DIVERSITY, REGENERATION AND CARBON STOCK OF TREES IN BUDDHIST SACRED SITES IN MID-WESTERN TERAI REGION, NEPAL

A THESIS
SUBMITTED FOR THE
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE MASTER'S DEGREE IN BOTANY

BY

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August, 2021

Dedicated to my dearest mother

DECLARATION

I, Renu Pokharel, hereby declare that the work enclosed here is entirely my own, except where stated otherwise by reference or acknowledgement, and has not been published or submitted elsewhere, in whole or in part, for the requirement for any other degree or professional qualification. Any literature, data or works done by others and cited within this thesis has been given due acknowledgement and listed in the reference section.

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RECOMMENDATION LETTER

This is to certify that MSc Dissertation entitled "**Diversity, Regeneration and Carbon Stock of Trees in Buddhist Sacred Sites in Mid-Western Terai Region, Nepal**" has been carriedout by "Miss Renu Pokharel" under our supervision. The entire work is based on original scientific investigations and has not been submitted for any other degree in any institutions. We recommend this thesis work to be accepted for the partial fulfilment of M.Sc. Degree in Botany, Department of Botany, Amrit Campus, Tribhuvan University.

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LETTER OF APPROVAL

The thesis work submitted by Renu Pokharel entitled "**Diversity, Regeneration and Carbon Stock of Trees in Buddhist Sacred Sites in Mid-Western Terai Region, Nepal**" submitted to Department of Botany, Amrit Campus, Tribhuvan University by "**Renu Pokharel**", **5-2-50-225-2010** has been accepted for the partial fulfilment of the requirement for Master's Degree in Botany.

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Renu Pokharel

ACRONYMS AND ABBREVIATION

^{o}C	Degree Celsius
%	Percentage
$<$	Less than
$>$	Greater than
A	Abundance
AGB	Above ground biomass
BGB	Below ground biomass
cm	Centimeter
C-stock	Carbon Stock
D	Density
DBH	Diameter at breast height
DFRS	Nepal's Department of Forest Research and Survey
et al.	and others
GPS	Global positioning system
H	Shannon-wiener index
IVI	Important value index
kg	Kilogram
LDT	Lumbini Development Trust
m	Meter
RA	Relative abundance
RD	Relative Density
RF	Relative Frequency
SF	Sacred Forest
sp.	Species

ABSTRACT

The research aimed to study diversity, regeneration, and carbon stock of tree species in three Buddhist sacred forest in Lumbini, Tilaurakot, and Ramagram of Nepal. Purposive sampling design was carried out with a total of 70 plots, among them 40 plots in Lumbini, 20 in Tilaurakot and 10 in Ramagram sacred forest were sampledfor data collection. Quadrats of 20m X20m, 5m X 5m, and 1m X1 m were laid used for sampling trees, saplings, and seedlings, respectively. A total of 60 tree species, within 45 genera and 19 families were recorded from three sacred sites. The family Fabaceae has been found to exhibit the highest tree diversity representing 47, 23 and 27 tree species in Lumbini, Tilaurakot and Ramagram, respectively. Tree species such *as Dalbergia sissoo, Schleichera oleosa* and *Terminalia arjuna* was found to be dominant in Lumbini, Tilaurakot and Ramagram, respectively. Regeneration status of species was determined based on population size of seedlings,saplings and trees. In Lumbini, 85.34% of overall population structure was occupied by trees, 7.78% by saplings and 6.88% by seedlings. In Tilaurakot, 82.55% by trees, 9.66% by saplings and 7.79 % by seedlings. In Ramagram 85.84% by trees, 10.62% by sapling and 3.54% by seedlings. Survival of seedlings and saplings in different forests was found to be very low. Overall density diameter distribution curves of three forest showed different pattern. In Lumbini it was deviated from J-shape, Tilaurakot was bell shaped, and in Ramagram it was also deviated from J-shaped size class indicating poor regenerationin sacred sites. Anthropogenic disturbances and poor management of sacred sites are responsible for poor survival of seedlings and saplings. Very discontinuous regeneration showed that some tree species although dominant at present may be at risk in future.

Carbon stock in Lumbini was found to be 24.06 ton/ha (highest contribution by *Shorea robusta* i.e. 28.30%), 41.41 ton/ha in Tilaurakot (highest contribution by *Scheichera oleosa* i.e. 51.62%) and 18.86 ton/ha in Ramagram i.e (highest by *Terminalia arjuna i.e* 26.67%). Carbon storage capacity was greater in Tilaurakot with greater DBH and older trees. Sacred forests are the source of various components e.g., food, fodder, fiber, medicinal, and they are also home to many threatened plant species. Sacred trees, preserved through past years should be respected and conserved for our future generation. Therefore, this research calls for plan to conserve biological diversity of sacred sites.

Keywords: Buddhist Sacred forest, tree species richness, forest structure, forest status, Regeneration.

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CHAPTER 1: INTRODUCTION

1.1. Background

Species diversity is the measure of diversity within an ecological community that integrates both species richness and the evenness of species abundances. The number of species in an area is called the species richness of the area. Diversity indices provide important information about the composition of a community. Species diversity can be expressed in a single index number. Ecologists have developed many indices of species diversity, among which Simpsons index (Simpsons, 1949) and Shannon-wiener Index, H 1 (Shannon and Weaver, 1949) are the most commonly used indices. Simpsons index (C) reflects dominance, while Shannon-wiener Index (H1) is thought to represent uncertainty or information about a community. The value of diversity index is higher in rich forest and lower in forest dominated by single species. Sacred groves are small patch of forests that are conserved through religious beliefs in the name of local goddesses, beliefs, and taboos. It is protected by local people for its spiritual and ecological value. They play an influential role in the conservation of biodiversity and its conservation has been an intrinsic part of human. They are considered as havens for many indigenous and threatened species (Bharathi and Prasad, 2015). They are the indications that they are storehouses of nature's unique biodiversity. A fewer attempt has been made in Nepal towards biodiversity and its conservation in sacred groves, many sacred groves have remained unexplored.

Regeneration is an important process for species in a community under variable environmental conditions which predicts the future health of the forest (Khumbongmayum *et al*., 2006). Natural regeneration is the process of re-growing or reproduction of plants through their juveniles so that plant species maintains and expand the population in a community with time and space (Bharali *et al*., 2012). Regeneration status is one of the key parameters of forest ecology which can tell us the future composition of a community under varied environmental conditions. Forest tree species require certain environmental and microhabitat conditions, thereby making forest regeneration a complex and multidimensional process (Smith *et al*., 1997). Not all seeds find suitable conditions for establishment (Harper *et al*., 1961). For regeneration, there has to be sufficient seed supply, rainfall, moisture, light and nutrients for a germinated seed (Mott and Groves, 1981). The regeneration of plants is generally controlled by various anthropogenic pressures such as felling, grazing, trampling, fire etc. (West *et al*., 1981). The population structure characterized by the presence of sufficient number of seedlings, saplings and young trees depicts satisfactory regeneration behavior, inadequate number of seedlings and saplings of tree species in a forest indicates poor regeneration, while complete absence of seedlings and saplings of tree species in a forest indicates no regeneration (Saxena and Singh, 1984). The issue of regeneration is mainly important for those forests which are under various anthropogenic pressures such as felling treetreesazing, trampling, etc (West *et al*., 1981). Thus, the study of regeneration of forest is important for the conservation and management of forests

Carbon stock in forest ecosystems refers to the amount of carbon stored in forest, mainly in living biomass and soil, but to a lesser extent also in dead wood and litter. Carbon is sequestered by plant photosynthesis and stored as biomass in different parts of the plant (Jana *et al*., 2009). Significant quantities of carbon can be sequestered in land and vegetation layers by regeneration of disturbed forest and conservation of forest (Brown *et al*., 1996). Carbon emission from deforestation accounts for an estimated 20% of global carbon emission (IPCC, 2007), second only to that produces by fossil fuel combustion (Campbell *et al*., 2008). A ton of carbon in trees is the result of the removal of 3.67 tons of carbon dioxide from the atmosphere (Hunt, 2009). It is believed that the goal of reducing carbon sources and increasing the carbon sink can be achieved efficiently by protecting and conserving the carbon pools in existing forests (Brown *et al*., 1996). The sink capacity of the forest increases when tree density and area expand. In an average 50% of the dry weight of the biomass is carbon (MacDicken, 1997). In Nepal, the projects like Forest Resource Assessment (FRA) conduct periodic inventories of various forest types regarding the forest carbon estimation. Regional and local carbon stock estimation activities are also being carried out from institutional and personal approaches. In view of this, the present study was undertaken to assess the tree diversity, regeneration status, and to estimate the carbon stock in selected three Buddhist sacred groves of Mid-western, Nepal.

1.2. Justification of the study

Recent and past human activities have made conservation efforts a serious threat. Many other sites have been degraded and others are prone to degradation. The factors contributing to the loss of biodiversity are excessive population growth in the areas (6.01 per households), excessive livestock grazing in the vicinity, and unsustainable use of forest resources and potential development of the ecotourism sites (UNDP, 2001). These are causing environmental degradation. To address the above burning issues, rigorous and concrete conservation plans are needed.

The alarming rate of biodiversity loss all over the country, especially in the religious forests due to human encroachment since the long time ago has drawn serious attention to Lumbini. Biodiversity conservation is strongly tied to people’s livelihoods because it is a source of food, medicine, revenue, employment, and other values (UNDP, 2000). The chosen three sites, for the study, Lumbini, Tilaurakot and Ramagram, are associated with Lord Buddha and possess highly religious and spiritual values in the Buddhist religion and have been the sites of faith for Buddhist people. But these sites have shown significant loss of biodiversity since a long time ago and have been shrunken to limited space. The causes, especially the over-dependency on natural resources and conversion of forest areas into agricultural land have typically multiple and synergistic effects on local biodiversity.

Therefore, the proposed research focuses to assess status of the existing condition of sacred forests by examining the overall biodiversity of trees, their regeneration and carbon stock in three sacred sites. It would help to develop the conservation and management practices of sacred sites and it would further preserve the existing diversity in plant species in Lumbini region and its associated religious sites.

1.3. Research Questions

The study focused on answering the following research question:

i. What is the diversity of tree species at the three religious sites?
ii. What is the regeneration status of tree species?
iii. How much carbon is stocked in the selected religious sites?

1.4. Objectives

Broad objective

The overll objectives of the study is to study the tree diversity, regeneration status and carbon stock in three different Buddhist sacred sites Lumbini, Tilaurakot and Ramagram in Mid-Western Nepal.

Specific objectives

i. To study and compare the diversity and population structure of tree species.
ii. To study the regeneration status of tree species
iii. To estimate the total carbon stock of tree species

1.5. Limitations

The major limitations of the study are:

i. Regeneration data were collected by only counting the number of seedlings and saplings in each plot; thus the status was accessed only by plotting density diameter curve (DBH-curve).

CHAPTER 2: LITERATURE REVIEW

2.1. Species Diversity

Nepal as nature's paradise, is a small, enchanting package of nature embracing the rich biological diversity in the tiny area. One of nature's gifts to Nepal is its vegetation. The small band of land holds over 170 bundles of vegetation (Shrestha, 2008). Species diversity is a key factor for the stability of the ecosystem. Ecologists have developed many indices of species diversity, among which Simpsons index (Simpsons, 1949) and Shannon-wiener Index, H 1 (Shannon and Weaver, 1949) are the most commonly used indices. Simpsons index (C) reflects dominance, while Shannon-wiener Index (H1) is thought to represent uncertainty or information about a community. The value of diversity index is higher in rich forest and lower in forest dominated by single species. Sharma (2012) found higher species richness at exploited forest than other land use types cropland, meadow and natural forest. The number of species and indices of species diversity of trees were positively associated with coppicing and also with total disturbance, which included foot trails and dung piles as evidence of livestock grazing (Shau *et al*., 2008). Tree diversity (species richness as well as species evenness), and floristic diversity were higher in natural sal forest than in planted sal forest (Chauhan *et al*., 2008).

The species diversity and regeneration pattern of trees differ in different vegetation types of the forest landscape. The regeneration of trees was higher in species-rich vegetation types with no sign of human disturbances. The change in species composition across mature and regenerating phases is more frequent in disturbed forests as compared to undisturbed or less disturbed forests with the occurrence of new species in all vegetation types (Jayakumar and Nair, 2013). Sapkota *et al*. (2009) studied spatial distribution; advanced regeneration and stand structure of in seasonally deciduous Shorea robusta forest of Nawalparasi district of Nepal found most disturbed forest had less trees species richness, in the more disturbed plots greater density of saplings and no significant difference in stem basal area. The overall stand density changed quadratically along the disturbance gradient. The effect of anthropogenic disturbances on plant composition and plant diversity was observed in many studies all over the world. Moreover, Mishra *et al*. (2004) studied the influence on three subtropical mountainous forest stands and showed that the more the disturbance intensity increased, the more the species richness and diversity of trees and shrubs decreased. The pole cutting and fuelwood cutting also had significantly decreased biomass, plant diversity and changed the species distribution pattern (Mligo, 2011). The disturbances directly cause loss of tree cover and subsequently affect other life forms, reducing overall forest species diversity (Campbell *et al*., 2017). Degradation of forests manifests through simplified forest structure, biodiversity loss, and alteration of forest ecosystem processes and functions occurring in many places (Charnley and Poe, 2007).

2.2. Forest Regeneration

Natural regeneration implies the process of re-growing or reproducing new individual plants which maintains the stable age structure of the plant species in a community (Singh and Singh, 1992). The pattern of population dynamics of seedlings, saplings and adults of a plant species can exhibit the regeneration profile, which is used to determine their regeneration status (Bekele 1994 and Teketay, 1996). Population structure is characterized by the presence of sufficient populations of seedlings, saplings and young trees indicate a successful regeneration of forest species (Saxena and Singh, 1984). Plants maintain and expand their populations in time and space by through process of regeneration (Bharali *et al.*, 2012). The inclusion of seedlings and saplings in plant population structures would provide information about the status of the species at an early stage of regeneration. Undisturbed old-growth forests with sustainable regeneration are found to have a reversed J-shaped size class distribution (West *et al*., 1981) and a bell-shaped size class distribution has been attributed to disturbed forests where regeneration is hampered (Saxena *et al*., 1984).

Ghimire *et al*. (2010) suggests Inverse J-shaped indicates, a forest in a state of regeneration. A shift from an inverse J-shape to a unimodal or multiple-peaked distribution is the result of substantial changes in the pattern of forest regeneration, suggesting that the forest is in trouble. Community forest resource inventory guideline (2004) suggested criteria based on number of seedlings and saplings in forest for evaluating regeneration condition of the forest. Regeneration is said to be good if the forest has seedlings > 5000 and sapsaplings2000 per ha (HMG, 2004). The number of species, as well as the density of seedlings, saplings and trees are found maximum in the disturbed site and also indicates differences between the disturbed site and relatively undisturbed site prior to management in terms of diversity, species composition and regeneration pattern (Sharma *et al*., 2020).

The issue of regeneration is mainly important for those forests which are under various anthropogenic pressures such as felling trees, grazing, trampling, etc (West *et al*., 1981). Trees are most vulnerable to climatic stresses during the regeneration phase. Climate change will affect flowering, pollination, seed formation, germination, and seedling survival. Regeneration depends on the future capacity of trees to produce viable seed (Johnstone *et al*., 2009). Plants generally survive in a limited range of environmental gradients, e.g. temperature and light availability (Block and Treter, 2001) and variation in these factors play important roles in shaping the age structure and forest regeneration (Duan *et al*., 2009). Bradshaw *et al*. (2000) explain the term regeneration phase as a critical life stage for species in which changes in climatic controls hinder or enhance a species response to change. Based on the results of Vetaas, (2000), he reported that above-ground factors are more important for seedling germination.

Good and Good (1972) mentioned three major components for successful regeneration of a species are: i) ability to initiate new seedlings; ii) ability of seedlings and saplings to survive; and iii) ability of seedlings and saplings to grow. Some studies show that understory shrubs can facilitate the seedlings establishment and growth of trees. For instance, in the case of woody species, shade appears to be a necessary condition for seedling establishment (Gomez-Aparicio *et al*., 2005). Awasthi *et al*. (2015) and Napit, (2015) found that regeneration of sal was higher than other associated species in LCF of Rupandehi and BNP, respectively. Study of regeneration pattern in sal forests from various parts of Nepal has found that regeneration status of sal was higher than the other associated species. Regeneration of sal was higher than other associated species in Terai and Churia forests of Nepal (DFRS, 2014).

2.3. Forest Tree carbon stock

Earth's terrestrial ecosystems are estimated to store around 2,050 gigatons (Gt) of carbon in their biomass and soil (up to 1 m depth). Protected areas worldwide cover 12.2% of the land surface, and contain over 312 GtC, or 15.2% of the global terrestrial carbon stock (Campbell *et al*., 2008). Wang *et al*. (2011) used tree species, size, and height, diversity indices as well as a combination of these diversity indices in Spruce-dominated forest in New Brunswick, Canada, to correlate aboveground C stocks and resulted Positive Relationship between Above-Ground Carbon stock and tree structural diversity. The total carbon stock in the forests of Nepal is estimated to be 880 M mt in 1990; 961 M mt in 2000 and 897 M mt in 2005 (Oli and Shrestha, 2009). FAO (2006) concluded that forestry and related statistics such as growing stock, biomass and carbon stock should be updated regularly at national level to safeguard the estimation of carbon emissions and carbon sequestration. In central Himalaya, the two types of forest i.e. degraded and non-degraded forest showed that, the carbon sequestration rate varied from 1.07 ton/ha/yr in Pine Degraded site to the 6.66 t/ha/yr in Pine non-degraded site (Jina *et al*., 2008). The rate of carbon sequestration by different forest types depended on the growing nature of the forest stands. Tropical riverine and Alnus nepalensis forest types demonstrated the highest carbon sequestration rates in Nepal (Baral *et al.,* 2009). The rate of carbon sequestration by different forest types depended on the growing nature of the forest stands. Tropical riverine and Alnus nepalensis forest types demonstrated the highest carbon sequestration rates in Nepal (Baral *et al*., 2009) Berenguer *et al*. (2014) studied large-scale field assessment of carbon stocks in human-modified tropical forests results of the largest field study to date on the impacts of human disturbances on above and belowground carbon stocks in tropical forests. There was positive correlation between biodiversity and C storage across land use, but no evidence for a positive relationship between tree-species diversity and aboveground biomass in either forests or agro-forests. However, results have highlighted the disproportionate contribution of a small number of species to stand-level carbon stocks.

2.4. Sacred forest and and its conservation

Lumbini and its nearby areas are rich in natural resources but poor in terms of infrastructure. Rural areas around Lumbini are continuing deterioration of natural ecosystems because of poverty, ill health, and illiteracy (Acharya, 2005). Poudel (2013) mentioned four major habitat types as farmland, forest, grassland, and wetland in Lumbini. The majority of trees in the grove were produced by plantation i.e. ex-situ conservation, and hence reflect the importance of sacred grove (Bhattarai and Baral, 2008). Siwakoti (2008) found LSG with stretches of *Saccharum*-dominated grassland and patches of Dalbergia forest. Bhattarai and Baral (2008) confirm Lumbini as *Dalbergia sissoo-Acacia catechu* type forest of Nepal. Siwakoti (2008) Survyed checklist of angiospermic flora in and around the Lumbini sacred garden (LSG), Nepal. A total of 354 species belonging to 75 families and 245 genera of angiospermic (258 dicots and 96 monocot) plants have been documented from the LSG and its adjoining areas. He also listed 246 species of herbs, 54 species of trees, 29 species of shrubs, and 25 species of climbers. A total of 65 tree species, 39 indigenous to Nepal. Of these tree species, 5 are of threatened, vulnerable and endangered categories. Awasthi *et al*. (2015) applied simple random sampling in managed and unmanaged parts of Lumbini Collaborative forest where sal forest being managed under Irregular Shelterwood System and found increase in regeneration as well as decrease in plant diversity in the managed 1st and 2nd-year stands as compared to the unmanaged stand at its initial level of implementation.

Seedling density of *Shorea robusta* was found higher in the managed blocks as compared to the unmanaged one in terms of height class. The indigenous tree species found in the Lumbini grove account for 11% of the total tree diversity of Nepal. Of these tree species, five are of threatened, vulnerable and endangered categories (Bhattarai and Baral, 2008). Many tree species such as *Aegle marmelos, Ficus religiosa*, *Ficus benghalensis,* and many more in Dakshinkali sacred forest are contemplated as holy and are conserved (Vaidya and Poudel, 2017). Sacred groves are distributed across the globe, and diverse cultures recognize them in different ways encoding various rules for their protection. Sacredness, religious beliefs and taboos promote sustainable utilization and conservation of the flora and fauna of the region. They also address due to passage of considerable changes in sacred groves, in their vegetation structure, peoples' perception and the religious beliefs a holistic understanding of the current structure and function of sacred grove is essential for assessing their ecological role and formulating strategies for their conservation (Khan *et al.*, 2008). Policy makers should give emphasis on using the silvicultural operations in Tilaurakot Collaborative forest management to maintain forest health (Belbase *et al*., 2019).

CHAPTER 3: MATERIALS AND METHODS

3.1. Study area

3.1.1 Location and description of study area

Lumbini

Lumbini, the birthplace of the "Lord Buddha" with cultural, archaeological and religious importance, lies in the foothills of the Siwalik range in the Rupandehi district of Terai region. It is located with an average altitude of 99m a.s.l. with co-ordinates Latitude 27° 47' 23" N and Longitude 83° 26' 77"E. Lumbini in total covers the area of 4.8 km long and 1.6 km width aligned north to south (i.e. 768 ha) and divided into the two monastic zones by long central canal filled with the water separates and on either side where large natural areas where monasteries, and different patches of forest are found. The villages surrounding Lumbini are indigenous Tharu people. Lumbini has a rich biodiversity that attracts more than 200 species of birds, including Sarus Crane (estimated to be about 100 pairs in Lumbini). It also attracts lovers of nature because of its rich natural biodiversity and unique ecosystems.

Tilaurakot

Tilaurakot is well known for its archaeological remains and cardinal point of the ancient city of Shakyan kingdoms, where Prince Siddhartha (Lord Buddha) spent his childhood and 29 years of his lifetime from birth. It lies in Tilaurakot municipality in Kapilvastu district, Lumbini Zone. It is located west of Lumbini at an average altitude of 90m with coordinates of 27° 34' 60" N and 83° 4' 0" E. It is situated. The site was listed as a UNESCO tentative site in 1996 by GoN.

Ramagram

Ramagram site is a stupa located in Ramagram Municipality in the west Parasi district of Terai, Nepal. The stupa is 35km east of Lumbini. It is located at an average altitude of 107m with co-ordinates of 27° 29' 55" N and 83° 41' 05" E. This Buddhist pilgrimage site, is one among the eight original relic stupas constructed some 2500 years ago (http://lumbinidevtrust.gov.np/en/ramagrama), and contains relics of Gautam Buddha in the entire world (UNESCO, 2014).

Figure: 3.1. Lumbini Sacred Garden (Source Google Map, accessessed on 4/23/2021)

Figure 3.2. Tilaurakot Sacred Garden (Source Google Map accessessed on 4/23/2021)

Figure 3.3. Ramagram Sacred Garden (Source Google Map accessessed on 4/23/2021)

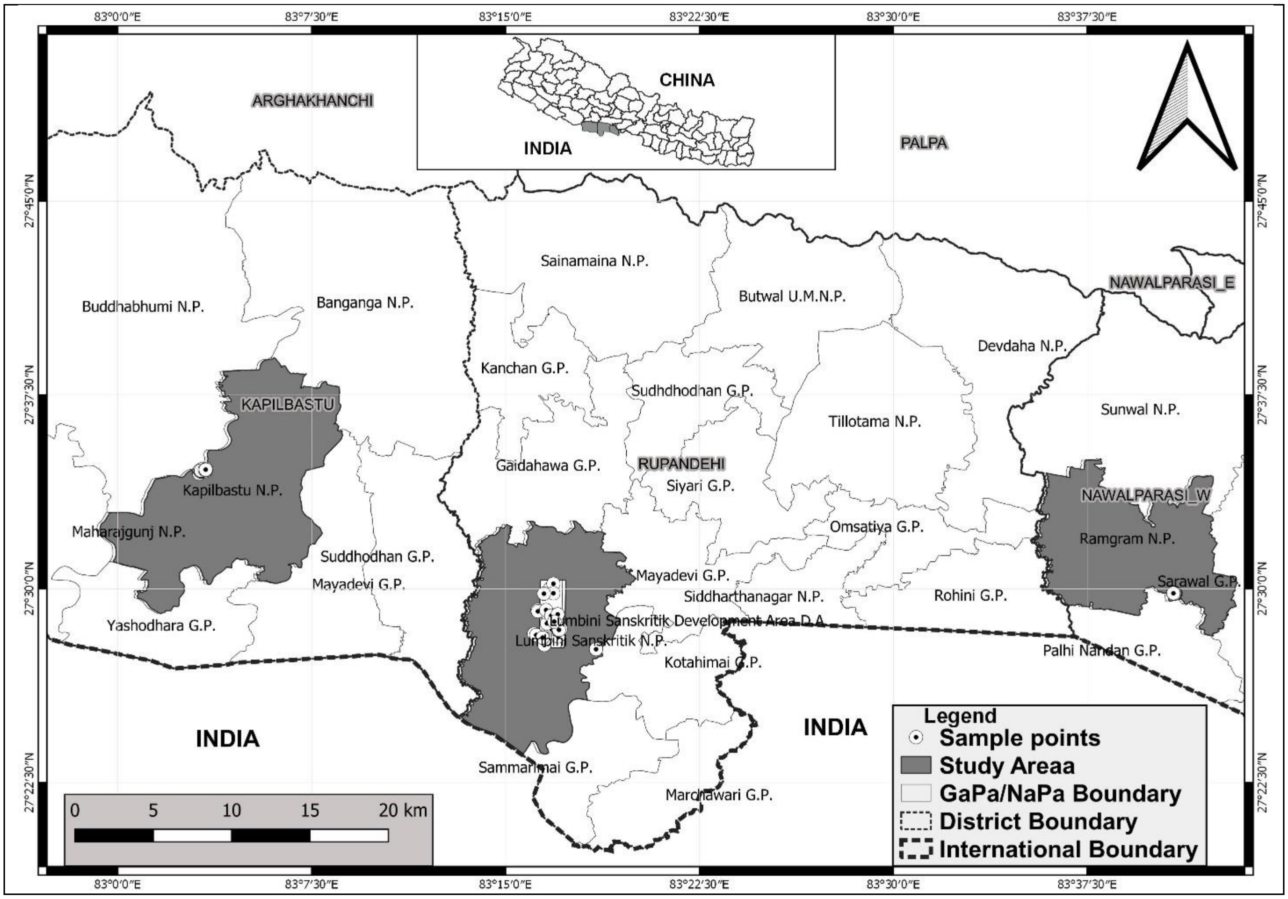

Figure 3.4. Map of the study area.

3.1.2. Vegetation

Lumbini belongs to the tropical vegetation zone of Nepal. Lumbini covers a diverse array of ecosystems. Forests, ponds, grasslands, wetlands, cultivated lands and settlements are the prominent features in the area. Lumbini is home to a number of diverse flora and fauna. Major dominant forest forming species are: *Shorea robusta*, *Terminalia spp.*, *Lagerstroemia parviflora*, and *Dalbergia sisoo*. *Dalbergia sissoo* is the major planted species (about 295,000 saplings) followed by *Shorea robusta*, *Syzygium cumini*, *Acacia catechu*, *Tectona grandis*, *Callistemon citrinus*, *Albizia* spp, *Mangifera indica*, etc (LDT, 1999). The forests are extremely used by the local people for cattle grazing, and forage collection for many years.

Tilaurakot belongs to the tropical vegetation zone of Nepal. It is a mixed forest. It consists of various other tropical tree species such *as Pterocarpus marsupium*, *Haldina cordifolia*, *Butea monosperma*, *Ficus religiosa* etc. The vegetation is degrading due to lack of proper conservation initiatives in Tilaurakot, as a result the existing vegetation is disaaearing rapidly. Ramagram belongs to the tropical vegetation zone of Nepal, and is a mixed forest. It is located on the bank of Jharia River. The forest is dominated by *Terminalia alata*. Some other associated tree species found on this site are *Dalbergia sissoo*, *Mangifera indica*, *Ficus* sp. etc.

3.1.3. Climate and Hydrology of study sites

Based on data from the nearest weather station in Lumbini (Figure 3.2). The highest average minimum temperature was recorded in August (26.42°C) and the lowest average minimum temperature was recorded in January (8.01°C), highest average maximum temperature was recorded in May (37.20°C) and lowest maximum temperature in January (19.80°C), the precipitation was highest in July (399.32 mm) and lowest in November December (0 mm) and the relative humidity was highest in February (84.76%) and lowest in April (67.14%).

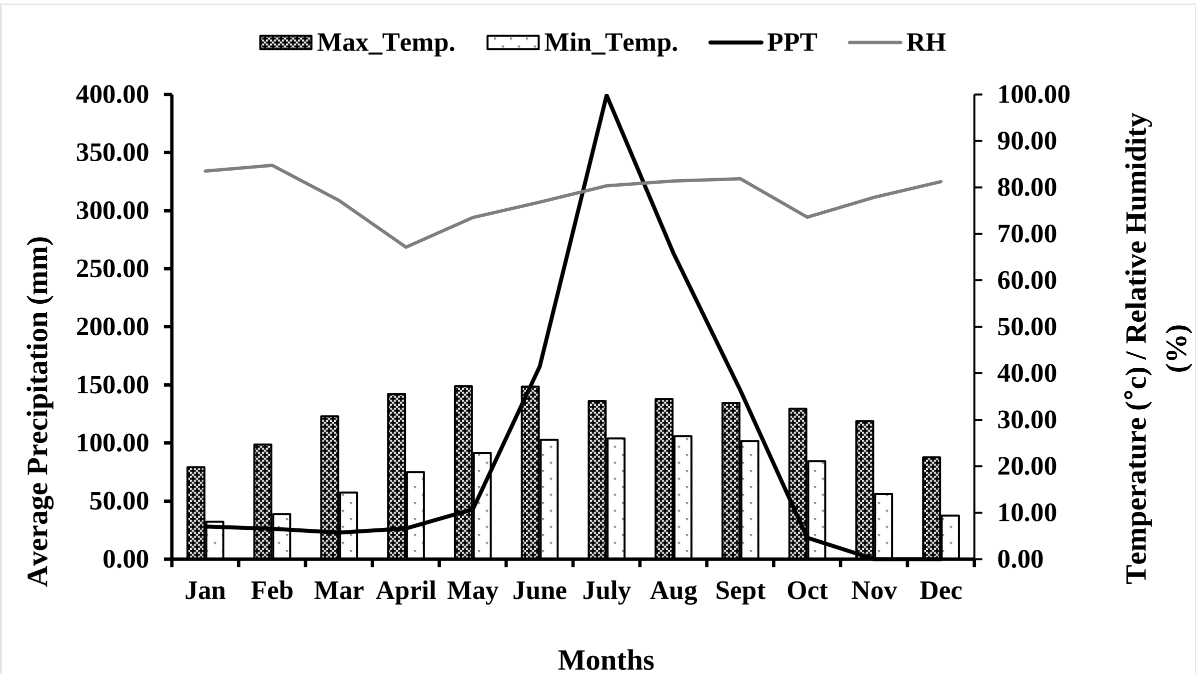

Figure 3.5. Climatic graph (2011-2020) recorded at nearby station of Lumbini, Rupandehi. (Source: DHM, 2020).

Based on data from the nearest weather station to Ramagram (Figure 3.3). The highest average minimum temperature was recorded in August (25.43°C) and the lowest in January (8.70°C), highest average maximum temperature was recorded in May (37.20°C) and lowest in January (22.26°C), the precipitation was highest in July (411.45 mm) and lowest in November (2.57 mm) and the relative humidity was highest in September (86.79%) and lowest in April (47.51%) (Figure 3.3).

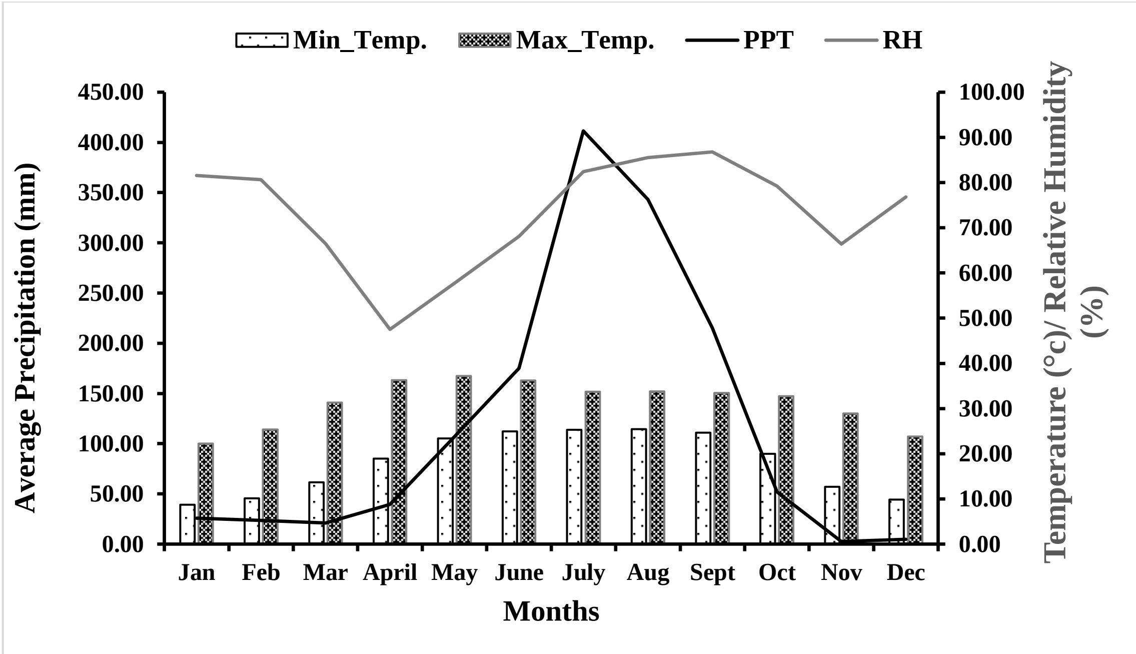

Figure 3.6. Climatic graph (2011-2020) recorded at nearby station of Ramagram, West Parasi (Source: DHM, 2020).

3.2 Methods

3.2.1. Vegetation sampling

All together, 70 plots were studied at three sacred sites.

Lumbini

The survey of the study sites was undertaken in January, 2019. Field work was carried out during the month of May between 22 and 29, 2019, for 8 days. Purposive sampling design was applied for the collection of data. A total of 40 plots were sampled in Lumbini's sacred forest. Quadrates of size 20m × 20m, with 40 plots was laid for tree sampling at study sites. Each tree was recorded using its local names/scientific names.

Tilaurakot

The field work was carried out during the month of July between 18 and 22, 2019, for 5 days. A total of 20 plots were sampled. Quadrates of size 20m × 20m, with 20 plots were laid for tree sampling in Tilaurakot.

Ramagram

Field work was carried out during the month of November between 25 and 27, 2019, for 3days. A total of 10 plots were sampled. Quadrates of size 20m × 20m with 10 plots were laid for tree sampling in Ramagram. For regeneration, sampling quadrats of size 20m×20m, 5m×5m, and 1m×1m were laid for trees, saplings, and seedlings at each corner of the main plot, respectively (Fig 3.4). The tree species (diameter at breast height (DBH, i.e. at 1.37m) tree height >5cm) which were occupied in 20m × 20m plot were noted and basically tree numbers, measurement of DBH by using DBH tape (Million Diameter Tape, 20m*5m, India, YAMMO) and height of the trees were taken by using clinometer. In each main plots, sub quadrat of 5m × 5m were laid inside one corner of the main plot and number of tree saplings (> height 1.37m, <5cm dbh,) were counted. Similarly, quadrats of 1m × 1m were laid at the same corners of saplings and seedlings (<1.37m height) were counted. Other parameters, forest type, physical location (latitude longitude, and altitude), litter depth, canopy cover, disturbances, and rental factors were recorded for each sampling plot (Appendix VI). The field data sheet used for vegetation sampling has been attached in appendices (Appendix VII).

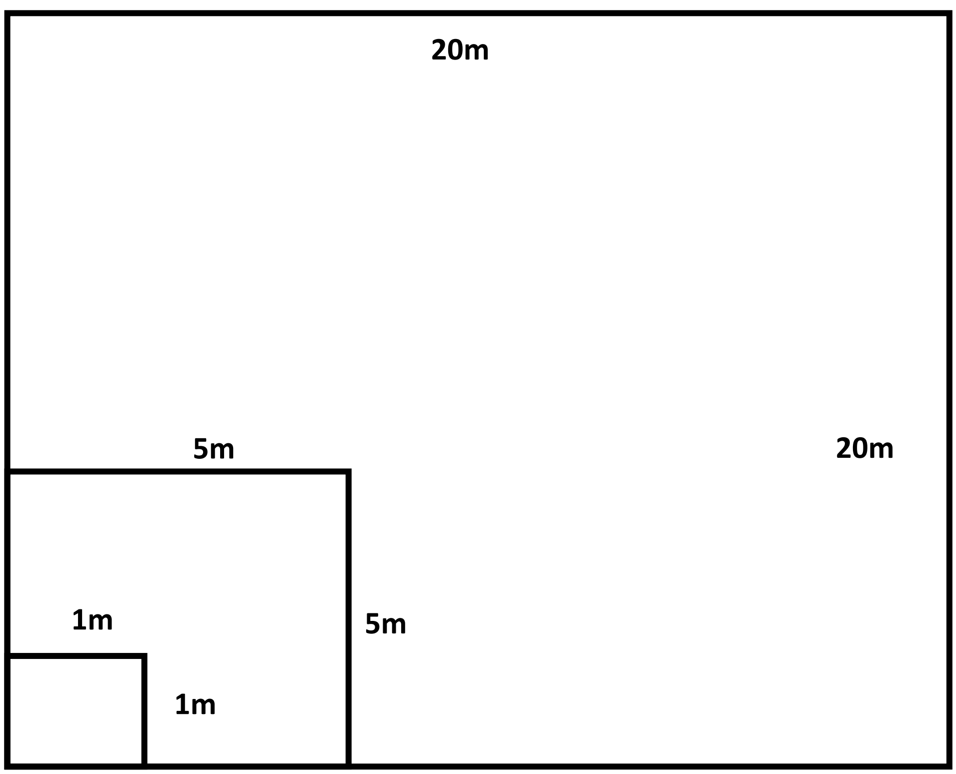

Figure 3.7 Sampling plot for trees, saplings and seedling

3.2.2. Plant Collection and identification

All plant species encountered inside each plot were identified using references such as Adrian and Storrs (1998). The local names of the most specimens were recorded by consulting local experts and later identified with the help of field guides as mentioned above.

3.3. Data analysis

3.3.1 Community Structures

After getting field data, density, frequency, abundance and the importance value index (IVI) of trees were calculated following Zobel *et al*. (1987). The density of seedlings and saplings in the forest was also calculated. The formulae which were used for the calculation of these attributes are given below:

1. $$\text{Density D (stem/ha)} = \frac{\text{Total individuals in all plots} \times 10{,}000}{\text{Total plots x size of plot}}$$

2. $$\text{Relative Density (RD)} = \frac{\text{Density of individual species}}{\text{Total density of all species}} \times 100\%$$

3. $$\text{Frequency (F)} = \frac{\text{Number of quadrat in which species occurred}}{\text{Total number of quadrat studied}} \times 100\%$$

4. $$\text{Relative Frequency (RF)} = \frac{\text{Frequency of individual species}}{\text{Sum of frequencies all species)}} \times 100\%$$

5. $$\text{Abundance (A)} = \frac{\text{Total number of individual species}}{\text{Total number of quadrat in which species occurred}}$$

6. $$\text{Relative Abundance (RA)} = \frac{\text{Abundance of individual Species}}{\text{Total abundance of all species)}} \times 100\%$$

7. Importance value index (IVI) = RD+ RF+RA

Species diversity is the combination of species richness and species evenness. Species richness is the number of species per sampling unit and species evenness is the distribution of individuals among the species. Evenness is the maximum when all the species have the same or nearly equal number of individuals.

Species diversity can be expressed in single index numbers. Among the several indices most commonly used, two indices are Simpson's index (Simpson, 1949) and Shannon-Wiener's index (Shannon and Weaver, 1949). Simpson's index reflects dominance (a measure of species diversity) because it is more sensitive to the most abundant species than to the rare species. Shannon Diversity Index (H) is a measure of diversity that combines species richness (the number of species in a given area) and their relative abundances.

For the analysis of vegetation following diversity indices were calculated.

Simpson's Index (SI)

$$(SI) = \frac{\sum (n-1)}{N\ (N-1)}$$

Where, n= number of individuals in the nth species,

N=the total number of individuals of all the species,

Simpson's Diversity Index (D)

It is calculated by using the 1- Simpson's Index, as the value of D increases, then species diversity also increases and its value ranges from 0-1.

Shannon Diversity Index (H)

$$H = \sum Pi \ln Pi$$

$$\text{Evenness} = \frac{\text{Shannon diversity index (H)}}{\text{Maximum Possible Value of H (Hmax)}}$$

Hmax = Ln (species richness)

Index of similarity (S)

S=2C/A+B

Where, A = Number of species in the community A,

B = Number of species in a community B, and

C = Number of common species in both communities

3.3.2. Regeneration of forest (DBH size-class diagram)

To assess the regeneration status of the forest, the density of seedling, sapling and tree of each tree species was determined separately following the method described by Zobel *et al*., (1987). Then dominant and co-dominant tree species (considered based on IVI values) were developed. Total number of plants of all species recorded in all 20 m × 20 m plots were divided into different size classes based on DBH of 10 cm intervals. Then, size class diagrams of dominant and co-dominant tree species were prepared to observe the distribution pattern of individuals in DBH classes. Total counts of plants were obtained by summation of the number of plants from all sampling plots.

3.3.3 Estimation of biomass and carbon stock

Estimation of Above and Below Ground Biomass

The allometric model developed for moist forest stands by Chave *et al*. (2005) was used.

AGB = 0.0509 × ρ*D2*H

Where, AGB = Above-ground biomass (kg),

ρ = wood density (g/cm3),

H = height of tree (m), and

D = Diameter of tree at breast height (cm).

Similarly, for estimation of below-ground biomass, the biomass of the root system (below-ground) of tree layers was estimated by assuming that it constitutes 15% of the above-ground biomass (MacDicken, 1997).

Wood Density

For dry wood density (ρ) of each tree species, the global database presented by Zanne *et al*. (2009) was used. For name of species and wood density see Appendix V.

Estimation of Carbon Stock

Total tree biomass was obtained by adding the above-ground and below-ground biomass of the tree layer. When above-ground biomass was multiplied by 0.47 and belowground biomass with 0.2 separately by default carbon fraction (IPCC, 2006), it gave total C-stock in Kg. Then the area of the total plot was calculated. Then, after carbon stock in kg were divided by the total area of the plot. The obtained value in kg/m2 was multiplied with 10,000 and divided by 1000 gave the C-stock in t/ha. Total carbon stock in forest was obtained by adding above ground and below-ground C-stock.

Carbon Stock of tree species

The carbon stock of individual species in a forest was determined by adding the carbon stock values of that particular species to all plots of that forest. Percentage contribution of carbon stock of each species in a forest was calculated by taking the proportion of sum of carbon stock of all species in forest to the sum of carbon stock of a particular species in the same forest. It was calculated by the following equation:

$$\text{Carbon stock of a tree species \%} = \frac{\text{Carbon stock of a particular tree species (ha)}}{\text{Sum of carbon stock of all tree species (ha)}} \times 100$$

3.3.4. Statistical analysis

The calculation of density, relative density, frequency, relative frequency, abundance, relative abundance, importance value index (IVI), species diversity, Regenerations, Carbon stock calculations, etc, were performed in Excel 2016 and presented in form of bar graphs, pie charts, figures and tables.

CHAPTER: 4 RESULTS

4.1. Vegetation structure

A total of 60 tree species belonging to 45 genera and 19 families were recorded in three Buddhist sacred forest sites in Mid-Western Terai Region with little differences in vegetation composition. A total of 47 species of trees belonging to 35 genera and 15 families were found in Lumbini; 23 tree species belonging to 20 genera and 11 families were found in Tilaurakot; and 27 tree species belonging to 23 genera and 13 families were recorded in Ramagram (Table 4.1)

Table 4.1. Tree diversity in three sacred forests.

S.N	Sites	Number of tree Species	Genus	Family
1.	Lumbini	47	35	15
2.	Tilaurakot	23	20	11
3.	Ramagram	27	23	13
	Total	**60**	**45**	**19**

The family Fabaceae, with 23 genera and 44 species, has been found to exhibit the highest generic and species diversity in all three sites, which was followed by Moraceae and Myrtaceae. In Lumbini, Family Fabaceae was found to be largest (15 species and 10 genera), followed by family Moraceae (7 species, 4 genera). In Tilaurakot, Family Fabaceae had the maximum number of tree species (7 species, 7 genera) followed by Family Moraceae (4 species, 1 genera). Similarly, in Ramagram, Family Fabaceae had the maximum number of tree species (6 species, 4 genera) followed by Moraceae (5 species, 3genera) (Figure: 4.1).

Tree species such as *Acacia catechu, Acacia nilotica, Acacia auriculiformis, Albizia lebbeck, Albizia procera, Bahunia purpurea, Cassia fistula, Dalbergia sissoo, Delonix regia, Dalbergia latifolia, Leucaena leucocephala, Saraca asoca and Tamarindus indica,* were present from family Fabaceae and *Artocarpus lakucha, Ficus religiosa, Ficus benghalensis, Ficus hispida, Ficus racemose, Morus alba* and *Streblus asper* from family Moraceae in Lumbini. Tree species such as *Butea monosperma, Acacia catechu, Dalbergia sissoo, Delonix regia, Pterocarpus marsupium* and *Tamarandus indica* were present from Family Fabaceae and *Ficus religiosa, Ficus benghalensis, Ficus hispida, Ficus racemose* were present from family Moraceae in Tilaurakot. Tree species such as *Acacia auriculiformis, Acacia catechu, Acacia nilotica, Bahunia sp., Cassia fistula, Dalbergia sissoo* were present from family Fabaceae and *Artocarpus lakoocha, Ficus religiosa, Ficus racemosa, Ficus infectoria* and *Streblus asper* were present from family Moraceae in Ramagram. (Table. 4.5)

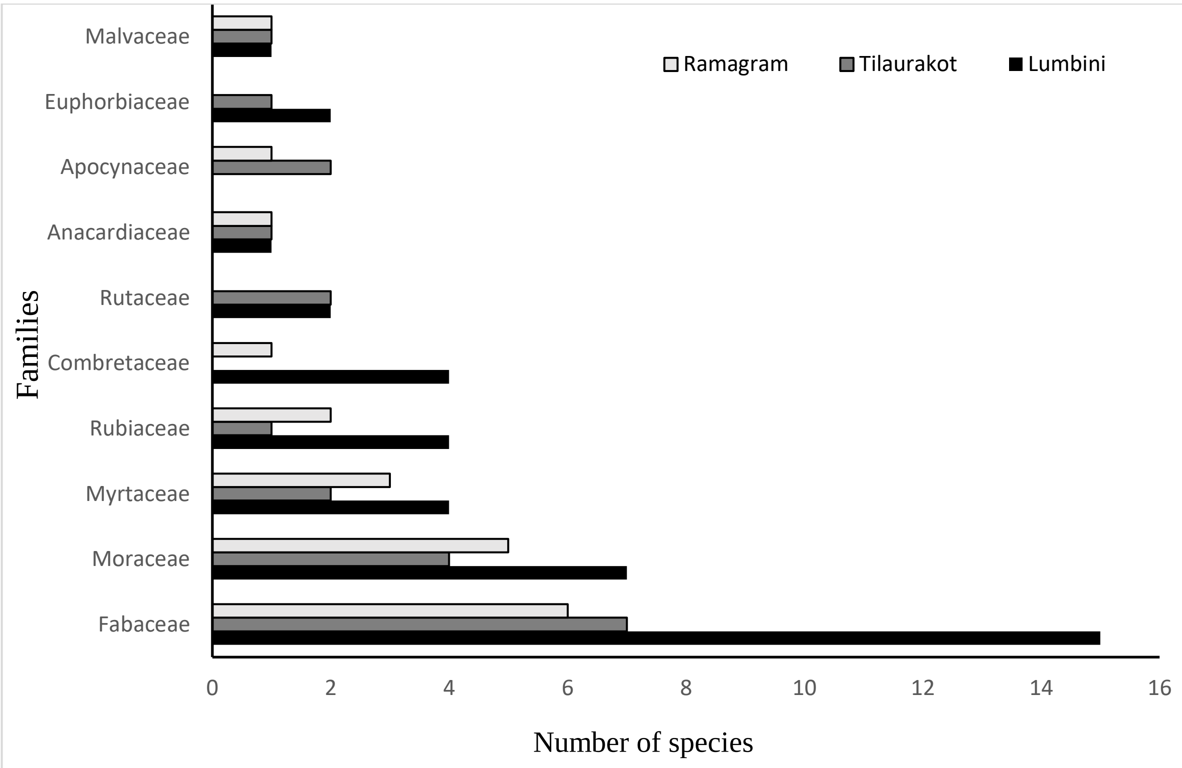

Figure 4.1. Families with higher number of tree species in three sites

Importance Value Index (IVI)

In Lumbini, the IVI value of the tree was recorded highest for *Dalbergia sissoo* (46.68) followed by *Shorea robusta* (40.58). Very low IVI values were obtained for tree species like *Morus alba* (Figure 4.2; Appendix I). In Tilaurakot, the highest IVI value of tree was recorded for *Schleichera oleosa* (43.36) followed by *Haldina cordifolia* (35.10) very lowest IVI value was recorded for *Plumeria rubra*. In Ramagram, the highest IVI value of tree was recorded for *Dalbergia sissoo* (30.07) followed by *Terminalia arjuna* (29.28) and the very lowest IVI was recorded for *Plumeria rubra*. Based on IVI values the dominant and co-dominant tree species in Lumbini were *Dalbergia sissoo and Shorea robusta*, in Tilaurakot *Schleichera oleosa* and *Haldina cordifolia* and in Ramagram *Dalbergia sissoo* and *Terminalia arjuna* (Table 4.2, Appendix I).

Table 4.2. IVI of top ten tree species in Lumbini, Tilaurakot and Ramagram

S. N	Scientific name	IVI		
		Lumbini	Tilaurakot	Ramagram
1	*Acacia auriculiformis*	9.30		13.02
2	*Acacia catechu*	11.56	10.04	
3	*Aegle marmelos*		16.65	
4	*Albizia lebbeck*	10.74		
5	*Bombax ceiba*	11.16	10.50	14.96
6	*Butea monosperma*		27.02	
7	*Callistemon citrinus*	10.53		11.86
8	*Dalbergia sissoo*	46.68	10.98	30.07
9	*Eucalyptus spp*	17.16		
10	*Ficus religiosa*		24.65	22.46
11	*Haldina cardifolia*		35.10	23.54
12	*Mangifera indica*		29.71	25.05
13	*Polyalthia longifolia*			14.32
14	*Schleichera oleosa*		43.36	
15	*Shorea robusta*	40.58		
16	*Syzigium cumini*	15.35	10.13	17.97
17	*Tectona grandis*	25.47		
18	*Terminalia arjuna*			29.28

4.2. Species Diversity

4.2.1. Species richness and evenness

Species richness (number of tree species) was found highest in Lumbini and lowest in Tilaurakot (Figure 4.2).

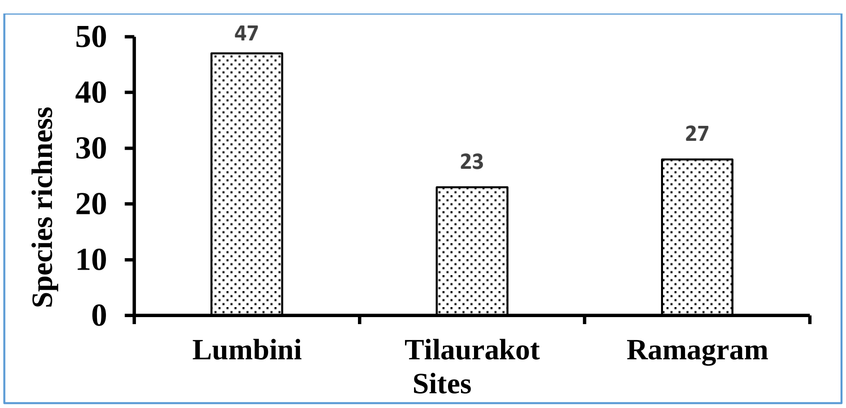

Figure 4.2. Species richness in three sites

Species evenness was found highest in Ramagram and minimum in Tilaurakot. The evenness value obtained for Ramagram (0.8304) was higher than that of Lumbini (0.6872), Tilaurakot (0.2666) (Figure 4.3)

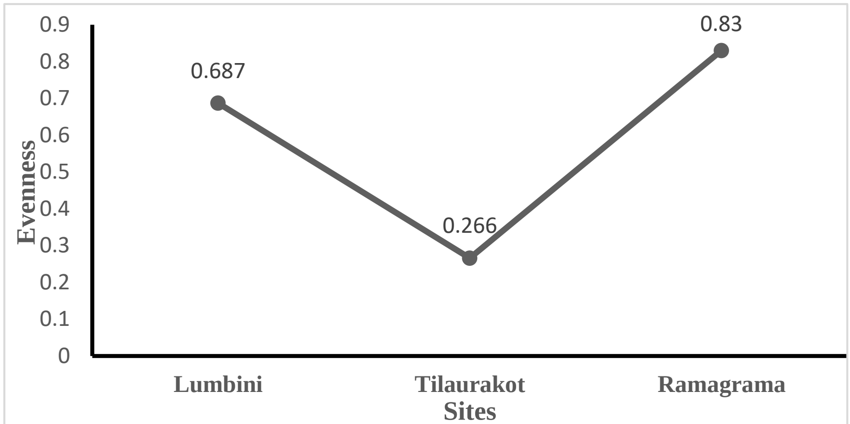

Figure 4.3. Species evenness in three sites

4.2.2. Diversity indices

The diversity index was highest at Ramagram and lowest at Tilaurakot. The diversity index varied among the three sites. Simpson's diversity index (SI) for trees was higher in Ramagram (0.999) than in Lumbini (0.885) and Tilaurakot (0.874). Shannon Wieners (H) values were higher in Ramagram (2.767) than others (Table 4.3).

Table 4.3. Diversity indices of three forest

Sites	Simpsons diversity index (SI)	Shannon-Wieners index (H)
Lumbini	0.885	2.646
Tilaurakot	0.874	0.878
Ramagram	0.999	2.767

4.2.3. Similarity Index

Lumbini, Tilaurakot and Ramagram share 11 common tree species. Among the trees, Sorenson similarity index between Lumbini and Ramagram values was found to be highest (56) followed by Tilaurakot and Ramagram (50.980) and very lowest was observed between Lumbini and Tilaurakot (45.71).

4.3. Population Structure and Regeneration

4.3.1. Percentage of seedlings, saplings and trees in study sites

The overall population of different growth forms of tree species was divided into seedlings, saplings, and trees. In Lumbini, the highest percentage (85.34%) was recorded for tree populations followed by saplings (7.78%) and seedlings (6.88%). In Tilaurakot, the highest percentage of population (82.55%) was recorded for trees followed by saplings (9.66%) and seedlings (7.79%). Similarly, in Ramagram also, the highest percentage (85.84%) was recorded for trees followed by saplings (10.62%) and seedlings (3.54) (Figure 4.4).

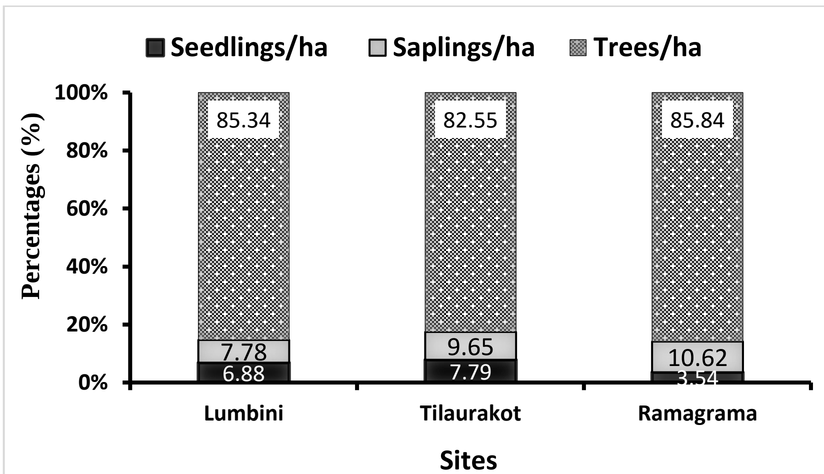

Figure 4.4. Seedling, sapling and tree (%) in three sites

4.3.2. Density Diameter class distribution curve and regeneration status

The proportion of different life stages (seedlings, saplings and trees) of different species helps in predicting any possible changes in forest composition.
In the present study, Lumbini, all the tree species with lower DBH class resulted in high tree density; highest density was found in DBH 20-30 cm, and tree density decline above DBH 30cm resulted in lowest tree density in higher DBH classes. In Tilaurakot, tree species with DBH 40–50 cm resulted in highest tree density and DBH below and above (40-50cm) resulted in lowest tree density, but DBH above 100 cm also showed high tree density in forest. Similarly, in Ramagram tree species with lower DBH classes resulted in higher tree density; highest density was found in DBH class 10-20 cm, higher DBH classes showed lowest tree density (Figure 4.5).

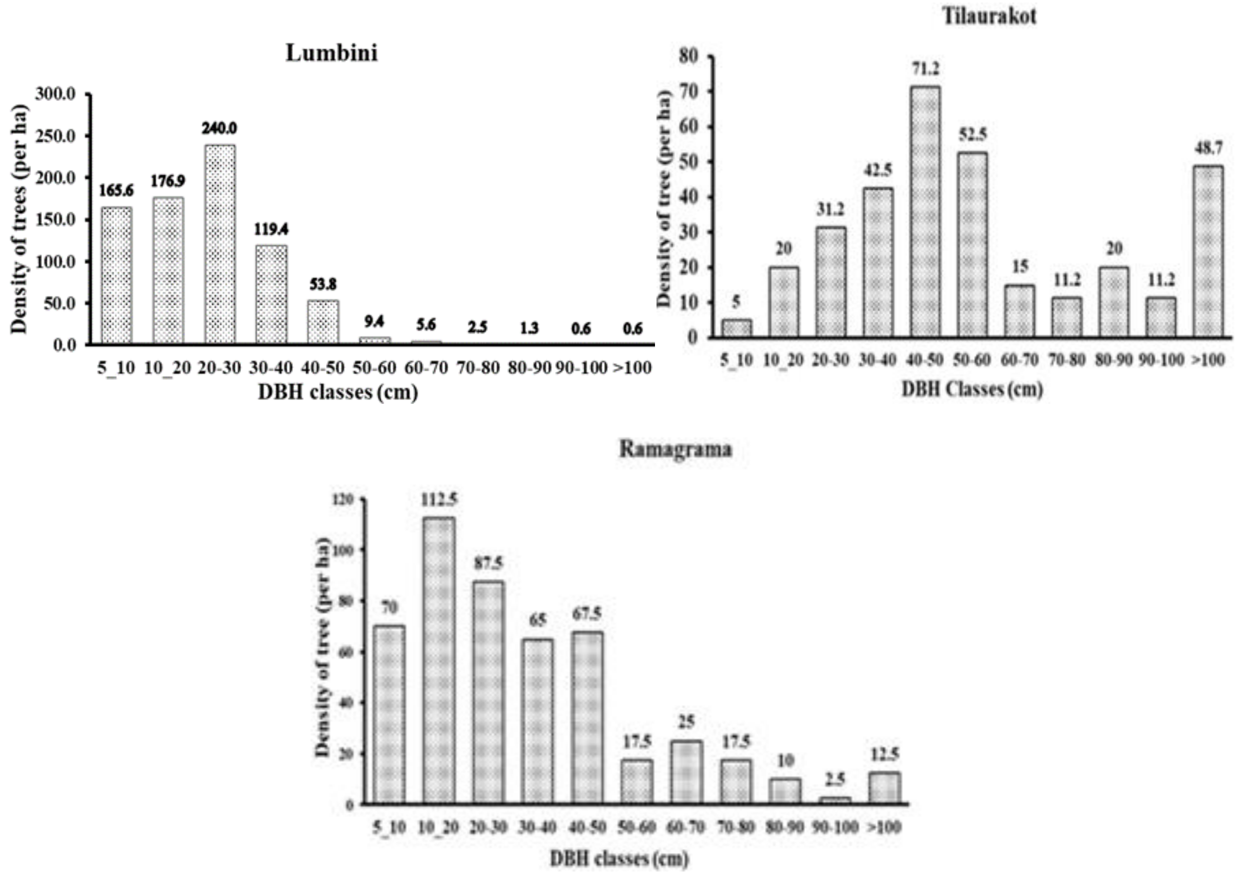

Figure 4.5. Tree Regenerations curves in Lumbini, Tilaurakot, and Ramagram forest

4.3.3. Regeneration of two dominant tree species of each forest

The dd curve of *Dalbergia sissoo* in Lumbini was similar to the inverse J-shape. *Dalbergia sissoo* with lower DBH classes (5-10 cm) contained higher tree density and very low density of *Dalbergia sissoo* was observed in higher DBH classes. The dd curve of *Shorea robusta* in Lumbini was quite similar to the bell shape (Figure 4.6). *Shorea robusta* with DBH (20-30cm) contained higher tree density, and DBH classes above and below (20-30cm) showed lowest tree density (Figure 4.6)

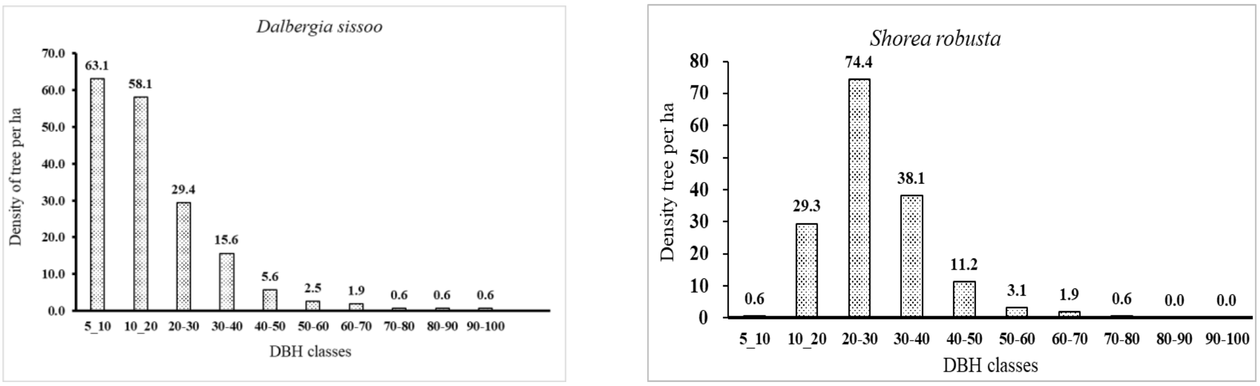

Figure 4.6. Density-diameter curve of dominant and co-dominant tree species in Lumbini forest.

The dd curve of *Schleichera oleosa* in Tilaurakot was deviated from the inverse J-shape. *Schleichera oleosa* with DBH class above 100cm showed highest density. *Haldina cordifolia* tree was quite similar to J-shape up to DBH 50-60cm; The highest tree density was observed at 50-60cm and the density of trees was irregular above this DBH (Figure 4.7)

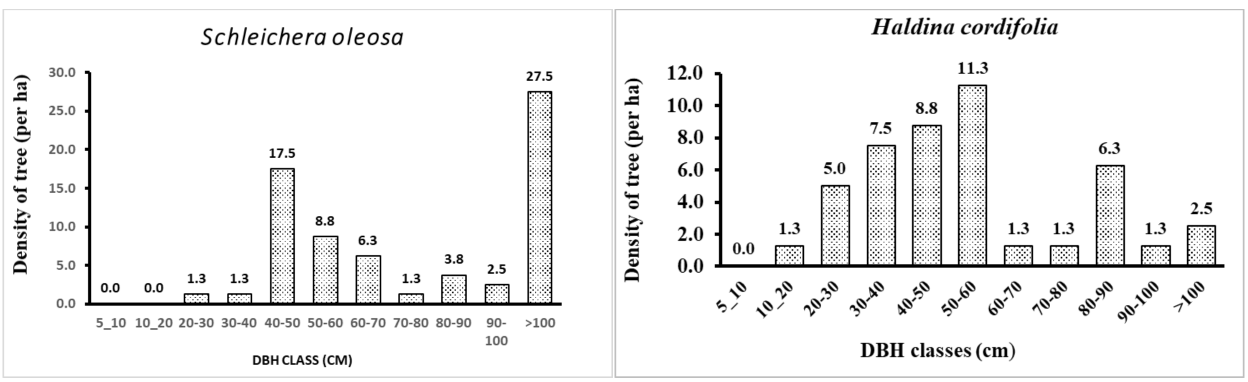

Figure 4.7. Density-diameter curve of dominant and co-dominant tree species in Tilaurakot forest

The dd curve of *Dalbergia sissoo* in Ramagram nearly resembled to inverse J-shape. Thus, in general, Sissoo forests were regenerating. Dalbergia sissoo trees with lower DBH (5-10cm) contained higher tree density and density of trees were decling above DBH 10cm. The dd curve of *Terminalia arjuna* in Ramagram was deviated from the inverse J-shape. *Terminalia arjuna* with DBH (10-20cm) contained higher tree density and DBH (50-100cm) showed lowest tree density (Figure4.8).

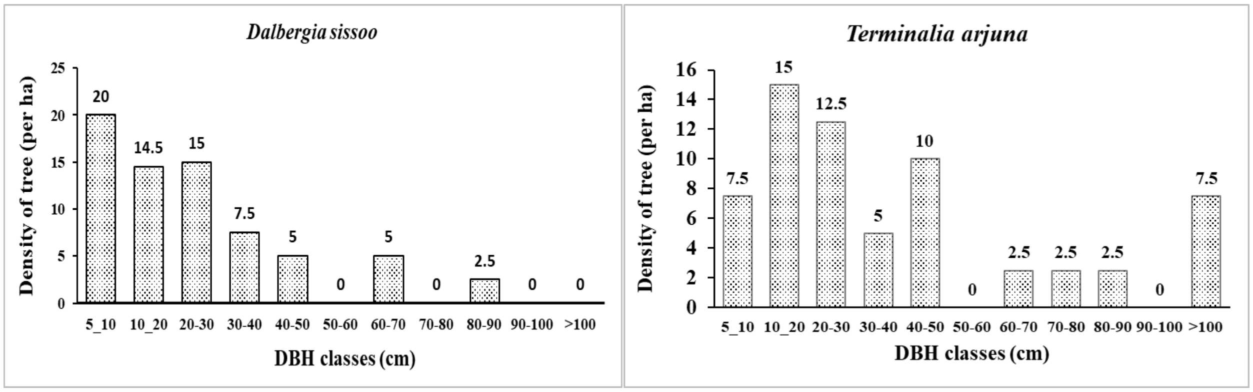

Figure 4.8. Density-diameter curve of dominant and co-dominant tree species in Ramagram forest

4.4. Carbon stock

4.4.1. Above Ground Biomass (AGB) and Below Ground biomass (BGB) of trees

Total carbon stock is the compilation of above-ground and below-ground carbon stock. The above ground carbon stock was of trees and below ground was resulted by 0.15 % of AGC. The total AGB of trees in Lumbini was found to be 42.59 ton/ha and BGB was 8.52 ton/ha. S*horea robusta* (12.05 ton/ha, 2.41 ton/ha) showed highest AGB and BGB followed by *Eucalyptus* sp (9.64 ton/ha, 1.93) in Lumbini. The total AGB of trees in Tilaurakot was found to be 73.43 ton/ha and BGB was 14.69 ton/ha. The dominant tree *Schleichera oleosa* (37.90 ton/ha, 7.58ton/ha) showed highest AGB and BGB followed by *Ficus religiosa* (9.29 ton/ha, 1.86 ton/ha) in Tilaurakot. The total AGB of trees in Ramagram was found to be 33.43 ton/ha and BGB was 6.69 ton/ha. The dominant tree *Terminalia arjuna* (8.58 ton/ha, 1.72 ton/ha) showed highest AGB and BGB followed by *Mangifera indica* (4.81 ton/ha, 0.96 ton/ha) in Ramagram (Appendix V, Table 4.4).

Table 4.4. Above ground biomass, below ground biomass, Total biomass and Carbon stock (t/ha) of top ten tree species in Lumbini, Tilaurakot and Ramagram Sacred Forest.

Lumbini

S.N	Tree species	AGB (ton/ha)	BGB (ton/ha)	Total Biomass	Carbon stock (ton/ha)
1	*Shorea robusta*	12.05	2.41	14.47	6.80
2	*Eucalyptus sps*	9.64	1.93	11.57	5.44
3	*Dalbergia sissoo*	5.50	1.10	6.60	3.10
4	*Syzigium cumini*	2.96	0.59	3.55	1.67
5	*Tectona grandis*	2.26	0.45	2.71	1.27
6	*Albizia lebbeck*	2.22	0.44	2.66	1.25
7	*Acacia auriculiformis*	0.96	0.19	1.16	0.54
8	*Ficus religiosa*	0.89	0.18	1.07	0.50
9	*Acacia catechu*	0.80	0.16	0.96	0.45
10	*Bombax ceiba*	0.77	0.15	0.92	0.43

Tilaurakot

S.N	Tree species	AGB (ton/ha)	BGB (tonha)	Total Biomass	Carbon stock (ton/ha)
1	*Schleichera oleosa*	37.90	7.58	45.48	21.37
2	*Ficus religiosa*	9.29	1.86	11.15	5.24
3	*Haldina cardifolia*	5.51	1.10	6.61	3.11
4	*Pterocarpus marsupium*	4.35	0.87	5.21	2.45
5	*Mangifera indica*	4.11	0.82	4.93	2.32
6	*Bombax ceiba*	2.57	0.51	3.09	1.45
7	*Butea monosperma*	2.34	0.47	2.80	1.32
8	*Aegle marmelos*	1.45	0.29	1.74	0.82
9	*Dalbergia sissoo*	1.42	0.28	1.70	0.80
10	*Syzigium cumini*	1.05	0.21	1.26	0.59

Ramagram

S.N	Tree species	AGB (ton/ha)	BGB (ton/ha)	Total Biomass	Carbon stock (ton/ha)
1	*Terminalia arjuna*	8.58	1.72	10.29	4.84
2	*Mangifera indica*	4.81	0.96	5.77	2.71
3	*Dalbergia sissoo*	3.13	0.63	3.75	1.76
4	*Artocarpus lakoocha*	2.66	0.53	3.19	1.50
5	*Polyalthia longifolia*	1.90	0.38	2.29	1.07
6	*Syzigium cumini*	1.78	0.36	2.14	1.00
7	*Acacia auriculiformis*	1.68	0.34	2.02	0.95
8	*Haldina cordifolia*	1.68	0.34	2.02	0.95
9	*Ficus religiosa*	1.40	0.28	1.67	0.79
10	*Garuga pinnata*	0.91	0.18	1.10	0.52

4.4.2. Carbon stock of forest

The total amount of carbon stock of trees in Lumbini was found to be 24.02 ton/ha, Tilaurakot was found to be 41.41 ton/ha, and Ramagram was found to be 18.86 ton/ha (Figure 4.9).

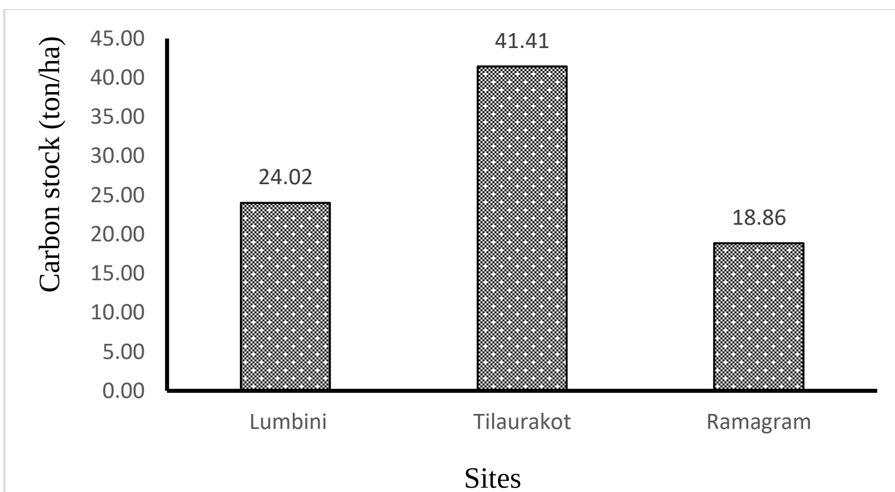

Figure 4.9. Carbon stock (ton/ha) in three sites

4.4.3. Carbon stock (%) contribution of tree species in three sites

In Lumbini Sacred Forest, *Shorea robusta* stored highest amount of carbon stock i.e. 6.80 ton/ha which was 28.26% of total carbon stock (24.02 ton/ha) followed by *Eucalyptus* sp. 23% and very lowest carbon stock contribution in forest by *Psidium guajava* 0.01%. In Tilaurakot, *Schleichera oleosa* stored the highest carbon stock, i.e. 21.37 ton/ha which was 52% of total carbon stock (41.41

ton/ha) followed by *Ficus religiosa* (13%) and very lowest by *Plumeria rubra* 0.01%. In Ramagram, *Terminalia arjuna* stored highest carbon stock i.e. 4.84 ton/ha which was 26% of total carbon stock (18.86 ton/ha) followed by *Mangifera indica* 13% and very lowest by *Citrus* sp. 0.03% (Figure 4.10).

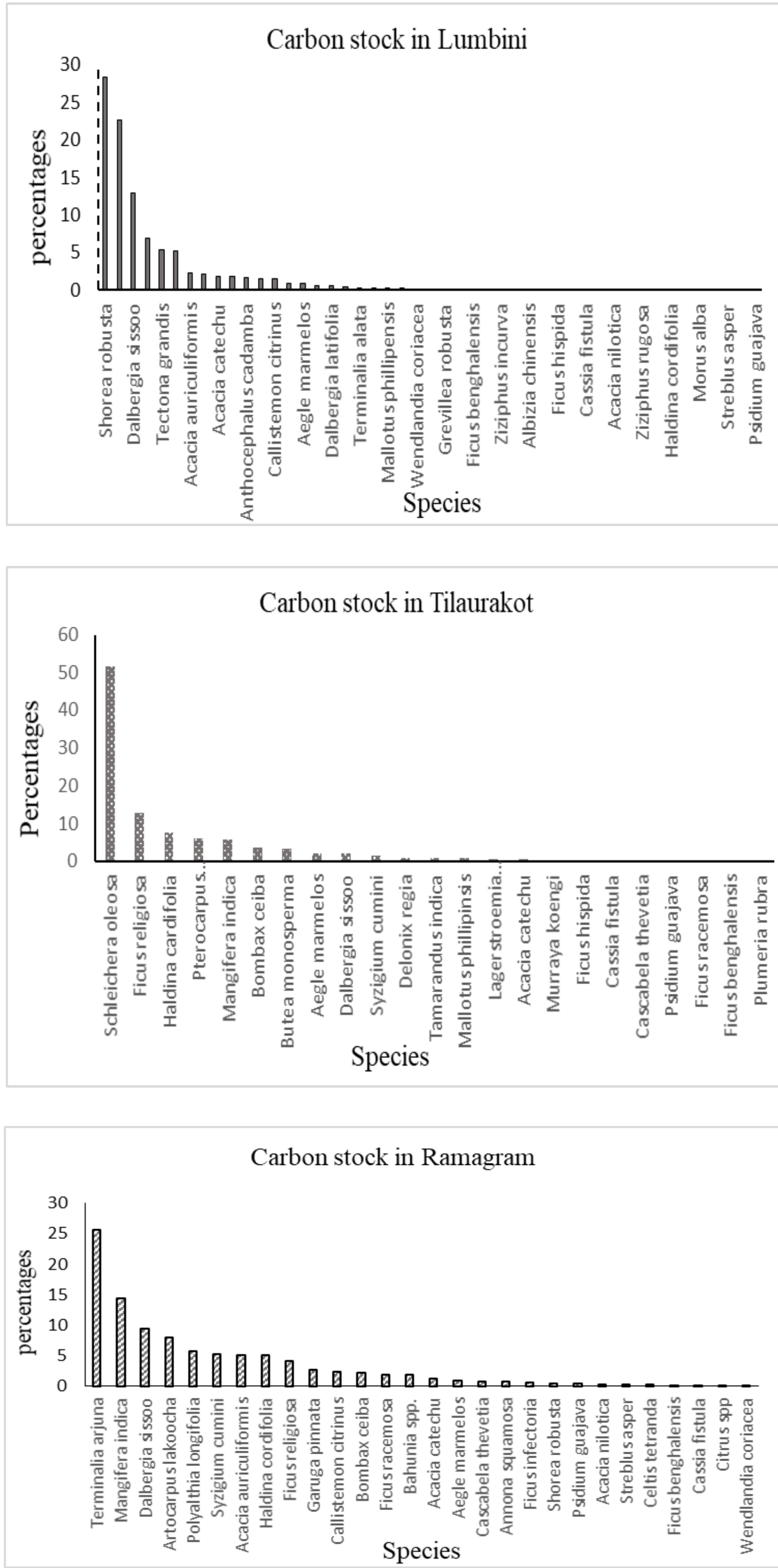

Figure 4.10. Carbon stock (%) in tree species in Lumbini, Tilaurakot, Ramagram

4.5. Use values and conservation status of tree species

4.5.1 Use values of tree species

The tree species found in these sacred sites have different use values such as food, fodder, timber, fuelwood, ornamental, medicinal uses, and religious values. Most of the plant species in these sacred forests had one or more ethnomedicinal importance. Different medicinal plants like *Ficus religiosa, Terminalia arjuna, Terminalia chebula, Terminalia bellirica, Cassia fistula* are found in these sacred sites. Some species like *Ficus religiosa, Ficus benghalensis, and Aegle marmelos* present in sites have different religious credences (Tables 4.5).

Table 4.5. Enumeration of Tree species in three sacred sites with their Families, Local names, and use values

Lumbini

S.N	Name of Tree species	Family	Local names	Use value
1	*Acacia auriculiformis A.Cunn.ex Benth.*	Fabaceae		-
2	*Acacia catechu (L.F.) Willd.*	Fabaceae	Khayar	Asthma, fodder Wooden nails
3	*Acacia nilotica ssp. Indica (Benth.)*	Fabaceae	Babul	-
4	*Aegle marmelos (L.)*	Rutaceae	Bel	Leaves and fruit used as religious purpose fruit edible
5	*Albizia chinensis (Osbeck) Merr.*	Fabaceae	-	-
6	*Albizia lebbeck (L.) Benth.*	Fabaceae	Sirish	Bark used to treat inflammation, Ornamental
7	*Albizia procera (Roxb.) Benth.*	Fabaceae	-	Ornamental
8	*Anthocephalus cadamba (Roxb.)*	Rubiaceae	Kadam	traditional medicine Stem used as tooth brush
9	*Artocarpus lakucha Wall.ex Roxb.*	Moraceae	Badhar	Bark and ripe fruit used to treat constipation
10	*Azadirachta indica Juss.*	Meliaceae	Neem	leaves used for various medicinal purposes

11	*Bahunia purpurea L.*	Fabaceae	koiralo	-
12	*Bombax ceiba L.*	Malvaceae	Simal	Bark, flower and young fruit used for skin diseases, Timber, furniture
13	*Callistemon citrinus*	Myrtaceae	Kalki	-
14	*Cassia fistula L.*	Fabaceae	Rajbrikshya	leaves of trees used for malaria, ulcers, constipation
15	*Citrus macrophylla Wester*	Rutaceae		-
16	*Dalbergia latifolia Roxb.*	Fabaceae	Satisaal	Furniture, bark used to treat worms timber, fuelwood, fodder,
17	*Dalbergia sissoo Roxb. ex Dc.*	Fabaceae	Sisau	medicinal value, high quality timber for furniture plough
18	*Delonix regia (Bojer ex Hook.) Raf.*	Fabaceae	Gulmohar	Ornamental as ingredient it reduces cough, colds
19	*Eucalyptus sp.*	Myrtaceae	-	-
20	*Ficus benghalensis L.*	Moraceae	Baar	treatment of wounds skin, religious value
21	*Ficus hispida L.f.*	Moraceae	khasreto	Fruit
22	*Ficus racemosa L.*	Moraceae	Dumri	Edible fruits
23	*Ficus religiosa L.*	Moraceae	Peepal	Worshped as religious plants, traditonal medicine
24	*Garuga pinnata Roxb.*	Burseraceae	-	Fruits edible, medicinal, firewood,
25	*Grevillea robusta A.*	Proteaceae	Kayio	poles used in house constructions
26	*Haldina cordifolia (Roxb.)*	Rubiaceae	Karma	Ayurvedic plant
27	*Leucaena leucocephala (Lam.) de Wit*	Fabaceae	Ipilipil	Valuable for its wood, small furniture fodder

28	*Mallotus philippensis Roena*	Euphorbiaceae	Sindhure	Fruit and seed useful timber skin diseases Timber, medicinal
29	*Mangifera indica L.*	Anacardiaceae	Aap	Edible fruits, improves digestion, timber wood
30	*Mitragyna parvifolia (Roxb.) korth*	Rubiaceae	-	-
31	*Morus alba L.*	Moraceae	Kimbu	Edible fruits
32	*Pithecellebium dulce*	Fabaceae	-	Timber wood
33	*Psidium guajava L.*	Myrtaceae	Amba	Edible fruits used for high blood pressure
34	*Saraca asoca (Roxb.) de Wilde*	Fabaceae	-	Ornamental, medicinal
35	*Shorea robusta Gaertn. f.*	Dipterocarpaceae	Sal	high quality beams, timber wood, medicinal
36	*Streblus asper Lour.*	Moraceae	Sihora	-
37	*Syzigium cumini (L.)*	Myrtaceae	Jamun	medicinal use, fruit
38	*Tamarindus indica L.*	Fabaceae	Emili	Medicinal value, fruit edible
39	*Tectona grandis L.*	Lamiaceae	Teak	Quality timber
40	*Terminalia alata* Heyne ex Roth	Combretaceae	Saj	-
41	*Terminalia arjuna (Roxb. ex Dc.) Wlight and Arn.*	Combretaceae	-	medicinal
42	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Barro	Medicinal value
43	*Terminalia chebula Retz.*	Combretaceae	Harro	Medicinal value
44	*Trewia nudiflora L.*	Euphorbiaceae	Bhilor	leaves applied on wounds to heal them
45	*Wendlandia coriacea*	Rubiaceae	-	-
46	*Ziziphus incurva Roxb.*	Rhmnaceae	Bayar	Fruit edible, raw or boiled dal ground and spiced with salt and sugar
47	*Ziziphus rugosa Lam.*	Rhmnaceae	-	Fruit edible

Tilaurakot

S.N	Name of tree species	Family	Local names	Use value
1	*Acacia catechu (L.f.) Willd.*	Fabaceae	Khayar	Asthma, fodder Wooden nails
2	*Aegle marmelos L. Correa.*	Rutaceae	Bel	Leaves and fruit used as religious purpose fruit edible

3	*Bombax ceiba L.*	Malvaceae	Simal	Bark, flower and young fruit used for skin diseases, Timber, furniture
4	*Butea monosperma (Lam.) Taub.*	Fabaceae	Palans	Ornamental, Medicinal, timber
5	*Cascabela thevetia L.*	Apocynaceae	-	Ornamental tree, Medicinal
6	*Cassia fistula L.*	Fabaceae	Rajbrikshya	Ornamental tree timber, fuelwood, medicinal
7	*Dalbergia sissoo Roxb. ex DC.*	Fabaceae	Sissoo	medicinal value ,fodder, timber
8	*Delonix regia (Bojer ex Hook.) Raf.*	Fabaceae	Gulmohar	used in tanning industry Ornamental tree, Firewood
9	*Ficus benghalensis L.*	Moraceae	Bar, bargat	religious value
10	*Ficus hispida L.f.*	Moraceae	Khasreto	-
11	*Ficus racemose L*	Moraceae	Dumri, Guilar	Edible fruit
12	*Ficus religiosa L.*	Moraceae	Peepal	Used as a traditional medicines, religious value
13	*Haldina cardifolia (Roxb.)*	Rubiaceae	Karma	Ayurvedic plant used for the skin diseases
14	*Lagerstroemia parviflora Roxb.*	Lythraceae	Bot dhaiero	Ornamental tree, timber wood
15	*Mallotus philippensis Muell. Arg*	Euphorbiaceae	Rohini	Fruit and seed useful timber skin diseases, Timber, medicinal
16	*Mangifera indica L.*	Anacardiaceae	Aap	Edible fruits, improves digestion, timber wood
17	*Murraya koengi L.*	Rutaceae	Karripatta	-
18	*Plumeria rubra*	Apocynaceae	-	Ornamental
19	*Psidium guajava L.*	Myrtaceae	Amba	Fruits used for high BP
20	*Pterocarpus marsupium Roxb.*	Fabaceae	-	Timber wood medicinal
21	*Schleichera oleosa Malay Lac.*	Sapindaceae	Kusum	Fruits edible Timber
22	*Syzigium cumini (L.)*	Myrtaceae	Jamun	Medicinal use
23	*Tamarandus indica L.*	Fabaceae	Emili	Medicinal value, fruit edible

Ramagram

S.N	Species name	Family	Local names	Use value
1	*Acacia auriculiformis A. Cunn.ex. Benth.*	Fabaceae	-	-
2	*Acacia catechu (L.F.) wild.*	Fabaceae	Khayar	Asthma, fodder Wooden nails
3	*Acacia nilotica ssp. Indica (Benth.)*	Fabaceae	Babul	-
4	*Aegle marmelos (L.)*	Rutaceae	Bel	Leaves and fruit used as religious purpose fruit edible
5	*Annona squamosal L.*	Annonaceae	Saripha	Fruit edible
6	*Artocarpus lakoocha wall.ex Roxb.*	Moraceae	Badhar	Fruit edible
7	*Bahunia sp.*	Fabaceae	koiralo	-
8	*Bombax ceiba L.*	Malvaceae	Simal	Bark, flower and young fruit used for skin diseases, Timber, furniture
9	*Callistemon citrinus*	Myrtaceae	Kalki	-
10	*Cascabela thevetia (L.) H. Lippold*	Apocynaceae	Shivaji ful	Ornamental tree,
11	*Cassia fistula L.*	Fabaceae	Rajbrikshya	Ornamental tree timber, fuelwood, medicinal
12	*Celtis tetranda Roxb.*	Ulmaceae	Khari	-
13	*Citrus spp*	Rutaceae		-
14	*Dalbergia sissoo Roxb. ex Dc*	Fabaceae	Sisau	Timber, fuelwood, fodder, medicinal value,
15	*Ficus infectoria*	Moraceae	Kavro	vegetables
16	*Ficus racemosa L.*	Moraceae	Dumri	Edible fruit
17	*Ficus religiosa L.*	Moraceae	Peepal	Used as a traditional medicines
18	*Garuga pinnata Roxb.*	Burseraceae	Dabdabey	-
19	*Haldina cordifolia (Roxb.)*	Rubiaceae	Karma,	Ayurvedic plant used for the skin diseases
20	*Mangifera indica L.*	Anacardiaceae	Aap	rituals
21	*Polyalthia longifolia (Sonn.)*	Annonaceae	Ashoka	-
22	*Psidium guajava L.*	Myrtaceae	Amba	fruits used for high BP
23	*Shorea robusta Gaertn. F.*	Dipterocarpaceae	Sal	Furniture,
24	*Streblus asper Lour.*	Moraceae	Sihora	-
25	*Syzigium cumini (L.)*	Myrtaceae	Jamun	Medicinal use
26	*Terminalia arjuna (Roxb. ex Dc.) wlight and Arn.*	Combretaceae	Arjun	

27	*Wendlandia coriacea*	Rubiaceae	-	-

4.5.2. Conservation status of tree species

The species in these sacred sites have different religious values that may provide homes for protection of different threatened species. International Union for Conservation of Nature (IUCN) Red List of Threatened Tree species like *Dalbergia latifolia* (Vulnarable), *Saraca asoca* (Vulnarable), were recorded in Lumbini (Table 4.6).

Table: 4.6 Conservation status of the tree species as per IUCN Red list of Threatened species, in Lumbini, Tilaurakot and Ramagram.

Sites	S.N	Name of Tree species	Conservation status
Lumbini	1	*Acacia auriculiformis* A.Cunn.ex Benth.	LC
	2	*Aegle marmelos* (L.)	NT
	3	*Albizia lebbeck (*L.) Benth.	LC
	4	*Albizia procera (*Roxb.) Benth.	LC
	5	*Azadirachta indica* Juss.	LC
	6	*Bombax ceiba* L.	LC
	7	*Cassia fistula* L.	LC
	8	*Dalbergia latifolia* Roxb.	VU
	9	*Dalbergia sissoo* Roxb. ex Dc.	LC
	10	*Delonix regia* (Bojer ex Hook.) Raf.	LC
	11	*Ficus hispida* L.f.	LC
	12	*Ficus racemosa* L.	LC
	13	*Grevillea robusta A.*	LC
	14	*Mallotus philippensis* Roena	LC
	15	*Mangifera indica* L.	DD
	16	*Psidium guajava* L.	LC
	17	*Saraca asoca* (Roxb.) de Wilde	VU
	18	*Shorea robusta* Gaertn. f.	LC
	19	*Streblus asper* Lour.	LC
	20	*Tamarindus indica* L.	LC
	21	*Terminalia bellirica* (Gaertn.) Roxb.	LC
	22	*Terminalia chebula Retz.*	LC
	23	*Ziziphus incurva Roxb.*	LC
Tilaurakot	1	*Aegle marmelos L. Correa.*	NT
	2	*Bombax ceiba L.*	LC
	3	*Butea monosperma (Lam.) Taub.*	LC
	4	*Cascabela thevetia L.*	LC

	5	*Cassia fistula L.*	LC
	6	*Dalbergia sissoo Roxb. ex DC.*	LC
	7	*Delonix regia (Bojer ex Hook.) Raf.*	LC
	8	*Ficus hispida L.f.*	LC
	9	*Ficus racemose L*	LC
	10	*Mallotus philippensis Muell. Arg*	LC
	11	*Mangifera indica L.*	DD
	12	*Plumeria rubra*	LC
	13	*Psidium guajava L.*	LC
	14	*Pterocarpus marsupium Roxb.*	NT
	15	*Schleichera oleosa Malay Lac.*	LC
	16	*Tamarandus indica L.*	LC
Ramagram	1	*Acacia auriculiformis A. Cunn.ex. Benth.*	LC
	2	*Aegle marmelos (L.)*	NT
	3	*Bombax ceiba L.*	LC
	4	*Cascabela thevetia (L.) H. Lippold*	LC
	5	*Cassia fistula L.*	LC
	6	*Dalbergia sissoo Roxb. ex Dc*	LC
	7	*Ficus racemosa L.*	LC
	8	*Mangifera indica L.*	DD
	9	*Psidium guajava* L.	LC
	10	*Shorea robusta Gaertn. F.*	LC
	11	*Streblus asper Lour.*	LC

Abbreviations: LC= Least Concern, NT= Near Threatened, VU= Vulnerable, DD= Data Deficient

According to LDT, officials, different forest management systems were adopted for the conservation of plants and Buddhist sacred sites, such as plantation program, maintenance of roads through forests, and preventing fires. The population around study sites are involved in agriculture and livestock farming, thus directly or indirectly they were dependent on forest products. But in Tilaurakot, local people were concerned about the conservation of forest. According to them, livestock grazing, fodder collection are restricted and management regulations are prepared and applied, such as domestic animals are not allowed to enter into the forest.

CHAPTER: 5 DISSCUSION

5.1. Vegetation structure

Overall, this study recorded 60 tree species from three sacred sites. Among these, the most species-rich families were Fabaceae followed by Moraceae at all three sites (Figure 4.1). In most of the studies, Fabaceae is considered the third largest family among the angiosperms after Orchidaceae and Asteraceae (Stevens, 2001). However, in the present study Fabaceae was the largest family in terms of the number of species. Dominance of Fabaceae in study sites may be related to traits like increased dispersal, efficiency (Arianoutsou *et al*., 2013). The family Moraceae is pantropical, well-represented in all tropical phytogeographic regions. This trait of Moraceae family might have adopted them to the tropical forests of our study sites.

In Lumbini forest, the highest IVI value of tree was recorded for *Dalbergia sissoo* (46.7) followed by *Shorea robusta* (40.6) (Appendix I). LDP developed greenery in Lumbini by planting over 3,71,182 tree saplings (Khan and Yoshino, 1995), *Dalbergia sissoo* represented the major planted tree species followed by *Shorea robusta*, *Syzygium cumini*. In the present study, *Dalbergia sissoo* represented highest the IVI and the highest number of tree density. *Dalbergia sissoo* was the dominant tree species in Lumbini in terms of density and frequency (LDT, 2008). Siwakoti (2008) found Lumbini with *Dalbergia sissoo* forest patches dominated by *Saccharum* grasslands. The study conducted by DFRS (2014) reported *Shorea robusta,* a prominent species in the lowland of Nepal. In another study, Terai Forest Inventory carried out by the DFRS (2014), found *Shorea robusta* a dominant species with a highest IVI of 180.09. This might be the reason for the dominancy of *Dalbergia sissoo* and *Shorea robusta* in Lumbini forest.

In Tilaurakot, highest value of IVI was recorded for *Schleichera oleosa* which prefers dry or moist soil. Terai region has its own natural diversity which supports the stable ecosystem with well adaptability of trees for the area (Bajpai *et al*., 2015). In Ramagram, the highest IVI value of tree was recorded for *Dalbergia sissoo*. *Dalbergia sissoo* is popular for plantations due to its fast growth and multiple use properties, which prefer well-drained, alluvial soils near rivers and streams. In Nepal sissoo is distributed from the terai up to 1400 m (Napier and Robbins, 1989). Ramagram our study site which is situated on the bank of Jharai river, provides better habitat for sissoo for its dominance.

5.2. Species Diversity

Understanding the diversity, forest contents, and structure is very essential in assessing sustainability of forest and species conservation (Kacholi, 2014). This study describes the status, composition, and diversity of trees in sacred forests. Lumbini forest recorded maximum tree diversity than other sites, but the number of tree species (i.e., 47 species) recorded in Lumbini of present study was found to be lower than the number of tree species recorded by Siwakoti (2008) (i.e., 54 species) and Bhattarai and Baral (2008), i.e., 65 species, which might be due to different disturbances in Lumbini. Harvesting of trees and livestock grazing had contributed to the reduction or absence of seedlings and saplings at the early stages of the tree species (Ghimire and Lekhak, 2007). The tree species richness in Lumbini showed a wide variation with Tilaurakot and Ramagram. Species diversity is significantly influenced by forest structure (Huang *et al*., 2003), renovations, excavations and development of architectural structures (Blicharska *et al*., 2013).

However, Tilaurakot forest though being highly protcected by LDT officials and from local people, have faced threats to its biodiversity due to the different practices of excavations and renovations of these site. Thus it may be affecting the growth of new species in the forest, which may threaten the long-term maintenance of these groves biodiversity.

5.3. Population structure and Regeneration

Undisturbed old-growth forests with sustainable regeneration were found to have an inverse J-shaped size class distribution (West *et al*., 1981) and a bell-shaped size class distribution has been attributed to disturbed forests where regeneration is hampered (Saxena *et al*., 1984)**.** Results show that overall regeneration curves of three forest were, Lumbini (deviated from J-shape), Tilaurakot (bell shape), and Ramagram (deviated from J-shape) indicating very poor regeneration in Tilaurakot and slightly good regeneration in Lumbini and Ramgram as compared to Tilaurakot.

According to the regeneration curves of Lumbini and Ramagram, maximum tree density was observed in the lower DBH classes (10-50cm) and declined above DBH classes 50cm. Mekuria and Shibra (2018) analyzed the density of tree species in the forest decreases with increasing DBH classes thus forest is characterized by high density of trees in the lower DBH class than in the higher DBH classes. Ghimire and Lekhak, (2007) explains regeneration of any species in a forest depends on the population of seedlings, saplings and adults. The presence of density of seedlings and saplings of these sacred sites were very low. During the study, in Lumbini tree cutting, fire, foot trails, dumping, litter collection, were observed. According to Tegenu and Mekuria (2018) In Nagasa sacred forest 18% seedlings, 12% sapling, 70% adult species were recorded representing the distribution of matured woody plant species greater than that of seedlings and saplings. Similar results were observed in present study in three sites, where tree species was found to be highest than saplings and seedlings. The forest of Lumbini and Ramagram was quite disturbed because of encroachment by local people for collecting litter, fuelwood, and grazing their livestock, which may have resulted reduction or absence of seedlings and saplings at the early stages of the tree species. The possible reasons for insufficient seedling and sapling for the tree species in the forest might be due to over grazing, forest product collections. Similar findings were also reported by Dereje (2007), Simon and Girma (2004). According to regeneration curves of Tilaurakot, The maximum density of trees belonging to class (40-50cm) indicates good regeneration of forest in past years but the tree density were resulted very low tree desnity in lowest DBH classes representing very poor regeneration at present.

5.4. Carbon stock

The highest Carbon stock was found in trees of Tilaurakot, with 41.41 ton/ha, followed by trees in Lumbini, with 24.02 ton/ha and Ramagram 18.86 ton/ha, highest the value of carbon stock was in Tilaurakot might be due to occurrence of majority of trees with greater pole size stand having species like as *Schleichera oleosa*, *Haldina cordifolia*, etc (Figure 4.7) also the wood densities of these species were high. The present study was also supported by Khanal (2008) in two community forests of Papain which AGC of trees was found to be higher due to greater pole sized of trees in forest, which consequently have higher biomass and carbon. The biomass of the vegetation depends on the diameter and age of the trees and forest. The higher value of carbon stock in Tilaurakot as compared to the other two sites in the present study might be due to larger pole-sized trees, type of tree species of forest, and older the age of forests.

5.5. Use value and their conservation

Forests are the source of various components, e.g., food, fodder, fiber, medicinal, and many other things for human benefits. The tree species enumerated in these sacred sites have different use values such as food, fodder, timber, fuelwood, ornamental, medicinal uses, and religious values. Most of the plant species in these sacred forests *Terminalia arjuna, Terminalia chebula*, *Terminalia bellirica*, *Cassia fistula* had one or more ethnomedicinal importance. The data collected from local peoples and some literatures related to tree species of studied sites revels, sacred forest are rich for human benefits (Table 5) (Bhakat and Pandit, 2003; Sivalingam. *et al,* Khumbongmayum *et al*. 2005d). Therefore, conservations and awareness to the villagers is also essential. Anthwal *et al*. (2006) reported several festivals in Uttarakhand associated with religious festivals and religious plants such as, *Azadirachta indica*, *Ficus bengalensis*, *Aegle marmelos*, due to popular and common beliefs.

Sacred plants are worshiped for getting the blessing of health and wealth (Sivalingam *et al*., 2016) sacred sites have different religious values that may serve as an instrument for the protection of different threatened species in forest. Thus, these sites are home to threatened, and endangered species. It serves as a guide against the extinction of rare and threatened species. The population around Lumbini, Ramagram are involved in agriculture and livestock farming and hence they are dependent on forest products which may exerts pressure in the forest ecology. Some species like *Ficus religiosa, Ficus benghalensis, and Aegle marmelos* present in sites have different religious credences (Tables 4.5) which may provide a protection of these species.

According to LDT different forest management systems were adopted for the conservation of forests. Plantation programs are also undergoing review. However, in Tilaurakot, local people are really concerned about the conservation of this forest. According to them, livestock grazing, fodder collection and other anthropogenic activities are restricted.

CHAPTER: 6 CONCLUSION AND RECOMMENDATION

6.1. Conclusion

A total of 60 tree species, 45 genera and 19 families were recorded from three sacred forests. Family Fabaceae contains the highest tree diversity in studied forests. Tree species such as *Dalbergia sissoo*, *Schleichera oleosa* and *Terminalia arjuna* were dominant tree species in Lumbini, Tilaurakot and Ramagram respectively.

Documenting tree species diversity, density and population structure provides a good database, useful for researchers for conservation and management in forests. More than 80% of the forest was occupied by trees; more or less than 10% by saplings and 5% by seedlings in three sites. The regeneration curves and population structures of seedlings and saplings, of the overall study area was not good. Survival of seedlings, saplings in different forests varied very low. Different anthropogenic disturbances such as collection of forest products, foot trails, livestock grazing, etc., are responsible for this condition in Lumbini and Ramagram and excavations of structures in Tilaurakot. This study also estimated highest carbon stock in Tilaurakot compared to the other two sites in the present study might be due to larger pole-sized trees, type of tree species of forest, and older the age of forests in Tilaurakot. The carbon storage capacity of old forests is greater than that of young forests.

Tree species enumerated in these sacred sites have different use values such as food, fodder, timber, fuelwood, ornamental, and medicinal uses. Sacred sites are home to threatened, and endangered species because they serve as an instrument for the protection of different threatened species.

A preservation of these forests is not only for conservation of biodiversity, but also for meeting the basic needs of the local population. Traditional worshipping has protected many plants with the fear of deity. These sacred trees, preserved through past years should be respected and conserved for future generation. Therefore, this research calls for an urgent conservation plan to conserve biological diversity ofss sacred sites.

6.2. Recommendations

- Preservation and urgent conservation plan should be done to preserve biological diversity of sacred sites.
- Dependence on forest products and uncontrolled grazing problems needs to be controlled.

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APPENDICES

Appendix I: Importance value index (IVI) of Tree species in Lumbini, Tilaurakot and Ramagram

S.N	Name of tree	Importance Value Index in three sites		
		Lumbini	Tilaurakot	Ramagram
1	*Acacia auriculiformis*	9.30		13.02
2	*Acacia catechu*	11.56	10.04	3.70
3	*Acacia nilotica*	3.88		3.70
4	*Aegle marmelos*	5.84	16.65	7.20
5	*Albizia chinensis*	2.22		
6	*Albizia lebbeck*	10.74		
7	*Albizia procera*	4.56		
8	*Annona squamosa*			3.70
9	*Anthocephalus cadamba*	7.57		
10	*Artocarpus lakoocha*	1.12		9.53
11	*Azadirachta indica*	1.12		
12	*Bahunia purpurea*	2.09		
13	*Bahunia sp.*			3.70
14	*Bombax ceiba*	11.16	10.50	14.96
15	*Butea monosperma*		27.02	
16	*Callistemon citrinus*	10.53		11.86
17	*Cascabela thevetia*		7.86	5.45
18	*Cassia fistula*	2.91	7.38	3.70
19	*Celtis tetranda*			6.16
20	*Citrus macrophylla*	1.67		
21	*Citrus sp.*			3.70
22	*Dalbergia latifolia*	2.22		
23	*Dalbergia sissoo*	**46.68**	10.98	**30.07**
24	*Delonix regia*	1.12	8.71	
25	*Eucalyptus sp.*	17.16		
26	*Ficus benghalensis*	1.12	3.32	3.70
27	*Ficus hispida*	6.69	4.73	
28	*Ficus infectoria*			3.70
29	*Ficus racemosa*	1.67		10.69
30	*Ficus religiosa*	2.22	24.65	22.46
31	*Garuga pinnata*	1.12		11.60
32	*Grevillea robusta*	2.72		
33	*Haldina cardifolia*	2.09	35.10	23.54

34	*Lagerstroemia parviflora*		7.16	
35	*Leucaena leucocephala*	8.81		
36	*Mallotus phillipensis*	1.67	6.06	
37	*Mangifera indica*	6.26	29.71	25.05
38	*Mitragyna parvifolia*	2.41		
39	*Morus alba*	1.12		
40	*Murraya koengi*		7.38	
41	*Pithecellebium dulce*	1.12		
42	*Plumeria rubra*		3.32	
43	*Polyalthia longifolia*			14.32
44	*Psidium guajava*	1.67	7.38	3.70
45	*Pterocarpus marsupium*		9.18	
46	*Saraca asoca*	4.08		
47	*Schleichera oleosa*		**43.36**	
48	*Shorea robusta*	40.58		3.70
49	*Streblus asper*	1.12		6.16
50	*Syzigium cumini*	15.35	10.13	17.97
51	*Tamarandus indica*	2.09	6.06	
52	*Tectona grandis*	25.47		
53	*Terminalia alata*	1.67		
54	*Terminalia arjuna*	4.95		29.28
55	*Terminalia bellirica*	2.22		
56	*Terminalia chebula*	1.12		
57	*Trewia nudiflora*	1.67		
58	*Wendlandia coriacea*	2.09		3.70
59	*Ziziphus incurva*	1.78		
60	*Ziziphus rugosa*	1.67		

Appendix II: Density of trees per hectare in three sites.

		Density of trees per hectare		
S. N	**Name of tree species**	**Lumbini**	**Tilaurakot**	**Ramagram**
1	*Acacia auriculiformis*	20.00		20
2	*Acacia catechu*	30.00	7.5	2.5
3	*Acacia nilotica*	5.00		2.5
4	*Aegle marmelos*	10.63	18.75	7.5
5	*Albizia chinensis*	1.88		
6	*Albizia lebbeck*	20.00		
7	*Albizia procera*	7.50		
8	*Annona squamosa*			2.5
9	*Anthocephalus cadamba*	15.00		
10	*Artocarpus lakoocha*	0.63		12.5
11	*Azadirachta indica*	0.63		
12	*Bahunia sp.*	1.88		
13	*Bahunia spp*			2.5
14	*Bombax ceiba*	29.38	8.75	25
15	*Butea monosperma*		37.5	
16	*Callistemon citrinus*	27.50		17.5
17	*Cascabela thevetia*		3.75	5
18	*Cassia fistula*	3.13	5	2.5
19	*Celtis tetranda*			5
20	*Citrus macrophylla*	1.25		
21	*Citrus sp.*			2.5
22	*Dalbergia latifolia*	1.88		
23	*Dalbergia sissoo*	158.75	10	67.5
24	*Delonix regia*	0.63	6.25	
25	*Eucalyptus sp.*	56.25		
26	*Ficus benghalensis*	0.63	1.25	2.5
27	*Ficus hispida*	9.38	2.5	
28	*Ficus infectoria*			2.5
29	*Ficus racemosa*	1.25	1.25	15
30	*Ficus religiosa*	1.88	30	45
31	*Garuga pinnata*	0.63		15
32	*Grevillea robusta*	3.13		
33	*Haldina cordifolia*	1.88	50	45
34	*Lagerstroemia parviflora*		5	
35	*Leucaena leucocephala*	21.25		
36	*Mallotus phillipensis*	1.25	3.75	

37	*Mangifera indica*	12.50	37.5	52.5
38	*Mitragyna parvifolia*	2.50		
39	*Morus alba*	0.63		
40	*Murraya koengi*		5	
41	*Pithecellebium dulce*	0.63		
42	*Plumeria rubra*		1.25	
43	*Polyalthia longifolia*			22.5
44	*Psidium guajava*	1.25	5	2.5
45	*Pterocarpus marsupium*		7.5	
46	*Saraca asoca*	5.63		
47	*Schleichera oleosa*		71.25	
48	*Shorea robusta*	116.88		2.5
49	*Streblus asper*	0.63		5
50	*Syzigium cumini*	46.88	8.75	32.5
51	*Tamarindus indica*	1.88	3.75	
52	*Tectona grandis*	90.63		
53	*Terminalia alata*	1.25		
54	*Terminalia arjuna*	5.00		65
55	*Terminalia bellirica*	1.88		
56	*Terminalia chebula*	0.63		
57	*Trewia nudiflora*	1.25		
58	*Wendlandia coriacea*	1.88		2.5
59	*Ziziphus incurva*	1.25		
60	*Ziziphus rugosa*	1.25		

Appendix III: Density of Seedlings (height < 1.3m) and Saplings (height > 1.3m and < 5cm dbh) per hectare of tree species in Lumbini, Tilaurakot and Ramagram.

S.N	Name of species	Lumbini		Tilaurakot		Ramagram	
		Sdlg/ha	Splg/ha	Sdlg/ha	Splg/ha	Sdlg/ha	Splg/ha
1	*Acacia nilotica*	0.625	3.75				
2	*Aegle marmelos*	0.625	3.75	1.25			
3	*Albizia lebbeck*	1.875					
4	*Albizia* sp.	5	2.5				
5	*Annona squamosa*						20
6	*Anthocephalous cadamba*		1.25				
7	*Artocarpus lacucha*			3.75			
8	*Azadirachta indica*	1.875	5				
9	*Bahunia* sp.	2.5	1.25				
10	*Bombax ceiba*	2.5	6.25	1.25	15		
11	*Butea monosperma*			7.5	30		
12	*Dalbergia sisso*	20.625	45	6.25	17.5	10	70
13	*Eucalyptus sp.*		2.5				
14	*Ficus racemosa*						10
15	*Ficus bejamina*					5	
16	*Ficus religiosa*					5	20
17	*Haldina cordifolia*	2.5	1.25	2.5			120
18	*Leguminasae*						
19	*Leucanea leucocephala*	4.375	8.75				
20	*Macaranga indica*		1.25				
21	*Mangifera indica*			2.5	2.5		
22	*Murraya koengi*		6.25				
23	*Psidium guajava*				2.5		
24	*Saraca asoca*	0.625					
25	*Schleichera oleosa*			1.25	10		
26	*Shorea robusta*	7.5					
27	*Syzigium cumini*	5	17.5	1.25			
28	*Tectona grandis*	2.5	16.25				
29	*Terminalia alata*		2.5				

30	*Terminalia arjuna*	1.25	
31	*Ziziphus sp.*	2.5	13.75

Sdlg/ha= Seedlings per hectare   splg/ha= Saplings per hectare

Appendix IV. Wood density of tree species used to estimate carbon stock

S.N	Species name	Wood density (g/cm3)
1	*Acacia auriculiformis*	0.68
2	*Acacia catechu*	0.88
3	*Acacia nilotica*	0.70
4	*Aegle marmelos*	0.75
5	*Albizia chinensis*	0.30
6	*Albizia lebbeck*	0.80
7	*Albizia procera*	0.64
8	*Annona squamosa*	0.73
9	*Anthocephalus cadamba*	0.73
10	*Artocarpus lakoocha*	0.64
11	*Azadirachta indica*	0.64
12	*Bahunia purpurea*	0.72
13	*Bahunia sp.*	0.72
14	*Bombax ceiba*	0.35
15	*Butea monosperma*	0.56
16	*Callistemon citrinus*	0.76
17	*Cascabela thevetia*	0.64
18	*Cassia fistula*	0.96
19	*Celtis tetranda*	0.55
20	*Citrus macrophylla*	0.60
21	*Citrus sp.*	0.60
22	*Dalbergia latifolia*	0.80
23	*Dalbergia sissoo*	0.77
24	*Delonix regia*	0.44
25	*Eucalyptus sp.*	0.98
26	*Ficus benghalensis*	0.39
27	*Ficus hispida*	0.41
28	*Ficus infectoria*	0.34
29	*Ficus racemosa*	0.38
30	*Ficus religiosa*	0.44
31	*Garuga pinnata*	0.64
32	*Grevillea robusta*	0.64
33	*Haldina cardifolia*	0.58
34	*Lagerstroemia parviflora*	0.62
35	*Leucaena leucocephala*	0.80
36	*Mallotus phillipensis*	0.64
37	*Mangifera indica*	0.675
38	*Mitragyna parvifolia*	0.64
39	*Morus alba*	0.89
40	*Murraya koengi*	0.68
41	*Pithecellebium dulce*	0.64

42	*Plumeria rubra*	0.573
43	*Polyalthia longifolia*	0.59
44	*Psidium guajava*	0.67
45	*Pterocarpus marsupium*	0.62
46	*Saraca asoca*	0.59
47	*Schleichera oleosa*	0.96
48	*Shorea robusta*	0.73
49	*Streblus asper*	0.72
50	*Syzigium cumini*	0.67
51	*Tamarandus indica*	0.85
52	*Tectona grandis*	0.71
53	*Terminalia alata*	0.75
54	*Terminalia arjuna*	0.94
55	*Terminalia bellirica*	0.76
56	*Terminalia chebula*	0.88
57	*Trewia nudiflora*	0.44
58	*Wendlandia coriacea*	0.73
59	*Ziziphus incurva*	0.76
60	*Ziziphus rugosa*	0.76

Appendix V: Carbon stock (ton/ha) of each tree species in Lumbini, Tilaurakot and Ramagram

LUMBINI

S.N	Plant species	AGB (tons/ha)	BGB (tons/ha)	Total Biomass	Carbon stock (tons/ha)	%
1	*Acacia auriculiformis*	0.96	0.19	1.16	0.54	2.26
2	*Acacia catechu*	0.80	0.16	0.96	0.45	1.88
3	*Acacia nilotica*	0.02	0.00	0.02	0.01	0.04
4	*Aegle marmelos*	0.36	0.07	0.44	0.20	0.85
5	*Albizia chinensis*	0.03	0.01	0.03	0.01	0.06
6	*Albizia lebbeck*	2.22	0.44	2.66	1.25	5.21
7	*Albizia procera*	0.37	0.07	0.45	0.21	0.87
8	*Anthocephalus cadamba*	0.71	0.14	0.85	0.40	1.66
9	*Artocarpus lakoocha*	0.02	0.00	0.02	0.01	0.05
10	*Azadirachta indica*	0.00	0.00	0.00	0.00	0.00
11	*Bahunia purpurea*	0.03	0.01	0.03	0.02	0.06
12	*Bombax ceiba*	0.77	0.15	0.92	0.43	1.80
13	*Callistemon citrinus*	0.62	0.12	0.75	0.35	1.47
14	*Cassia fistula*	0.02	0.00	0.03	0.01	0.05
15	*Citrus macrophylla*	0.01	0.00	0.01	0.00	0.02
16	*Dalbergia latifolia*	0.26	0.05	0.31	0.15	0.61
17	*Dalbergia sissoo*	5.50	1.10	6.60	3.10	12.91
18	*Delonix regia*	0.02	0.00	0.02	0.01	0.04
19	*Eucalyptus spp.*	9.64	1.93	11.57	5.44	22.64
20	*Ficus benghalensis*	0.05	0.01	0.06	0.03	0.11
21	*Ficus hispida*	0.02	0.00	0.03	0.01	0.05
22	*Ficus racemosa*	0.00	0.00	0.00	0.00	0.01
23	*Ficus religiosa*	0.89	0.18	1.07	0.50	2.09
24	*Garuga pinnata*	0.02	0.00	0.03	0.01	0.06
25	*Grevillea robusta*	0.07	0.01	0.09	0.04	0.17
26	*Haldina cordifolia*	0.01	0.00	0.01	0.00	0.01
27	*Leucaena leucocephala*	0.27	0.05	0.32	0.15	0.63
28	*Mallotus phillipensis*	0.10	0.02	0.12	0.06	0.23
29	*Mangifera indica*	0.64	0.13	0.77	0.36	1.50
30	*Mitragyna parvifolia*	0.10	0.02	0.12	0.05	0.23
31	*Morus alba*	0.00	0.00	0.00	0.00	0.01
32	*Pithecellebium dulce*	0.00	0.00	0.00	0.00	0.01
33	*Psidium guajava*	0.00	0.00	0.00	0.00	0.00
34	*Saraca asoca*	0.03	0.01	0.04	0.02	0.07
35	*Shorea robusta*	**12.05**	**2.41**	**14.47**	**6.80**	**28.30**
36	*Streblus asper*	0.00	0.00	0.00	0.00	0.00
37	*Syzigium cumini*	2.96	0.59	3.55	1.67	6.95

38	*Tamarindus indica*	0.19	0.04	0.23	0.11	0.45
39	*Tectona grandis*	2.26	0.45	2.71	1.27	5.30
40	*Terminalia alata*	0.15	0.03	0.18	0.08	0.35
41	*Terminalia arjuna*	0.06	0.01	0.07	0.03	0.14
42	*Terminalia bellirica*	0.14	0.03	0.17	0.08	0.34
43	*Terminalia chebula*	0.08	0.02	0.09	0.04	0.18
44	*Trewia nudiflora*	0.02	0.00	0.03	0.01	0.05
45	*Wendlandia coriacea*	0.08	0.02	0.09	0.04	0.18
46	*Ziziphus incurva*	0.03	0.01	0.03	0.02	0.07
47	*Ziziphus rugosa*	0.01	0.00	0.01	0.00	0.02
		42.59	**8.52**	**51.11**	**24.02**	**100.0**

TILAURAKOT

S.N	Plant species	AGB (ton/ha)	BGB (ton/ha)	Total Biomass	Carbon stock (ton/ha)	%
1	*Acacia catechu*	0.37	0.07	0.44	0.21	0.50
2	*Aegle marmelos*	1.45	0.29	1.74	0.82	1.98
3	*Bombax ceiba*	2.57	0.51	3.09	1.45	3.50
4	*Butea monosperma*	2.34	0.47	2.80	1.32	3.18
5	*Cascabela thevetia*	0.11	0.02	0.13	0.06	0.15
6	*Cassia fistula*	0.13	0.03	0.16	0.08	0.18
7	*Dalbergia sissoo*	1.42	0.28	1.70	0.80	1.93
8	*Delonix regia*	0.70	0.14	0.84	0.40	0.96
9	*Ficus benghalensis*	0.01	0.00	0.01	0.00	0.01
10	*Ficus hispida*	0.21	0.04	0.26	0.12	0.29
11	*Ficus racemosa*	0.03	0.01	0.04	0.02	0.04
12	*Ficus religiosa*	9.29	1.86	11.15	5.24	12.66
13	*Haldina cardifolia*	5.51	1.10	6.61	3.11	7.51
14	*Lagerstroemia parviflora*	0.41	0.08	0.49	0.23	0.56
15	*Mallotus phillipinsis*	0.52	0.10	0.62	0.29	0.70
16	*Mangifera indica*	4.11	0.82	4.93	2.32	5.59
17	*Murraya koengi*	0.24	0.05	0.29	0.13	0.32
18	*Plumeria rubra*	0.01	0.00	0.01	0.00	0.01
19	*Psidium guajava*	0.05	0.01	0.06	0.03	0.07
20	*Pterocarpus marsupium*	4.35	0.87	5.21	2.45	5.92
21	*Schleichera oleosa*	**37.90**	**7.58**	**45.48**	**21.37**	**51.62**
22	*Syzigium cumini*	1.05	0.21	1.26	0.59	1.43
23	*Tamarandus indica*	0.65	0.13	0.78	0.37	0.89
		73.43	**14.69**	**88.11**	**41.41**	**100.00**

RAMAGRAM

S.N	Plant species	AGB (ton/ha)	BGB (ton/ha)	Total Biomass	Carbon stock (ton/ha)	%
1	*Acacia auriculiformis*	1.68	0.34	2.02	0.95	5.03
2	*Acacia catechu*	0.43	0.09	0.52	0.24	1.29
3	*Acacia nilotica*	0.11	0.02	0.13	0.06	0.33
4	*Aegle marmelos*	0.29	0.06	0.34	0.16	0.86
5	*Annona squamosa*	0.24	0.05	0.29	0.14	0.73
6	*Artocarpus lakoocha*	2.66	0.53	3.19	1.50	7.96
7	*Bahunia spp.*	0.63	0.13	0.76	0.36	1.89
8	*Bombax ceiba*	0.75	0.15	0.90	0.42	2.25
9	*Callistemon citrinus*	0.79	0.16	0.94	0.44	2.36
10	*Cascabela thevetia*	0.25	0.05	0.30	0.14	0.76
11	*Cassia fistula*	0.03	0.01	0.04	0.02	0.10
12	*Celtis tetranda*	0.08	0.02	0.10	0.05	0.25
13	*Citrus spp*	0.03	0.01	0.04	0.02	0.10
14	*Dalbergia sissoo*	3.13	0.63	3.75	1.76	9.35
15	*Ficus benghalensis*	0.04	0.01	0.04	0.02	0.11
16	*Ficus infectoria*	0.18	0.04	0.21	0.10	0.53
17	*Ficus racemosa*	0.66	0.13	0.79	0.37	1.96
18	*Ficus religiosa*	1.40	0.28	1.67	0.79	4.17
19	*Garuga pinnata*	0.91	0.18	1.10	0.52	2.73
20	*Haldina cordifolia*	1.68	0.34	2.02	0.95	5.03
21	*Mangifera indica*	4.81	0.96	5.77	2.71	14.38
22	*Polyalthia longifolia*	1.90	0.38	2.29	1.07	5.70
23	*Psidium guajava*	0.12	0.02	0.15	0.07	0.37
24	*Shorea robusta*	0.16	0.03	0.19	0.09	0.47
25	*Streblus asper*	0.11	0.02	0.13	0.06	0.32
26	*Syzigium cumini*	1.78	0.36	2.14	1.00	5.33
27	*Terminalia arjuna*	8.58	1.72	10.29	4.84	25.67
28	*Wendlandia coriacea*	0.01	0.00	0.01	0.01	0.03
		33.43	**6.69**	**40.12**	**18.86**	**100.00**

Appendix VI: Geographical position of plots with Longitude, Latitude, Altitude, Litter depth(cm), Canopy coverage (%), and Disturbance level (1-3) of three sites.

LUMBINI

Plots	Longitude(oE)	Latitude(oN)	Altitude(m)	Litter depth(cm)	Canopy (%)	Disturbance level
plot 1	83°16'42"	27°28'28'	98	1	30	0
plot2	83°16'41"	27°28'26"	66	1	25	1
plot3	83°16'47"	27°28'26"	90	0.75	20	1
plot 4	83°16'36"	27°28'40"	94	5	40	2
plot 5	83°16'35"	27°28'05"	68	5	80	3
plot 6	83°16'6"	°27'28"16	83	1	30	2
plot 7	83°16'6"	27°28'16"	85	2	45	2
plot 8	83°16'11"	27°28'13"	87	10	12	1
plot 9	83°16'44"	27°30'2"	107	1	70	2
plot 10	83°16'51"	27°30'12"	94	1	75	1
plot 11	83°16'51"	27°29'50"	100	2	45	2
plot 12	83°16'28"	27°29'9"	96	10	75	1
plot 13	83°16'28"	27°29'7"	72	9	80	1
plot 14	83°16'31"	27°29'8"	81	10	75	1
plot 15	83°16'31"	27°29'7"	101	2	60	3
plot 16	83°16'14"	27°29'11"	57	1	40	2
plot 17	83°16'15"	27°29'8"	81	1	40	2
plot 18	83°16'29"	27°29'49"	91	5	60	2
plot 19	83°16'30"	27°27'50"	80	5	60	1
plot 20	83°16'33"	27°27'60"	80	10	50	2
plot 21	83°18'30"	27°27'40"	82	7	40	2
plot 22	83°16'31"	27°28'4"	80	7	90	2
plot 23	83°16'26"	27°28'7"	82	7	95	0
plot 24	83°17'2"	27°28'10"	84	5	75	0
plot 25	83°16'53"	28°28'10"	84	3	70	2
plot 26	83°16'34"	27°29'11"	92	2	70	0
plot 27	83°16'53"	27°28'59"	94	1	60	1
plot 28	83°16'54"	27°28'55"	93	2	45	2
plot 29	83°16'53"	27°28'49"	91	0.5	20	0
plot 30	83°17'1"	27°29'1"	86	2	30	3
plot 31	83°16'58"	27°28'58"	86	2	30	2
plot 32	83°16'46"	27°28'58"	87	2	45	2
plot 33	83°16'59"	27°28'49"	92	1.5	55	3
plot 34	83°17'02"	27°28'24"	97	1	30	2
plot 35	83°17'4"	27°28'26"	85	1.5	35	1

plot 36	83°17'8"	27°28'27"	86	1.5	45	2
plot 37	83°17'3"	27°28'25"	84	1	40	2
plot 38	83°17'4"	27°28'25"	87	2	55	1
plot 39	83°17'1"	27°29'1"	86	1	30	2
plot 40	83°16'53"	27°28'44"	86	2	65	1

TILAURAKOT

Plots	Longitude (°E)	Latitude(°N)	Altitude (m)	Litter depth (cm)	Canopy (%)	Disturbance level
plot 1	83°3'9"	27°34'31"	105	2	23	0
plot2	83°3'9"	27°34'30"	117	3	55	0
plot3	83°3'9"	27°34'29"	104	2	45	0
plot 4	83°3'9"	27°34'28"	108	2	40	1
plot 5	83°3'14"	27°34'32"	101	0.5	30	0
plot 6	83°3'14"	27°34'33"	94	0.5	20	0
plot 7	83°3'24"	27°34'34"	106	1	10	0
plot 8	83°3'23"	27°34'37"	97	1	90	1
plot 9	83°3'25"	27°34'39"	91	1.5	25	0
plot 10	83°3'17"	27°34'39"	111	1	35	0
plot 11	83°3'16"	27°34'35"	99	1	20	0
plot 12	83°3'16"	27°34'35"	79	0.5	22	0
plot 13	83°3'10"	27°34'35"	69	1.5	55	1
plot 14	83°3'12"	27°34'33"	120	1	35	0
plot 15	83°3'12"	27°34'33"	109	2	45	0
plot 16	83°3'13"	27°34'34"	108	3	40	0
plot 17	83°3'13"	27°34'35"	117	1	57	1
plot 18	83°3'22"	27°34'37"	114	2.5	55	0
plot 19	83°3'24"	27°34'36"	116	1	70	0
plot 20	83°3'24"	27°34'37"	101	2	57	0

RAMAGRAM

Plots	Longitude(oE)	Latitude(oN)	Altitude(m)	Litter depth(cm)	Canopy (%)	Disturbance level
plot 1	83°40'51"	27°29'52"	91	1	20	2
plot2	83°40'55"	27°29'50"	101	2	40	1
plot3	83°40'54"	27°29'50"	109	2	50	1
plot 4	83°40'53"	27°29'50"	84	2	54	1
plot 5	83°40'53"	27°29'51"	101	2	60	1
plot 6	83°40'51"	27°29'51"	98	2	63	1
plot 7	83°40'51"	27°29'50"	109	2	59	1
plot 8	83°40'52"	27°29'49"	109	2	50	1
plot 9	83°40'49"	27°29'51"	116	2	52	1
plot 10	83°40'50"	27°29'50"	83	2	55	1

Appendix VII: Data sheet for Tree, Saplings and Seedlings.

Name of Recorder:

Data sheet for vegetation sampling

Plot characteristics

Date District: Locality: Plot No:

Altitude (m): Latitude: Longitude:

Forest type: Canopy cover (%): Disturbance, Grazing (0-3):

Litter collection: Yes/No Litter Cover thickness (cm): Litter type:

For trees, Plot No: Quadrat No: Quadrat size: 20m*20m

SN	Name of species	DBH(cm)	Height(m)	SN	Name of species	DBH(cm)	Height(m)
1				16			
2				17			
3				18			
4				19			
5				20			
6				21			
7				22			
8				23			
9				24			
10				25			
11				26			
12				27			
13				28			
14				29			
15				30			

Tree sapling: Plot No: Sapling (>1.3 ht &<5cm dbh) Quadrat size: 5m*5m

SN	Name of species	Number	SN	Name of species	Number
1			8		
2			9		
3			10		
4			11		
5			12		
6			13		
7			14		

Tree seedlings: Plot No: Seedling (<1.3m height) Quadrat size: 1m* 1m

SN	Name of species	Number	SN	Name of species	Number
1			7		
2			8		
3			9		
4			10		
5			11		
6			12		

PHOTO PLATES

	
Photo 1: Sal forest in Lumbini Sacred Forest (LSF)	**Photo 2:** Sissoo forest in LSF
	
Photo 3: *Schleichera oleosa* (kusum trees) in Tilaurakot Sacred Forest (TSF)	**Photo 4:** Ramagram Sacred Forest (RSF)

Photo 5: Grazing inside LSF

Photo 6: Rubbish dumping inside sacred sites

Photo 7: Local people carrying grass from TSF.

Photo 8: Local peoples around LSF depending on forest products.

	
Photo 9: Seedling of *Syzigium cumini* in LSF	**Photo 10** Collecting informations about Buddha and Buddhist sites with monks