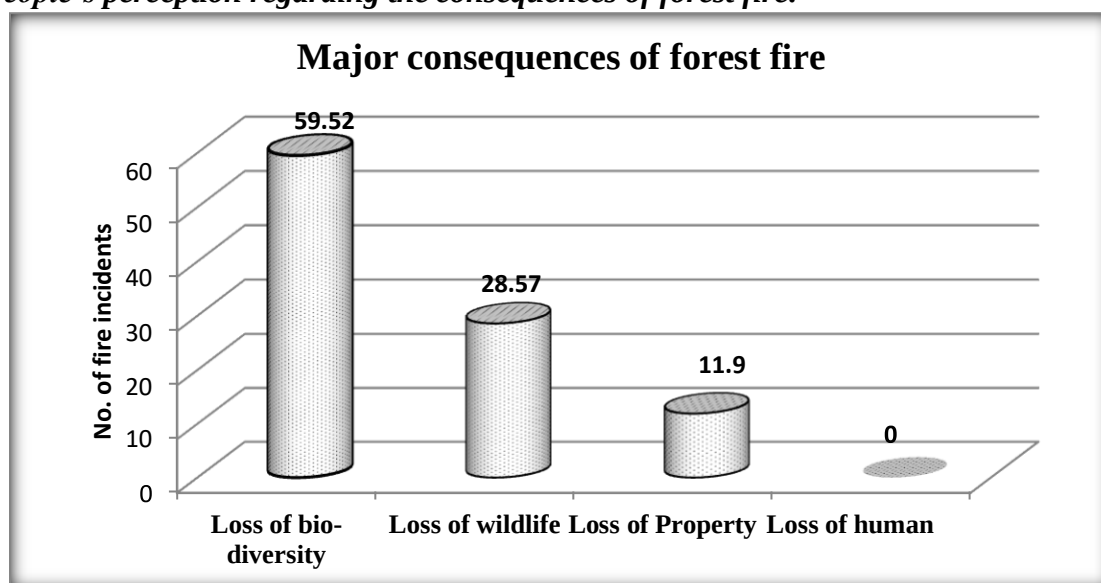


Figure 13 *People's perception regarding the consequences of forest fire*

All respondent categories believe that major causes of fire incidence were Trans-boundary (43%) and local user (25%) which was deliberately (52.94%) caused to fulfill the basic requirements of local forest product. And majority of people believe that loss of bio-diversity (59.52%) was the major consequences of forest fire followed by loss of wildlife habitat (28.57%).

4.2. Discussions

4.2.1 Distribution of forest fire and MODIS data verification:

Fire incidences are on increases at an alarming rate in some area of Palpa district. With the help of MODIS fire data it was easy to detect those areas. The seven place of Palpa District; Municipality (Tansen) and VDC (Telgha, Dobhan, Masyam, Gothadi, Jamire, and Archale) were the area where most of the forest fire occurred. And from the field verification about 80% was accurate and 20% was not detected as the data by the MODIS. Although the occurrence of forest fire was frequent in the area (Tansen, Municipality and Telgha, VDC). MODIS fire products also suffer from high omission error due to persistent cloud cover; difference between the time of fire occurrence and satellite overpass and too coarse pixel size to detect small patchy fires (e.g. Roy et al. 2008). Similar to the study of Roy, my study too may face the same obstacle that's why the MODIS data did not detect the fire on these two areas.

4.2.2 Distribution of forest fire in relation to Bio-physical attributes:

Slope and Aspect:

Almost all the study area was assigned in steep area. As well all know that among the entire factor slope is considered to be the most critical. A fire burning up to slope of +20 to +39% will spread twice as fast a fire on level terrain (Brown & Devis, 1973). From the above analysed result this study too shows the same, as the frequent occurrence of forest fire was obtained in the slope ranging from 15% to 30%. It is so because there is more human access as compare to the slope ranging 30% to 45%.

Generally, the slope facing the north is cooler while that facing the South is warmer. So in North there were no forest fire was identified and area having the slope facing southeast and southwest occurred a more forest fire i.e. 51.52% and 33.33% respectively.

Human interference

After the observation, this study revealed that almost all the fire was caused by human induce. People are totally depending on the forest for different activities which are responsible for forest fire. This result shows, about 88% was the human interference in the study area that cause the forest fire.

Distance:

Anthropogenic variables such as increased proximity to road and recreational areas have also been identifies as increasing the risk of forest fire ignition (Sowmya and

Somashekar, 2010). Here, the result too shows the same. The study area has three types road; metalled, gravelled and earthen road. The forest area close to road and settlement area i.e. 1 to 30 metre was more prone to the forest fire than the forest of distance with 100m far. It is so because the road works both as promoter and barrier of the fire. The area close to the road has more chances of disturbance from the user in the form of cigarettes and other inflammable material and other hand it becomes as the fire line. Similarly, there are settlements in the whole study area. The disturbance caused by settlers of this area is the main cause of forest fire. This study shows that the forest close to the settlement area were more prone of forest fire.

4.2.3 Influence of vegetation types on fire occurrence:

Crown cover and Ground litter:

The forest area having the thin crown cover is more susceptible to fire. It is so because with the thin crown cover it facilitates the direct sunlight and contributes the forest fire. Here the result shows the crown covers with thin (50%) has the more occurrence of fire in the study area.

Similarly, the ground litters such as small trees, weeds, shrubs etc. are the main factor contributing the forest fire. E.g. In California shrub land commonly known as Chaparra, is a widespread plant community of low growing species which are the major factor of fire. The result too shows the frequent occurrence of fire in the dense ground litter i.e. 54.17% having with the thin crown cover. It is so because the dense ground litters contain the dead materials and volatile fuels that facilitate the fire.

Forest type:

Vegetation is also a key factor in forest fire vulnerability and spread. The fire ignition factor and the sustaining of fire in different forest types are different. Eucalyptus and Pine are highly fire prone species which are the main factor of forest fire in the north Portugal (Mendes, 2004). In terai-bhabar of Nepal, *Shorea robusta* leaf litter burnt every year and in the middle mountain Region Pine forest burnt more frequently due to the resin content. (Bajracharya, 2001). The result of this study shows the same. During the field visit the main species found in Palpa District are mainly Sal (*Shorea robusta*), Ashna (*Terminalia tomentosa*), Salla (*Pinus roxburghii*), Chilauni (*Schima wallichii*), Utis (*Alnus nepaliensis*), Simal (*Bombax ceiba*), Katush (*Castanopsis spp*), *Ficus spp*, etc. But most of the fire incidents were found firstly in the Sal forest

(*Shorea robusta*) and secondly, in pine forest (*Pinus roxburghii*). It is so because in Sal forest there was more deposition of leaf litter in the ground as well as Sal tree is light demander species which is mostly found in the south facing slope in which direct sunlight occurred and in Pinus forest it is due to the resin content which is more susceptible to the fire.

4.2.3 Influence of monthly pattern on forest fire:

Many studies have shown that late dry-season burning has more significant impact on vegetation cover than burning in the early season (Bucini & Lambin, 2002). For example, in a study in the Kruger National Park, South Africa, the severity of fires was shown to be greatest at the end loads (Govender et al. 2006). Additionally, the significant factor is always fuel moisture content, which is generally lower during the dry-season and therefore material is more flammable (van Wilgen et al. 2004). Here the result too shows that most of the fires were in hot and dry season. In the rainy and wet summer months (May to January) there were almost no fire due to heavy rain and enough moisture content available in an area. Only the few fires were occurred in the months January and February and fires peak in March–April. It is so because most of the trees species shed their leaves during dry season (March to May). Large amount of dry leaves, twigs and litter which accumulate on the forest floor accompanied by undergrowth species, grasses, weeds, and alien species served as fuel for the outbreaks of forest fire. Also in these months, there is hot temperature; low relative humidity and precipitation, high wind velocity all these factor are served the forest fire.

4.2.4 Major Causes and consequences of forest fire:

Almost all the study area, about 88% result show there was a great influence of human. It was observed that the main cause of the forest fire according to the local people of Archale, Dobhan, Gothadi and Jyamire was trans-boundary (43%) with the neighbouring district i.e. Nawalparasi and Rupandehi which were more susceptible to fire. The majority of forest fires are caused by human activities (intentional and unintentional) and few fires are naturally caused in Nepal (NBS, 2002). This study too shows the main cause of forest fire was intentional i.e. deliberate (52.94%) (e.g. cleaning the agriculture land, benefits of forest products after forest fires, sprouting of grassland). Secondly is carelessness (41.18%), mainly from the smokers, travellers, picnickers, campfire etc. Third cause of forest fire is accidental (5.88%) which was

unknown or people made fire unintentionally (e.g. People made fire in small area without precaution, they cannot control the fire as a result fire spread in large area and create a serious problems). And at last not the least; nature cause was not detected according to the local people.

It revealed from the people perception of study area was that loss of bio-diversity was the major consequences of forest fire followed by loss of wildlife habitat. It was about 59.52% (loss of bio- diversity), 28.57% (loss of wildlife) and 11.9% (loss of property). Like this many studies shows same, E.g. The forest fire in Parnitha (Portugal) cause the damage to the population of several protected birds, mammals and other vertebrates and invertebrates (WWF, 2007). The forest fire predominantly occurs within this Terai region, with districts such as Chitwan, Nawalparasi and Palpa particularly badly affected (ICIMOD, 2010). The respondent also told that due to the forest fire there was a huge emission of carbon dioxide.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION:

5.1 CONCLUSION:

Fire is a significant force in the forest environment. Depending upon specific land management objective, plus a host of environmental variables, fire will sometimes be an enemy, at times a friend, and frequently its effects will be mixed between the two extremes. The study concluded that the occurrence of forest fire was comparatively decreased after handover the national forest to the community forest. Though there was decreasing in number of fire incident but still it is a serious problems as it destroyed all the flora and fauna of the environment, as a result there was loss of biodiversity and create the different adverse effect in the environment. The frequent fire was occurred between January to June that is hot and dry season. Most of the fires were found in the trans-boundary area of terai region such as Rupandehi and Nawalparasi District. Despite the fact that most of the forest fires in the study area were human induced cause deliberation (52.94%), carelessness (41.18%), and accidental (5.88%), and the area near to road and settlement have a more fire risk area. Similarly, topographical factors have a large effect on the spreading speed of fire. The slope ranging 15% to 30% and southeast and southwest facing aspect i.e. 51.52% and 33.33% have a frequent forest fire. This study also concludes that though there were frequent occurrences of fire incident in this district but there was lack of record in District Forest office and at last the result of this study will be useful for further research on forest fire.

5.2 RECOMMENDATION:

1. Though there were frequent occurrence of fire incident in this district but there was lack of record in District Forest office. Because of that it is quite difficult to know the accurate result of forest fire. Thus it is highly recommended that keeping the records and maintaining proper data base system regarding control fire applied and determining actual burnt area together with factors responsible for fire.
2. Patrolling and special consideration must be taken by the forest department during the dry and hot season with equipped fire crews. As well as trained the people with modern technology of fire crews at CFUG level, Illaka forest office and district forest office.
3. Include the forest fire management activities in the curriculum of school level books to other related organization. For the effective fire management a high

frequency communication system must be improved (wireless network, telescopes, walkie-talkies etc.) as well as all the existing road needs to be maintained.

4. All the existing forest roads and all the compartment lines also serve as fire lines, Both sides of forest roads up to 10m distance need to be cut and burn.
5. Government should sanction more budgets for using modern technology, for installing watch towers and other infrastructures and should urgently focus more in high risk area.
6. Forest acts and regulation should be effectively followed and existing human resources with local users should be trained and mobilized in fire prevention and controlling activities.
7. Among the main initiatives to counteract forest fires, it is recommended to diversify forest composition (e.g. re-introducing broadleaf trees), improve forest management, integrate forest policy with other policies and coordinate with private stakeholder and adopt other ancillary measures – like prescribed fire which could reduce fire risk.

5.3 Further research potential:

1. There is further scope of carrying research in forest fire in continuation or independently.
2. A study can be done on impact of socio-economic condition and conflict factor.
3. The variables such as wind velocity, rainfall, relative humidity etc. can be added in the model.
4. One can also take into consideration other environment models, which are dealing with the issue of pollution etc.

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