

**ENVIRONMENTAL IMPACT ASSESSMENT  
(SPECIAL INVESTIGATION)  
ON  
HYDROPOWER DEVELOPMENT OF  
AYEYAWADY RIVER BASIN ABOVE MYITKYINA,  
KACHIN STATE, MYANMAR**

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**Biodiversity And Nature Conservation Association (BANCA)**



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**Yangon**

**MYANMAR**

# Flora Ecology Report

## Chapter I

### 1. Myitsone Dam

#### 1.1. General Introduction

The northern part of Myanmar lies in four WWF Eco-region namely East-Himalayan alpine shrub/meadow, Mizoram-Manipur-Kachin moist evergreen forests, Northern Triangle temperate forest. The Kachin State is also located within two priority corridor, namely Northern Mountain Forest Complex and Upper Chindwin lowlands for conservation investment in Myanmar (Tordoff et. al., 2004). This large conservation area including Pidaung Wildlife Sanctuary (W.S), Khakaborazi National Park, Indawgyi W.S, Hukaung Valley W.S, Hukaung Valley W.S (Extension), Hpongan Razi W.S and Bumphabum W.S, are one of the biodiversity hotspots and is nationally essential, regionally significant and globally outstanding. Kachin State is one of the most interesting botanical and zoological natural sanctuaries in Southeast Asia. The state is well known for rich biodiversity and it has a wealth of abundant valuable natural resources (Naw, L.B.2007).

Vegetation ecology includes the investigation of species composition and sociological interaction of species in communities (Mueller-Dombois and Ellenberg, 1974). The structural property of a community is the quantitative relationship in between the species growing around. The quantitative study of vegetation is called phytosociology and its principal aim is to describe the vegetation, explain or predict its pattern and classify it in a meaningful way (Ilorka and Khatri, 2003). It indicates species diversity which determines the distribution of individuals among the species in a particular habitat. A sound understanding of species diversity is necessary for appropriate conservation and restoration of the biological diversity.

Specific community types are often named by describing the particular plants in that community. However, plant communities are often too heterogeneous to be described by a single dominant species or by listing all the species present. Thus, communities are often described by the species or genera that are determined to be the most dominant in the community. The dominant species can be quantified by calculating a statistic known as 'importance value' (Smith and Smith, 2001). Once importance values are determined, a specific community can be described in terms of its most important species. Importance values can be calculated after the size and number of individual trees of the various species is measured. The trees with the highest importance values will be those that exist in the greatest number or are of the greatest size, these are the trees that may have the greatest effect on the community.

What is the value of knowing the physical structure of a plant community? It can tell us something about the biological structure of the community, something about interactions between species and how the community functions in gathering energy and cycling nutrients. The structure of the plant community determines the animals that can be present, so is of use in wildlife management. Studies of plant communities over the course of many years have allowed biologists to understand ecological succession, the replacement of species by other species over time (and therefore the replacement of communities over time). In addition to dominance and importance, community structure includes characteristics such as the number of species, and the relative abundance of each species (Krebs, 1985). The number of species is known as the **species richness**; it is simply the number of different species of organisms in a community. Measuring the relative abundance of species, **species heterogeneity**, or species diversity is a bit more complex.

Information on the distribution and abundance of tree species is of primary importance in the planning and implementation of biodiversity conservation. Tree species diversity in the study area varies greatly from place to place mainly due to variation in biogeography, habitat and disturbance. On account of their economic exploitation, evergreen forests are most threatened ecosystems in Kachin State. But so far no efforts have been made to quantify the tree species parameters in this study area. The present study is an attempt to record structural composition and diversity of tree species along the altitudinal gradients in Myitsone area.

## 1.2. Objectives

The main objectives of the present study are to record the floristic composition and forest structure of each dam site, to evaluate the forest by quantitative analysis, to clarify the tree species diversity, to highlight the impact of dam on forest ecosystem, to formulate appropriate conservation and management strategies for terrestrial ecosystem.

## 1.3. Study area

The location of Myitsone area is (25° 45' N, 97° 45' E) in Myitkyina District, Kachin State, which is situated in junction of the N' mai Hka River and the Malihka River. The N' mai Hka River and the Malihka river, their rivulets and the Tanaikha river flow into the Ayeyarwaddy river. From biodiversity standpoint, the study area lies WWF Eco-regions of Mizoram-Manipur-Kachin moist evergreen forest. A detailed map of the study area is given in figure (1).

### 1.3.1. Climate

There are three distinct seasons; a cool and dry season between November and February, warm and dry season between March and May, warm and wet season between June and October, and there is usually no rain in December and January. The annual rainfall during rainy season is rather uniform. The monthly mean rainfall is from 569 mm (max.) to 0 mm (min.). The highest mean temperature is 28.6° C and the lowest 18.1° C. The monthly mean humidity ranges from 68% to 62%. The monthly mean wind speed and direction were recorded for the year of 2008. The highest wind speed is 2.4 m.p.h and the lowest 0.5 m.p.h. in this study area.

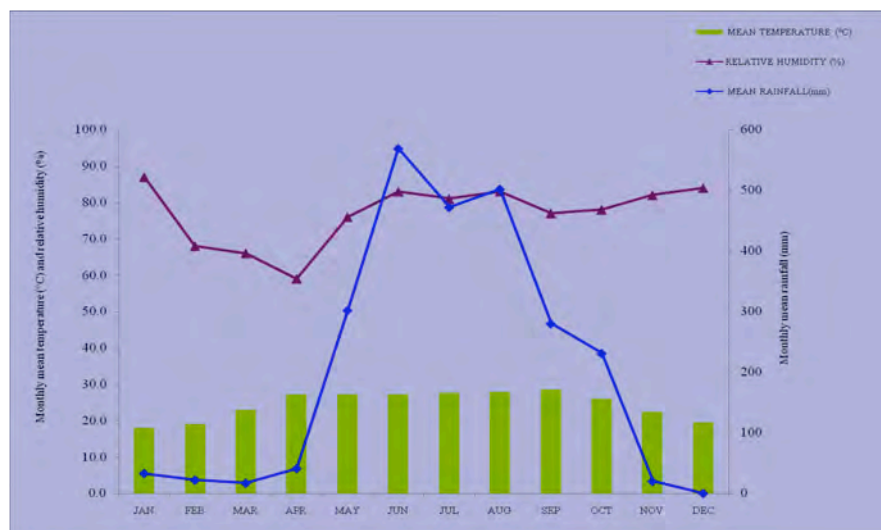


Figure (2) Monthly Mean Rainfall, Temperature and Humidity (2008)

## 1.4 Methodology

### 1.4.1. Data collection

To clarify the tree species composition and their distribution, twenty five quadrats (20x20 m each) were set up and observed in the flooded area of Myitsone dam site. The spatial location (latitude, longitude and altitude) of each quadrat was collected using a Global Positioning System (GPS). Care has been taken to cover different elevation, slope, aspects, drainage density, rainfall and temperature gradients to study overall spectrum of tree species diversity. Samples were taken for almost all individuals  $\geq 3$ cm diameter at breast height (DBH). The families were identified by using key to the families of the flowering plants, issued by Department of Botany, Yangon University (1994). Specimen identification was performed with the use of literatures by Backer *et al.*, 1963, and Kress *et al.* 2003 and confirmed at Herbarium in Department of Botany, University of Yangon, where all materials had been mounted for herbarium sheets and deposited.

### 1.4.2. Data analysis

The field data collected was analyzed for number of species, stand density (trees) per hectare, basal area per hectare. Quantitative analysis of dominance and their relative values of frequency, density and basal area were calculated and summed to get Importance Value Index. Population structure of tree species were analyzed across fixed DBH classes. Species and their corresponding individuals were proportionately analyzed by height class intervals. Diversity statistics applied to the data, generated in this study were calculated using the software package; Species Diversity & Richness IV (SDR) for window 2007.

### 1.4.3. Participants

U Nyo Maung, Dr Myint Aung, Dr Win Myint, Dr Kalayar Lu, Daw Thin Thin Su, Daw Khin Swe Lwin, Daw Khin Khin Soe, U Tayzar Aung, and U Nay Phyo Aung.

## 1.5. Results

### 1.5.1. Forest composition

In the twenty five sampling plots (1ha), total number of species with DBH  $\geq 3$ cm was 231 species; of which 61 species are under identification. The dominant families of tree species were Euphorbiaceae (14 species), Lauraceae (12 species), Moraceae (11 species), Fagaceae (11 species), Anacardiaceae (9 species), Verbenaceae (8 species), Meliaceae (7 species), Dipterocarpaceae (6 species), Rubiaceae (6 species), Annonaceae (5 species), Lythraceae (5 species) Figure (3). The main vegetation types discovered in Myitsone Dam site can be grouped into five formations; low land evergreen forest, oak forest, lowland secondary forest, bamboo forest, and grass land. In some disturbed sites, wild banana and bamboo can be seen as in patches. In low land evergreen forests, *Dipterocarpus turbinatus*, and *D. obtusifolious* occupied mostly in crown cover and in some places *Baccurea sapida*, *Chisocheton siamensis*, and *Dracotonmelon* sp. are mixed with them. The ground cover is dominated by *Pronephrium triphyllum*, *Begonia roxburghii*. Oak forest mainly composed of *Fagus crenata*, *F.* sp., *Castanopsis diversifolia*, *C. indica*, *C. tribuloides*, *C.* spp. (chestnuts). The ground cover of Oak forest is dominated by *Gnetum* spp., *Molineria capitulata* (Kywet-malut), and *Psychotria* sp. In the lowland secondary forest, *Gnetum* sp., *Piper* sp., *Commelina* sp., *Selaginella* sp. and *Phrynium capitatum* are occupied in most places. In the bamboo forest *Dendrocalamus hamiltonii* Nees (Wabo Myatsan), *D. longistathus* mainly occur.

*D. giganteus* Munro (Wabowa), *Cephalostachyum pallidum* Munro (Tinkhawa), *Pseudostachyum* sp. (Wanibar), and *Bambusa lundsi* Gamble are mixed in the area. *Phragmites* sp., and *Chrysopogon aciculatus* are commonly occur in grass land.

The species area curves of the investigated stands are shown in the figure (4). The species area curves, which express the number of species in relation to change in area of habitat, not only to consider the minimum representative area but also to detect the habitat diversity within the survey area (Fangliang He and Pierre Legendre, 1996). The trend of species area curve showed tendency towards flattening. Therefore the sample areas can be said to be sufficient as a minimum representative area for the study.

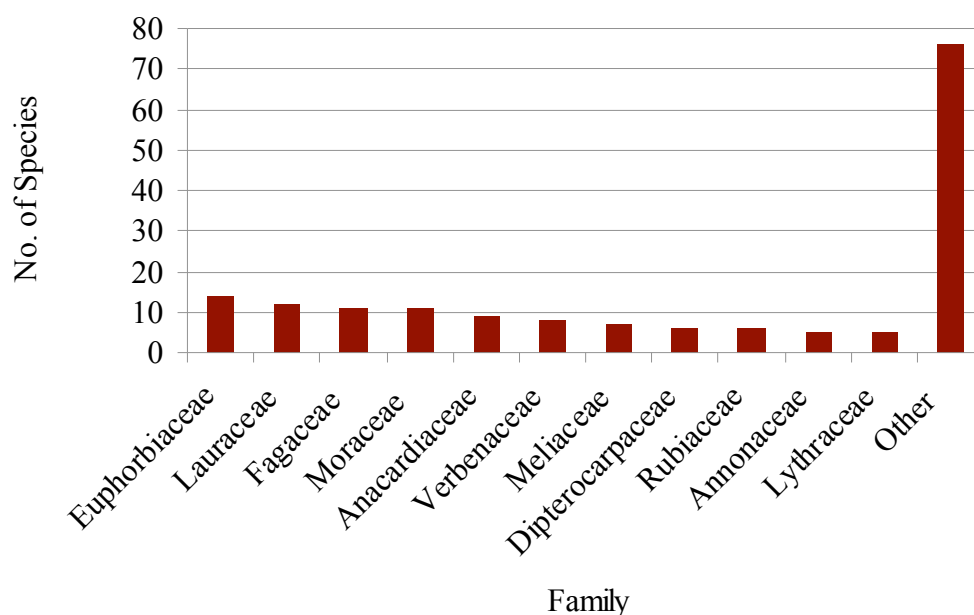


Figure (3) Ranking of dominant family by number of species composition

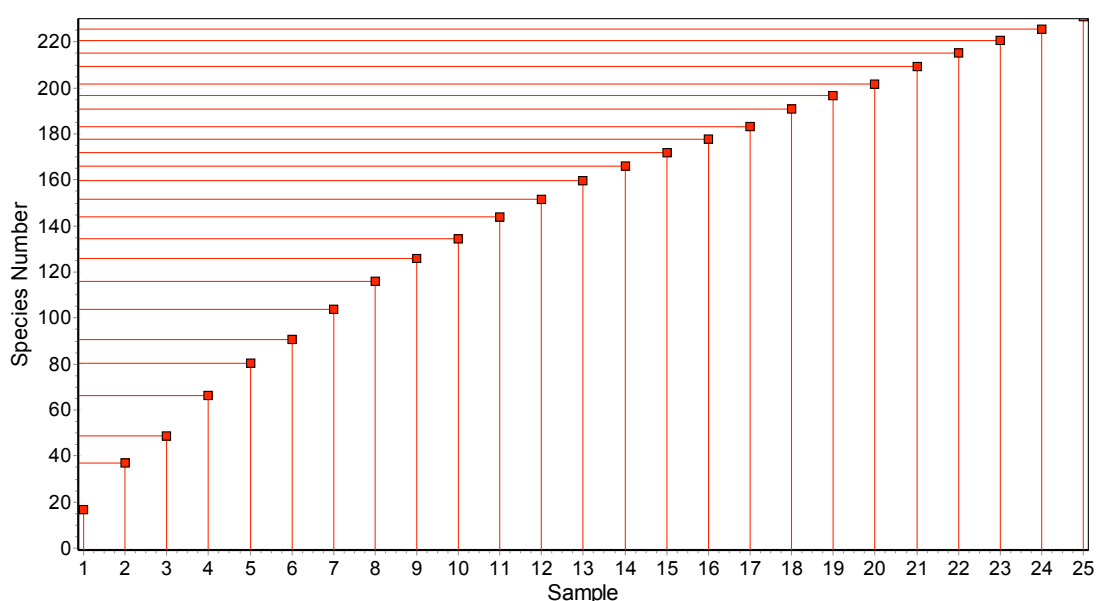


Figure (4) Plot of species accumulation in the Myitsone Dam Site

### 1.5.2. Important Value Index (IVI)

Ranking of ecological significance by IVI of tree species in the study area are given in appendix (1). The tree layer in the study area is dominated by *Dracontomelon* sp. with the highest IVI of 14.33%, the second most dominant species is *Fagus crenata* Blume (IVI = 10.53%) and *Dipterocarpus obtusifolius* Teysm.ex.Mig. (IVI= 9.43%) is the third. The number of species greater than 5% IVI value was only nine species (Figure 5). Those nine species could be considered as ecological indicator species of Myitsone area. Representation of 231 species and the high proportion of dominant species in the study area can directly be attributed to the favorable climatic and edaphic condition.

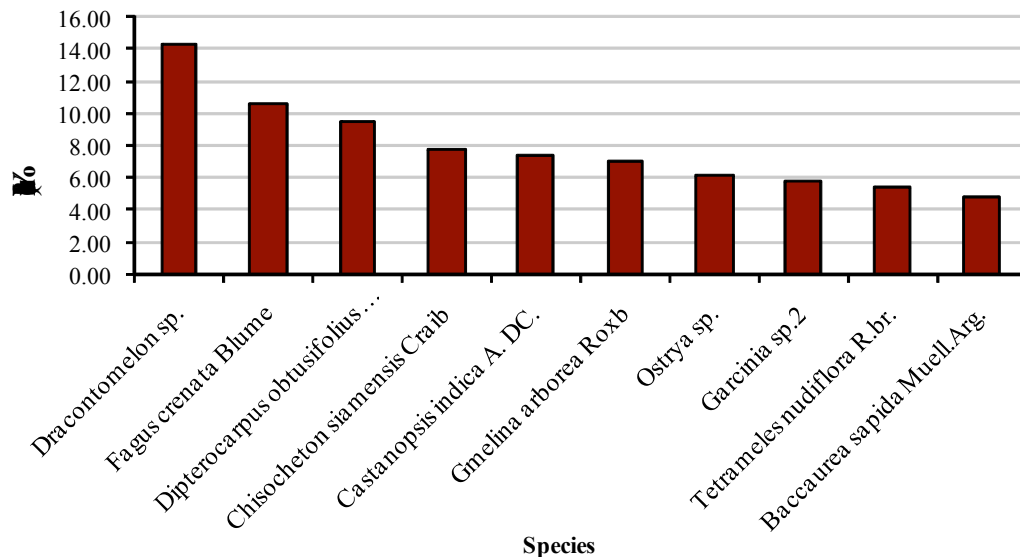


Figure (5) Important Value Index of top ten species in the Myitsone Dam Site

### 1.5.3. Species distribution by frequency classes

In order to clarify the homogeneity or heterogeneity of the floristic distribution in the study area, species distribution by frequency classes was examined. According to the outcome of frequency chart, 99.56% of the total number of species was in lower frequency classes, A and B, while low value was observed only in higher frequency class D (Table 1, Figure 6). It indicates that the forest in Myitsone area is floristically heterogeneous according to Lamprecht (1989). The species which fall in high frequency class D was *Chisocheton siamensis* Craib. The species can be considered as the most common species in the Myitsone area.

Table (1) Species distribution by frequency classes  $\geq 3$ cm

| Frequency Class | Frequency Range | No of Species | % of Total Species<br>Frequency Distribution |
|-----------------|-----------------|---------------|----------------------------------------------|
| A               | 1-20 %          | 216           | 93.51                                        |
| B               | 21-40 %         | 14            | 6.06                                         |
| C               | 41-60 %         | 0             | 0                                            |
| D               | 61-80 %         | 1             | 0.43                                         |
| E               | 81-100 %        | 0             | 0                                            |

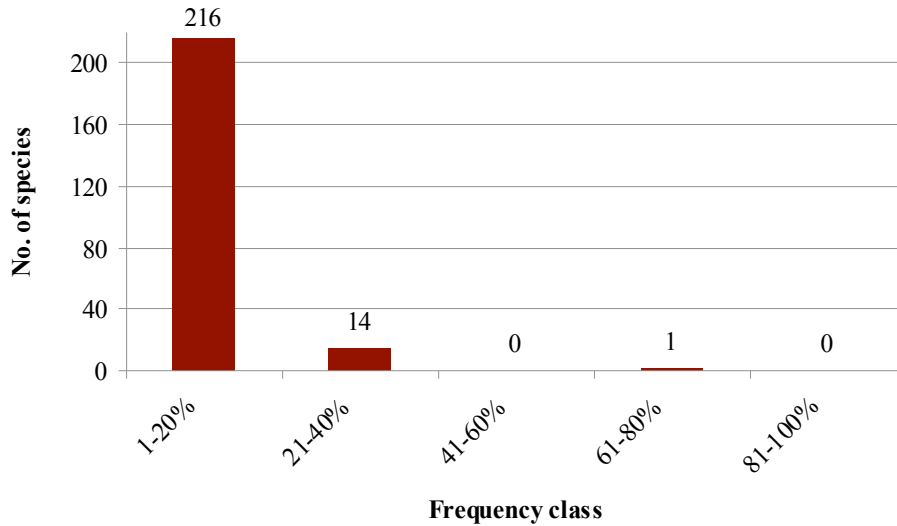


Figure (6) Species distribution by frequency classes  $\geq 3\text{cm}$

#### 1.5.4. Diversity indices and evenness

Among the different measurement of species diversity indices, the floristic diversity of the Myitsone area was analyzed using the Shannon Wiener index (H), Simpsons index (D), Brillouin (D), Shannon Maximum and minimum evenness (E), Brillouin (E) because these indices not only take taxa richness into account but also depend on the relative distribution of individuals. The value of diversity indices and evenness indices of individual sample plot and all sample indices are shown in table (2) and (3). According to the result, though the diversity indices of individual sample plot are not too high, all sample index are relatively high. Diversity value for all sample index of Shannon Wiener index (H) is 4.749, Simpsons index (D) is 73.07, Brillouin (D) is 4.512. Presence of high species diversity and richness indicates uniqueness and potentiality of study area for conservation of ecosystem in totality.

Table (3) Species diversity indices in the Myitsone Dam site

| <b>Sample</b>       | <b>Shannon Wiener H</b> | <b>Variance H</b> | <b>Simpsons Index (D)</b> | <b>Brillouin (D)</b> |
|---------------------|-------------------------|-------------------|---------------------------|----------------------|
| MS 1                | 3.056                   | 0.018             | 19.45                     | 2.501                |
| MS 2                | 2.560                   | 0.015             | 9.45                      | 2.225                |
| MS 3                | 2.175                   | 0.019             | 6.19                      | 1.869                |
| MS 4                | 2.086                   | 0.035             | 4.94                      | 1.723                |
| MS 5                | 2.576                   | 0.009             | 12.95                     | 2.222                |
| MS 6                | 2.901                   | 0.017             | 12.41                     | 2.459                |
| MS 7                | 2.179                   | 0.024             | 5.34                      | 1.868                |
| MS 8                | 2.226                   | 0.020             | 6.66                      | 1.897                |
| MS 9                | 2.932                   | 0.009             | 21.85                     | 2.469                |
| MS 10               | 2.842                   | 0.013             | 15.38                     | 2.402                |
| MS 11               | 2.223                   | 0.032             | 5.67                      | 1.843                |
| MS 12               | 2.770                   | 0.015             | 12.38                     | 2.351                |
| MS 13               | 2.562                   | 0.019             | 12.07                     | 2.113                |
| MS 14               | 2.340                   | 0.016             | 10.65                     | 1.937                |
| MS 15               | 1.317                   | 0.050             | 2.68                      | 1.049                |
| MS 16               | 1.994                   | 0.039             | 3.91                      | 1.647                |
| MS 17               | 3.017                   | 0.015             | 26.05                     | 2.423                |
| MS 18               | 2.624                   | 0.014             | 11.51                     | 2.249                |
| MS 19               | 2.715                   | 0.010             | 13.14                     | 2.373                |
| MS 20               | 3.215                   | 0.013             | 19.37                     | 2.717                |
| MS 21               | 3.148                   | 0.011             | 12.77                     | 2.78                 |
| MS 22               | 2.195                   | 0.019             | 8.17                      | 1.825                |
| MS 23               | 2.789                   | 0.015             | 21.30                     | 2.239                |
| MS 24               | 1.517                   | 0.012             | 4.24                      | 1.328                |
| MS 25               | 2.401                   | 0.019             | 10.90                     | 1.972                |
| All Sample Index    | 4.749                   |                   | 73.07                     | 4.512                |
| Jackknife Std Error | 0.098                   |                   | 11.55                     | 0.09697              |

Table (3) Evenness indices in the Myitsone Dam site

| <b>Sample</b>       | <b>Shannon<br/>Maximum</b> | <b>Shannon<br/>Minimum</b> | <b>Simpsons<br/>Evenness (E)</b> | <b>Brillouin (E)</b> |
|---------------------|----------------------------|----------------------------|----------------------------------|----------------------|
| MS 1                | 3.401                      | 2.377                      | 0.648                            | 0.9005               |
| MS 2                | 3.135                      | 1.398                      | 0.411                            | 0.8161               |
| MS 3                | 2.639                      | 1.122                      | 0.442                            | 0.8176               |
| MS 4                | 2.773                      | 1.49                       | 0.309                            | 0.7413               |
| MS 5                | 2.833                      | 1.287                      | 0.762                            | 0.9113               |
| MS 6                | 3.401                      | 1.912                      | 0.414                            | 0.8548               |
| MS 7                | 2.89                       | 1.285                      | 0.297                            | 0.7473               |
| MS 8                | 2.708                      | 1.239                      | 0.444                            | 0.8179               |
| MS 9                | 3.135                      | 1.791                      | 0.950                            | 0.9419               |
| MS 10               | 3.135                      | 1.726                      | 0.669                            | 0.9093               |
| MS 11               | 2.89                       | 1.581                      | 0.315                            | 0.7613               |
| MS 12               | 3.178                      | 1.7                        | 0.516                            | 0.872                |
| MS 13               | 2.89                       | 1.733                      | 0.671                            | 0.8907               |
| MS 14               | 2.565                      | 1.408                      | 0.819                            | 0.9113               |
| MS 15               | 1.946                      | 1.9811                     | 0.383                            | 0.6572               |
| MS 16               | 2.773                      | 1.423                      | 0.245                            | 0.7034               |
| MS 17               | 3.219                      | 2.386                      | 1.042                            | 0.9459               |
| MS 18               | 3.045                      | 1.487                      | 0.548                            | 0.8622               |
| MS 19               | 3.091                      | 1.336                      | 0.597                            | 0.8796               |
| MS 20               | 3.584                      | 2.161                      | 0.538                            | 0.9013               |
| MS 21               | 3.714                      | 1.616                      | 0.312                            | 0.8472               |
| MS 22               | 2.485                      | 1.296                      | 0.681                            | 0.8813               |
| MS 23               | 2.944                      | 2.061                      | 1.121                            | 0.9473               |
| MS 24               | 1.792                      | 0.5779                     | 0.707                            | 0.8425               |
| MS 25               | 2.708                      | 1.6                        | 0.727                            | 0.8908               |
| All Sample Index    | 5.442                      | 1.273                      | 0.316                            | 0.8755               |
| Jackknife Std Error | 0.07223                    | 0.08403                    | 0.045                            | 0.01204              |

### 1.5.5. Forest structure

Stem density of  $\geq 3\text{cm}$  was  $1486 \text{ ha}^{-1}$  and basal area was  $60.35 \text{ m}^2/\text{ha}$  in the Myitsone dam site Table (4). Among the 25 sample plots studies, 231 tree species were recorded. Only one individual of 73 species were found and these species were considered as unique species.

The 10 most abundance species in terms of basal area occupied 49.45% of the total, of which *Dracotomelon* sp. was the most dominant species in the study area with 11.24%, followed by *Dipterocarpus obtusifolius* 6.74%, *Gmelina arborea* 5.31%, *Fagus crenata* 4.36%, *Tetrameles* sp. 4.27%, *Semecarpus* sp. 4.07%, *Castanopsis indica* 4.05%, *Tetrameles nudiflora* 4.02%, *Lithocarpus* sp. (3) 3.11%, and UN (61) 2.23% of the total basal area (Figure (7)).

Table (4) Consolidated detail of species inventory in the Myitsone Dam site

| Description                           | Results |
|---------------------------------------|---------|
| No. of Sample points                  | 25      |
| No. of tree species                   | 231     |
| Density (stem/ha)                     | 1486    |
| Basal area ( $\text{m}^2/\text{ha}$ ) | 60.35   |
| Total no. of unique species           | 73      |

The distribution of the basal area across DBH interval classes reveals the dominance of small stemmed individuals in the study area. The population structure by DBH class decreased from class to class with a steeper gradient in lower DBH classes and with a gentle slope in higher classes Figure (8) and Table (5). Out of total number of stems inventoried, 55.38% of stems were accumulated in the 3-30cm DBH class, 18.78% of stems in the 30-60cm, 11.64% in the 60-90cm, 5.59% in the 90-120cm, 3.23% in 120-150cm, only 5.28% occurs in 150-480cm. The highest DBH was measured in the case of *Gmelina arborea* (470cm), *Dracotomelon* sp. (430cm), *Tetrameles nudiflora* (380cm), *Dracotomelon* sp. (350cm).

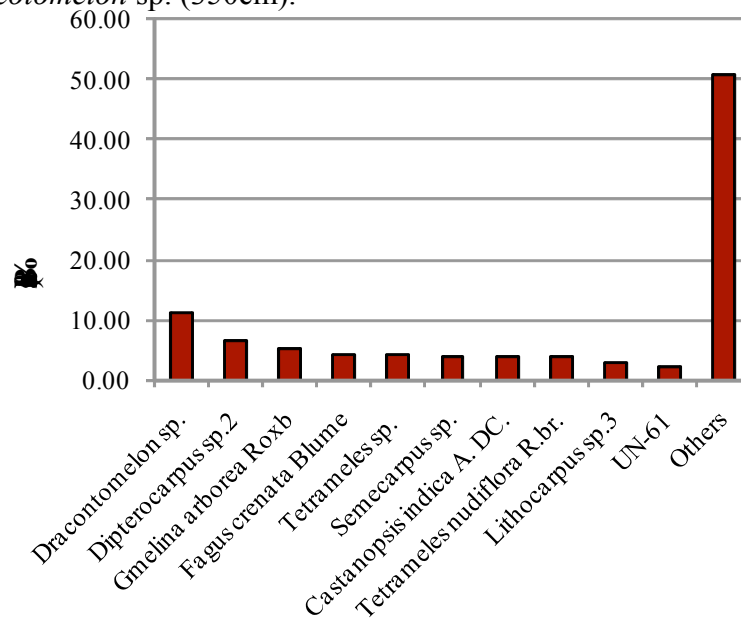


Figure (7) Ranking of relative basal area by species in the Myitsone Dam site

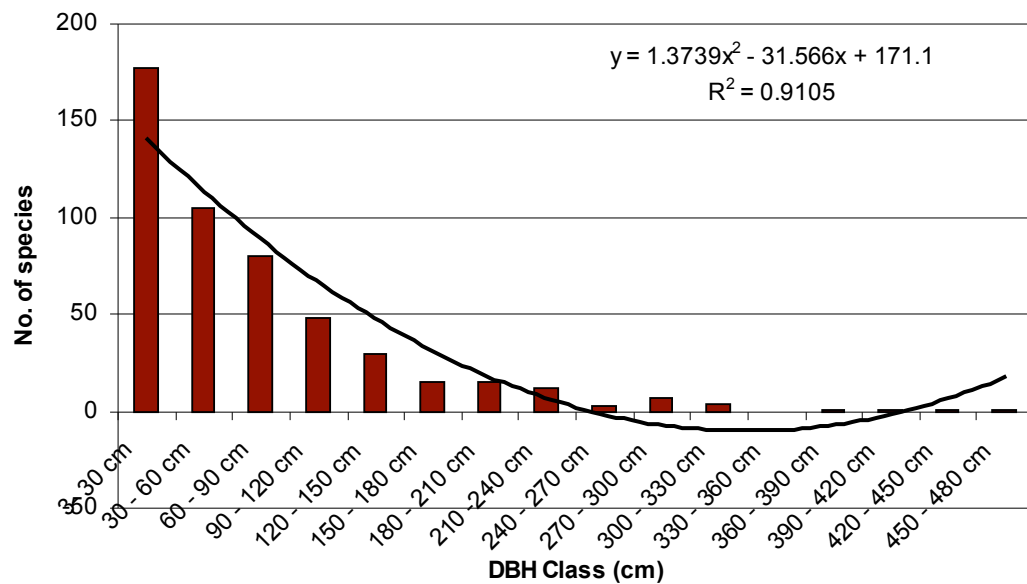


Figure (8) Species distribution by DBH classes

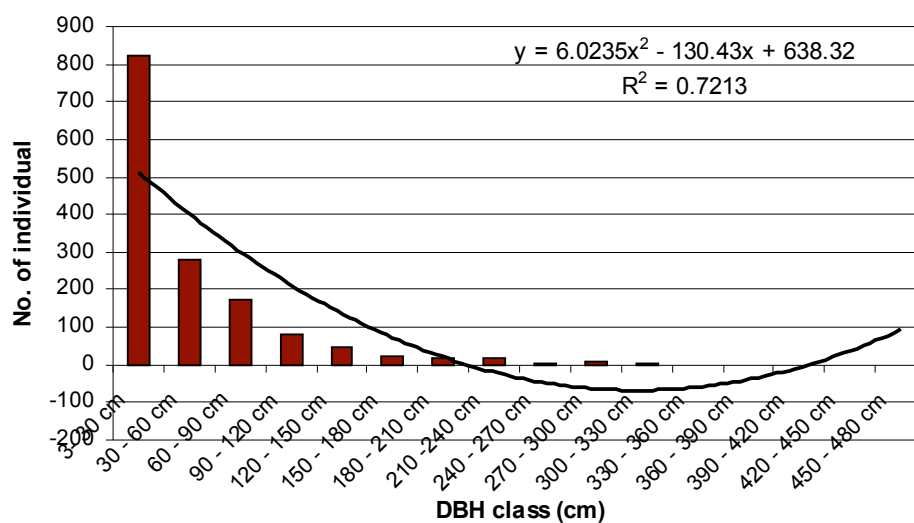


Figure (9) Population distribution by DBH classes

Table (5) Population density of tree species across DBH class interval

| DBH Classes  | No. of species | % of species | Total number of individual | % of total species | % of total individual |
|--------------|----------------|--------------|----------------------------|--------------------|-----------------------|
| 3-30 cm      | 177            | 76.29        | 823                        | 35.40              | 55.38                 |
| 30-60 cm     | 105            | 45.26        | 279                        | 21.00              | 18.78                 |
| 60-90 cm     | 80             | 34.48        | 173                        | 16.00              | 11.64                 |
| 90-120 cm    | 48             | 20.69        | 83                         | 9.60               | 5.59                  |
| 120-150 cm   | 30             | 12.93        | 48                         | 6.00               | 3.23                  |
| 150-180 cm   | 15             | 6.47         | 25                         | 3.00               | 1.68                  |
| 180-210 cm   | 15             | 6.47         | 19                         | 3.00               | 1.28                  |
| 210-240 cm   | 12             | 5.17         | 17                         | 2.4                | 1.14                  |
| 240-270 cm   | 3              | 1.29         | 3                          | 0.6                | 0.20                  |
| 270-300 cm   | 7              | 3.02         | 7                          | 1.4                | 0.47                  |
| 300-330 cm   | 4              | 1.72         | 5                          | 0.8                | 0.34                  |
| 330-360 cm   | -              | -            | -                          | -                  | -                     |
| 360-390 cm   | 1              | 0.43         | 1                          | 0.2                | 0.07                  |
| 390-420 cm   | 1              | 0.43         | 1                          | 0.43               | 0.07                  |
| 420-450 cm   | 1              | 0.43         | 1                          | 0.43               | 0.07                  |
| 450-480 cm   | 1              | 0.43         | 1                          | 0.43               | 0.07                  |
| <b>Total</b> | <b>232</b>     |              | <b>1486</b>                | <b>100.00</b>      | <b>100.00</b>         |

Tree distribution by height intervals shows that among the total number of 1486 individuals, 656 individuals (44.15%) belong to 3-10m category, followed by 494 individuals (33.24%) in 10-17m, 225 individuals (15.14%) in 17-24m, and 96 individuals (6.46%) in 24-31m. The height class of >31m includes only (0.47%) of total individuals (Table (6)). <3m high trees of 8 individuals (0.54%) infer natural regeneration is poor or frequent disturbance on ground cover plant. The population structure by height classes in the Myitsone area is highest in 3-10m class and gradually decreases to higher class (Figure 10 and 11). The tallest individual trees were *Dipterocarpus obtusifolius* (35m), *Dracontomelon* sp. (35m), *Duabanga grandiflora* (35m), *Cedrela toona* (35m), *Ficus* sp.3 (33m), and *Phoebe* sp.2 (33m). Total picture of height class shows that, 44.68% belong to <3-10m category, 48.38% in 10-24m, and 6.93% in 24->31m. The overall population structure indicates that study area represents mature stand.

Table (6) Population density of tree species across height class interval

| Height classes | No. of species | Total number of individual | % of total species | % of total individual |
|----------------|----------------|----------------------------|--------------------|-----------------------|
| < 3m           |                | 8                          | 1.58               | 0.54                  |
| 3-10 m         |                | 656                        | 37.92              | 44.15                 |
| 10-17 m        |                | 494                        | 31.15              | 33.24                 |
| 17-24 m        |                | 225                        | 19.86              | 15.14                 |
| 24-31 m        |                | 96                         | 8.13               | 6.46                  |
| > 31 m         |                | 7                          | 1.35               | 0.47                  |
| <b>Total</b>   |                | <b>1486</b>                | <b>100.00</b>      | <b>100.00</b>         |

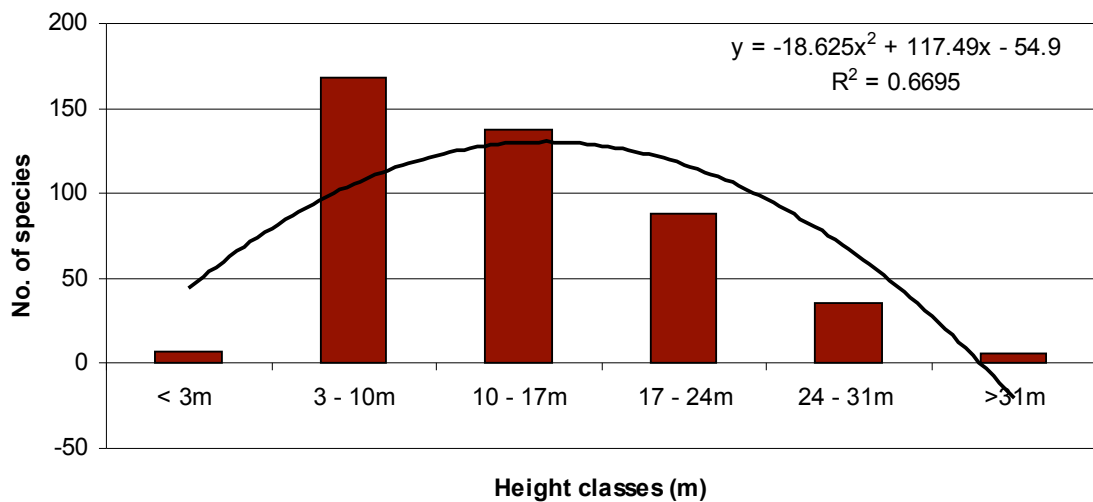


Figure (10) Species distribution by height classes

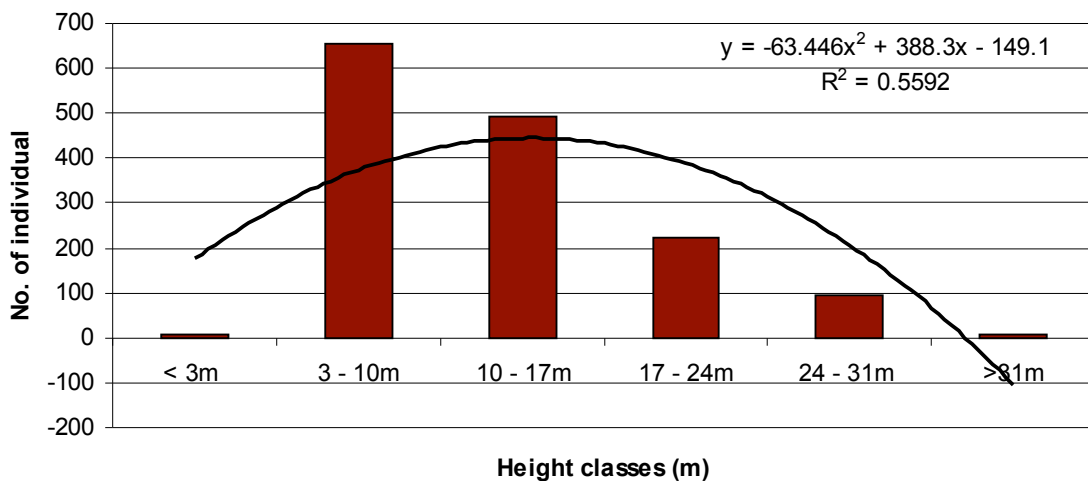


Figure (11) Population distribution by DBH classes

## 1.6. Discussion and Conclusion

A total of 231 tree species representing 176 genera and 48 families were analyzed in the study area. The main vegetation types discovered in Myitsone Dam site can be grouped into five formations, i.e. low land evergreen forest, oak forest, lowland secondary forest, bamboo forest, and grass land. In some disturbed sites, wild banana and some bushes can be seen in patches.

The important value index is imperative to compare the ecological significance of species (Lamprecht, 1989). It indicates the extent of dominance of a species in the structure of a forest stand (Curtis and McIntosh, 1950). It is stated that species with the greatest important value are the leading dominants of the forest. Accordingly, the ten leading dominants in study area were *Dracontomelon* sp, *Fagus crenata*, *Dipterocarpus obtusifolius*, *Chisocheton siamensis*, *Castanopsis indica*, *Gmelina arborea*, *Ostrya* sp., *Garcinia* sp.2, *Tetrameles nudiflora*, and *Baccaurea sapida* contributing highest IVI value (14.33, 10.53, 9.43, 7.73, 7.34, 7.06, 6.12, 5.8, 5.43, 4.84) respectively. Those tree species could be considered as ecological indicator species of the study area.

In mature site, the largest trees can reach up to >31m in height while the main canopy is 24-31m with well developed understoreys. The canopy of the forest is more or less

close, but in some disturbed sites, the canopy is open and the estimated height was probably not more than 15m, including stunted and cutover regrowth of the tree species.

Diversity indices are commonly used to assess the state of an ecosystem (e.g., as a criterion for conservation evaluation), with high diversity generally being considered a desirable property in a community or ecosystem. Presence of high species diversity and richness indicates that uniqueness and potentiality of Myitsone area for conservation of ecosystem in totality.

The forest structures in the study area show all types of disturbance. The surrounding Myitsone area has insufficient protection status that allows the exploitation of natural resources; such as logging, shifting cultivation, hunting and gold mining. Logging and gold mining are the major destructive force and one of the influencing factors for forest structure and surrounding ecosystem.

The following species that recorded in the study area assessed in IUCN Red list as follows;

| No. | Botanical Name                                   | Family           | Red Lists                    | Year      |
|-----|--------------------------------------------------|------------------|------------------------------|-----------|
| 1.  | <i>Aquilaria malaccensis</i> Lam.                | Thymeliaceae     | Vu Alcd                      | IUCN-2000 |
| 2.  | <i>Caesalpinia sappan</i> L.                     | Caesalpiniaceae  | Lower Risk/<br>Least concern | IUCN-2009 |
| 3.  | <i>Dipterocarpus turbinatus</i> Gaertn.f.        | Dipterocarpaceae | RC Alcd + 2cd                | IUCN-2000 |
| 4.  | <i>Holarrhena pubescens</i> Wall. ex G.Don       | Apocynaceae      | EX                           | IUCN-2000 |
| 5.  | <i>Shorea assamica</i> Dyer                      | Dipterocarpaceae | Cr Alcd, B1 + 2c             | IUCN-2000 |
| 6.  | <i>Elaeocarpus prunifolius</i> Wall. Ex C.Muell. | Elaeocarpaceae   | VU B1 + 2c                   | IUCN-2000 |

### 1.7. Recommendation

1. Infrastructure development as well as new access road from Myitkyina to Putao should be carried out with great care and it should have minimal impacts on environment, and social and cultural aspects of the indigenous people.
2. Extension of the existing national park and wildlife sanctuaries should be implemented, to balance the forest ecosystem services loss due to dam construction.
3. In addition, one or more compensatory protected area should be established and managed under the project.

The remaining forest cover should be systematically managed and conserved since the action not only maintain the watershed area but also support the biodiversity rich ecosystem.

### Appendix (1) Ranking of Important Value Index (IVI) in the Myitsone Area

| No. | Species Name                                    | R.D. % | R.D.m % | R.F % | IVI % |
|-----|-------------------------------------------------|--------|---------|-------|-------|
| 1   | <i>Dracontomelon</i> sp.                        | 1.48   | 11.245  | 1.60  | 14.33 |
| 2   | <i>Fagus crenata</i> Blume                      | 4.17   | 4.362   | 2.00  | 10.53 |
| 3   | <i>Dipterocarpus obtusifolius</i> Teysm.ex.Mig. | 2.29   | 6.743   | 0.40  | 9.43  |
| 4   | <i>Chisocheton siamensis</i> Craib              | 4.04   | 0.894   | 2.80  | 7.73  |
| 5   | <i>Castanopsis indica</i> A. DC.                | 2.29   | 4.053   | 1.00  | 7.34  |
| 6   | <i>Gmelina arborea</i> Roxb                     | 0.74   | 5.318   | 1.00  | 7.06  |
| 7   | <i>Ostrya</i> sp.                               | 4.04   | 0.085   | 2.00  | 6.12  |
| 8   | <i>Garcinia</i> sp.2                            | 2.29   | 2.114   | 1.40  | 5.80  |
| 9   | <i>Tetrameles nudiflora</i> R.br.               | 0.40   | 4.023   | 1.00  | 5.43  |
| 10  | <i>Baccaurea sapida</i> Muell.Arg.              | 2.15   | 0.691   | 2.00  | 4.84  |
| 11  | <i>Tetrameles</i> sp.                           | 0.20   | 4.277   | 0.20  | 4.68  |
| 12  | <i>Mallotus</i> sp.                             | 1.28   | 2.199   | 1.20  | 4.68  |
| 13  | <i>Semecarpus</i> sp.                           | 0.20   | 4.079   | 0.20  | 4.48  |
| 14  | <i>Myristica angustifolia</i> Roxb.             | 3.43   | 0.001   | 1.00  | 4.43  |
| 15  | <i>Lithocarpus</i> sp.3                         | 0.67   | 3.111   | 0.20  | 3.98  |
| 16  | <i>Mesua nervosa</i> Planch.&Triana             | 1.68   | 0.002   | 2.00  | 3.68  |
| 17  | <i>Wisteria</i> sp.                             | 1.88   | 0.813   | 0.80  | 3.50  |
| 18  | <i>Bischofia javanica</i> Blume                 | 0.74   | 2.049   | 0.60  | 3.39  |
| 19  | <i>Cinnamomum</i> sp.                           | 1.28   | 0.302   | 1.80  | 3.38  |
| 20  | <i>Cananga</i> sp.                              | 1.68   | 0.747   | 0.80  | 3.23  |
| 21  | <i>Machilus</i> sp.1                            | 0.74   | 2.064   | 0.40  | 3.20  |
| 22  | <i>Symplocos</i> sp.1                           | 1.95   | 0.007   | 1.20  | 3.16  |
| 23  | <i>Ficus</i> sp.1                               | 0.87   | 0.731   | 1.40  | 3.01  |
| 24  | <i>Arenga</i> sp.                               | 1.08   | 1.372   | 0.40  | 2.85  |
| 25  | <i>Diospyros</i> sp.                            | 1.01   | 0.226   | 1.60  | 2.84  |
| 26  | <i>Lithocarpus</i> sp. 1                        | 1.55   | 0.211   | 1.00  | 2.76  |
| 27  | <i>Albizia lucidior</i> (Steud.) Nielsen        | 0.81   | 1.343   | 0.60  | 2.75  |
| 28  | <i>Mallotus paniculatus</i> Muell. Arg.         | 2.42   | 0.004   | 0.20  | 2.63  |
| 29  | <i>Litsea</i> sp.1                              | 1.82   | 0.009   | 0.80  | 2.63  |
| 30  | <i>Leea</i> sp.                                 | 1.28   | 0.051   | 1.20  | 2.53  |
| 31  | UN-61                                           | 0.07   | 2.233   | 0.20  | 2.50  |
| 32  | <i>Lithocarpus</i> sp. 2                        | 1.01   | 0.466   | 1.00  | 2.48  |
| 33  | <i>Glochidion</i> sp.                           | 1.41   | 0.182   | 0.80  | 2.40  |
| 34  | <i>Schima wallichii</i> (DC.) Korth.            | 0.61   | 0.671   | 1.00  | 2.28  |
| 35  | <i>Castanopsis</i> sp.1                         | 0.87   | 0.560   | 0.80  | 2.23  |
| 36  | <i>Lagerstromia macrophylla</i> Kurz            | 0.54   | 0.885   | 0.80  | 2.22  |
| 37  | <i>Symplocos</i> sp.2                           | 0.40   | 0.866   | 0.80  | 2.07  |
| No. | Species Name                                    | R.D. % | R.D.m % | R.F % | IVI % |

| 38  | UN-8                                               | 0.61   | 0.638   | 0.80  | 2.04  |
|-----|----------------------------------------------------|--------|---------|-------|-------|
| 39  | <i>Alphonsea</i> sp.                               | 0.67   | 0.157   | 1.20  | 2.03  |
| 40  | <i>Shorea</i> sp.                                  | 0.13   | 1.420   | 0.40  | 1.95  |
| 41  | <i>Actinodaphane</i> sp.                           | 0.54   | 0.605   | 0.80  | 1.94  |
| 42  | UN-59                                              | 1.21   | 0.104   | 0.60  | 1.91  |
| 43  | <i>Pavetta indica</i> L.                           | 0.07   | 1.605   | 0.20  | 1.87  |
| 44  | <i>Ardisia</i> sp.                                 | 0.61   | 0.037   | 1.20  | 1.84  |
| 45  | <i>Ficus</i> sp. 3                                 | 0.13   | 1.365   | 0.20  | 1.70  |
| 46  | <i>Stereospermum colaris</i> (B. -H. ex Dillw.)    | 0.54   | 0.156   | 1.00  | 1.69  |
| 47  | <i>Ziziphus</i> sp.                                | 0.81   | 0.082   | 0.80  | 1.69  |
| 48  | <i>Cedrela toona</i> Roxb.                         | 0.27   | 0.757   | 0.60  | 1.63  |
| 49  | <i>Ficus fistulosa</i> Reinw.                      | 0.81   | 0.217   | 0.60  | 1.62  |
| 50  | <i>Lannea coromandelica</i> (Houtt.) Merr.         | 0.20   | 0.821   | 0.60  | 1.62  |
| 51  | <i>Fagus</i> sp.                                   | 0.54   | 0.681   | 0.40  | 1.62  |
| 52  | <i>Toisusu urbaniana</i> Seem.                     | 0.13   | 1.266   | 0.20  | 1.60  |
| 53  | <i>Drimycarpus racemosus</i> Hook.f.               | 0.54   | 0.253   | 0.80  | 1.59  |
| 54  | <i>Duabanga grandiflora</i> (Roxb. ex DC.) Walp.   | 0.40   | 0.777   | 0.40  | 1.58  |
| 55  | UN-38                                              | 0.20   | 0.956   | 0.40  | 1.56  |
| 56  | <i>Swintonia floribunda</i> Griff.                 | 0.74   | 0.004   | 0.80  | 1.54  |
| 57  | <i>Sterculia</i> sp.                               | 0.61   | 0.116   | 0.80  | 1.52  |
| 58  | <i>Pittostoropsis kerii</i> Craib                  | 0.07   | 1.218   | 0.20  | 1.49  |
| 59  | <i>Oroxylum indicum</i> (L.) Kurz                  | 0.47   | 0.005   | 1.00  | 1.48  |
| 60  | <i>Ficus</i> sp.2                                  | 0.61   | 0.230   | 0.60  | 1.44  |
| 61  | <i>Pterospermum cinnamomum</i> Kurz                | 0.27   | 0.561   | 0.60  | 1.43  |
| 62  | <i>Ostodes paniculata</i> Blume                    | 0.61   | 0.201   | 0.60  | 1.41  |
| 63  | <i>Arenga triandra</i> Roxb.                       | 0.54   | 0.013   | 0.80  | 1.35  |
| 64  | <i>Vitex</i> sp.                                   | 0.34   | 0.206   | 0.80  | 1.34  |
| 65  | UN-1                                               | 0.07   | 1.034   | 0.20  | 1.30  |
| 66  | UN-13                                              | 0.74   | 0.073   | 0.40  | 1.21  |
| 67  | <i>Garcinia</i> sp.1                               | 0.34   | 0.254   | 0.60  | 1.19  |
| 68  | <i>Dipterocarpus</i> sp.3                          | 0.27   | 0.112   | 0.80  | 1.18  |
| 69  | <i>Anacardium</i> sp.                              | 0.13   | 0.646   | 0.40  | 1.18  |
| 70  | <i>Micromelum minutum</i> (G. Forst.) Wight & Arn. | 0.07   | 0.878   | 0.20  | 1.15  |
| 71  | UN-5                                               | 0.87   | 0.062   | 0.20  | 1.14  |
| 72  | <i>Knema furfuracea</i> (HK. F.et Th.) Warb.       | 0.61   | 0.110   | 0.40  | 1.12  |
| 73  | <i>Wendlandia tinctoria</i> DC.                    | 0.87   | 0.025   | 0.20  | 1.10  |
| 74  | UN-43                                              | 0.87   | 0.006   | 0.20  | 1.08  |
| 75  | <i>Hibiscus macrophyllus</i> Roxb.                 | 0.13   | 0.539   | 0.40  | 1.07  |
| 76  | <i>Symplocos macrophylla</i> Wight                 | 0.13   | 0.698   | 0.20  | 1.03  |
| No. | Species Name                                       | R.D. % | R.D.m % | R.F % | IVI % |

|            |                                                 |               |                |              |              |
|------------|-------------------------------------------------|---------------|----------------|--------------|--------------|
| 77         | <i>Lagerstroemia tomentosa</i> Presl            | 0.34          | 0.094          | 0.60         | 1.03         |
| 78         | UN-46                                           | 0.61          | 0.022          | 0.40         | 1.03         |
| 79         | UN-24                                           | 0.20          | 0.609          | 0.20         | 1.01         |
| 80         | <i>Syzygium</i> sp.1                            | 0.40          | 0.004          | 0.60         | 1.01         |
| 81         | <i>Shorea obtusa</i> Wall                       | 0.47          | 0.132          | 0.40         | 1.003        |
| 82         | <i>Spondias pinnata</i> (L.) Kurz.              | 0.20          | 0.195          | 0.60         | 0.997        |
| 83         | <i>Casearia</i> sp.                             | 0.67          | 0.121          | 0.20         | 0.994        |
| 84         | UN-25                                           | 0.54          | 0.036          | 0.40         | 0.974        |
| 85         | <i>Adenantra</i> sp.                            | 0.47          | 0.299          | 0.20         | 0.970        |
| 86         | <i>Duabanga denticulata</i> Kunth               | 0.27          | 0.287          | 0.40         | 0.956        |
| 87         | <i>Dracaena</i> sp.                             | 0.54          | 0.017          | 0.40         | 0.955        |
| 88         | <i>Aglaiia lawii</i> (Wight) Sald.& Rama.       | 0.40          | 0.142          | 0.40         | 0.946        |
| 89         | UN-3                                            | 0.74          | 0.003          | 0.20         | 0.943        |
| 90         | <i>Dalbergia</i> sp.                            | 0.34          | 0.205          | 0.40         | 0.942        |
| 91         | <i>Phoebe</i> sp.2                              | 0.54          | 0.002          | 0.40         | 0.941        |
| 92         | <i>Ficus hispida</i> L.f.                       | 0.27          | 0.233          | 0.40         | 0.902        |
| 93         | <i>Spondias</i> sp.                             | 0.27          | 0.223          | 0.40         | 0.893        |
| 94         | UN-23                                           | 0.27          | 0.221          | 0.40         | 0.890        |
| 95         | <i>Aralia</i> sp.                               | 0.40          | 0.082          | 0.40         | 0.885        |
| 96         | UN-40                                           | 0.20          | 0.274          | 0.40         | 0.875        |
| 97         | <i>Sterculia lanceolata</i> Buch-Ham.           | 0.27          | 0.001          | 0.60         | 0.870        |
| 98         | <i>Dipterocarpus</i> sp.1                       | 0.27          | 0.199          | 0.40         | 0.868        |
| 99         | <i>Terminalia chebula</i> Retz.                 | 0.27          | 0.190          | 0.40         | 0.859        |
| 100        | UN-45                                           | 0.20          | 0.431          | 0.20         | 0.833        |
| 101        | <i>Castanopsis</i> sp.2                         | 0.20          | 0.209          | 0.40         | 0.811        |
| 102        | <i>Polyalthia</i> sp.                           | 0.40          | 0.000          | 0.40         | 0.804        |
| 103        | <i>Antidesma</i> sp.                            | 0.54          | 0.064          | 0.20         | 0.802        |
| 104        | <i>Croton joufra</i> Roxb.                      | 0.34          | 0.061          | 0.40         | 0.797        |
| 105        | <i>Vitis</i> sp.                                | 0.13          | 0.458          | 0.20         | 0.792        |
| 106        | <i>Sterculia balanghas</i> L.                   | 0.07          | 0.519          | 0.20         | 0.786        |
| 107        | <i>Litsea</i> sp.2                              | 0.20          | 0.370          | 0.20         | 0.771        |
| 108        | <i>Ficus semicordata</i> Buch.-Ham. ex J.E. Sm. | 0.34          | 0.034          | 0.40         | 0.771        |
| 109        | UN-14                                           | 0.27          | 0.093          | 0.40         | 0.762        |
| 110        | <i>Artocarpus lakoocha</i> Roxb.                | 0.13          | 0.223          | 0.40         | 0.758        |
| 111        | <i>Terminalia</i> sp.                           | 0.34          | 0.019          | 0.40         | 0.756        |
| 112        | <i>Morinda</i> sp.                              | 0.13          | 0.211          | 0.40         | 0.745        |
| 113        | <i>Schefflera</i> sp.                           | 0.34          | 0.008          | 0.40         | 0.744        |
| 114        | UN-60                                           | 0.27          | 0.071          | 0.40         | 0.740        |
| 115        | <i>Meliosma simplicifolia</i> Walp.             | 0.27          | 0.056          | 0.40         | 0.725        |
| <b>No.</b> | <b>Species Name</b>                             | <b>R.D. %</b> | <b>R.D.m %</b> | <b>R.F %</b> | <b>IVI %</b> |

| 116 | <i>Syzygium</i> sp.3                            | 0.47   | 0.053   | 0.20  | 0.724 |
|-----|-------------------------------------------------|--------|---------|-------|-------|
| 117 | UN-53                                           | 0.27   | 0.027   | 0.40  | 0.696 |
| 118 | <i>Quercus</i> sp.                              | 0.47   | 0.006   | 0.20  | 0.678 |
| 119 | <i>Schima</i> sp.                               | 0.20   | 0.074   | 0.40  | 0.676 |
| 120 | UN-32                                           | 0.07   | 0.391   | 0.20  | 0.659 |
| 121 | <i>Rapanea</i> sp.                              | 0.20   | 0.248   | 0.20  | 0.649 |
| 122 | <i>Dysoxylum binectariferum</i> Hook.f.         | 0.20   | 0.019   | 0.40  | 0.621 |
| 123 | <i>Dolichandrone serrulata</i> Seem.            | 0.20   | 0.217   | 0.20  | 0.619 |
| 124 | <i>Ficus annulata</i> Bl.                       | 0.13   | 0.075   | 0.40  | 0.610 |
| 125 | <i>Garcinia merguensis</i> Wight                | 0.20   | 0.008   | 0.40  | 0.610 |
| 126 | <i>Knema erratica</i> (Hk. F & Th.) Sinclair    | 0.40   | 0.001   | 0.20  | 0.604 |
| 127 | UN-4                                            | 0.13   | 0.266   | 0.20  | 0.601 |
| 128 | <i>Mangifera indica</i> L.                      | 0.07   | 0.316   | 0.20  | 0.583 |
| 129 | UN-42                                           | 0.20   | 0.176   | 0.20  | 0.578 |
| 130 | <i>Berrya</i> sp.                               | 0.34   | 0.038   | 0.20  | 0.575 |
| 131 | <i>Streblus</i> sp.                             | 0.07   | 0.296   | 0.20  | 0.563 |
| 132 | UN-55                                           | 0.13   | 0.015   | 0.40  | 0.550 |
| 133 | <i>Chukrasia tabularis</i> A. Juss Wight & Arn. | 0.27   | 0.078   | 0.20  | 0.547 |
| 134 | <i>Callicarpa arborea</i> Roxb.                 | 0.13   | 0.012   | 0.40  | 0.546 |
| 135 | <i>Syzygium</i> sp.2                            | 0.27   | 0.075   | 0.20  | 0.545 |
| 136 | UN-51                                           | 0.13   | 0.008   | 0.40  | 0.542 |
| 137 | <i>Alstonia scholaris</i> (L.) R.Br.            | 0.13   | 0.007   | 0.40  | 0.541 |
| 138 | UN-50                                           | 0.13   | 0.006   | 0.40  | 0.540 |
| 139 | <i>Gnetum montanum</i> Markgraf                 | 0.13   | 0.002   | 0.40  | 0.537 |
| 140 | UN-57                                           | 0.13   | 0.001   | 0.40  | 0.536 |
| 141 | <i>Lagerstroemia parviflora</i> Roxb.           | 0.13   | 0.191   | 0.20  | 0.525 |
| 142 | <i>Castanopsis diversifolia</i> King            | 0.07   | 0.244   | 0.20  | 0.511 |
| 143 | UN-22                                           | 0.13   | 0.156   | 0.20  | 0.491 |
| 144 | <i>Macaranga</i> sp.                            | 0.27   | 0.021   | 0.20  | 0.490 |
| 145 | <i>Anneslea fragrans</i> Wall.                  | 0.07   | 0.203   | 0.20  | 0.470 |
| 146 | <i>Diospyros packmanni</i> C.B. Clarke          | 0.20   | 0.056   | 0.20  | 0.458 |
| 147 | UN-2                                            | 0.20   | 0.049   | 0.20  | 0.451 |
| 148 | <i>Elaeocarpus</i> sp.                          | 0.20   | 0.037   | 0.20  | 0.439 |
| 149 | UN-9                                            | 0.13   | 0.100   | 0.20  | 0.434 |
| 150 | UN-12                                           | 0.13   | 0.087   | 0.20  | 0.421 |
| 151 | UN-47                                           | 0.20   | 0.010   | 0.20  | 0.412 |
| 152 | UN-30                                           | 0.20   | 0.006   | 0.20  | 0.408 |
| 153 | <i>Myristica</i> sp.                            | 0.07   | 0.140   | 0.20  | 0.408 |
| 154 | <i>Litsea monopetala</i> (Roxb.) Pers.          | 0.20   | 0.005   | 0.20  | 0.407 |
| No. | Species Name                                    | R.D. % | R.D.m % | R.F % | IVI % |

| 155 | UN-56                                                 | 0.13   | 0.069   | 0.20  | 0.404 |
|-----|-------------------------------------------------------|--------|---------|-------|-------|
| 156 | UN-36                                                 | 0.20   | 0.001   | 0.20  | 0.403 |
| 157 | UN-10                                                 | 0.20   | 0.000   | 0.20  | 0.402 |
| 158 | UN-15                                                 | 0.07   | 0.132   | 0.20  | 0.399 |
| 159 | UN-39                                                 | 0.07   | 0.127   | 0.20  | 0.394 |
| 160 | <i>Glyscomis</i> sp.                                  | 0.07   | 0.127   | 0.20  | 0.394 |
| 161 | UN-48                                                 | 0.07   | 0.122   | 0.20  | 0.39  |
| 162 | <i>Litsea glutinosa</i> (Lour.)C.B. Rob.              | 0.13   | 0.052   | 0.20  | 0.39  |
| 163 | <i>Casearia grewiaefolia</i> Vent.                    | 0.13   | 0.048   | 0.20  | 0.38  |
| 164 | <i>Meliosma</i> sp.                                   | 0.07   | 0.110   | 0.20  | 0.38  |
| 165 | UN-33                                                 | 0.13   | 0.032   | 0.20  | 0.37  |
| 166 | UN-49                                                 | 0.07   | 0.087   | 0.20  | 0.35  |
| 167 | UN-28                                                 | 0.07   | 0.076   | 0.20  | 0.34  |
| 168 | <i>Bischofia</i> sp.                                  | 0.13   | 0.008   | 0.20  | 0.34  |
| 169 | <i>Nephelium</i> sp.                                  | 0.13   | 0.008   | 0.20  | 0.34  |
| 170 | <i>Betula</i> sp.                                     | 0.13   | 0.008   | 0.20  | 0.34  |
| 171 | <i>Canthium</i> sp.                                   | 0.13   | 0.005   | 0.20  | 0.34  |
| 172 | <i>Machilus</i> sp.2                                  | 0.13   | 0.003   | 0.20  | 0.34  |
| 173 | <i>Goniothalamus</i> sp.                              | 0.13   | 0.003   | 0.20  | 0.34  |
| 174 | <i>Callicarpa</i> sp.1                                | 0.13   | 0.002   | 0.20  | 0.34  |
| 175 | <i>Clerodendrum</i> sp.                               | 0.13   | 0.002   | 0.20  | 0.34  |
| 176 | <i>Sapindus</i> sp.                                   | 0.13   | 0.002   | 0.20  | 0.34  |
| 177 | <i>Capparis</i> sp.                                   | 0.13   | 0.001   | 0.20  | 0.34  |
| 178 | <i>Albizia</i> sp.                                    | 0.07   | 0.065   | 0.20  | 0.33  |
| 179 | <i>Mussaenda</i> sp.                                  | 0.07   | 0.065   | 0.20  | 0.33  |
| 180 | <i>Adina cordifolia</i> Hook.f.                       | 0.07   | 0.059   | 0.20  | 0.33  |
| 181 | <i>Viburnum</i> sp.                                   | 0.07   | 0.054   | 0.20  | 0.32  |
| 182 | <i>Boehmerra cledemioides</i> Miq.                    | 0.07   | 0.054   | 0.20  | 0.32  |
| 183 | <i>Syzygium megacarpum</i> (Craib) Rathakr.& N.C.Nair | 0.07   | 0.049   | 0.20  | 0.32  |
| 184 | UN-6                                                  | 0.07   | 0.049   | 0.20  | 0.32  |
| 185 | UN-17                                                 | 0.07   | 0.047   | 0.20  | 0.31  |
| 186 | UN-16                                                 | 0.07   | 0.038   | 0.20  | 0.31  |
| 187 | UN-52                                                 | 0.07   | 0.037   | 0.20  | 0.30  |
| 188 | <i>Ficus roxburghii</i> Wall.                         | 0.07   | 0.036   | 0.20  | 0.30  |
| 189 | <i>Holarrhena pubescens</i> Wall. ex G.Don            | 0.07   | 0.030   | 0.20  | 0.30  |
| 190 | <i>Juglans regia</i> L.                               | 0.07   | 0.030   | 0.20  | 0.30  |
| 191 | <i>Grewia</i> sp.                                     | 0.07   | 0.026   | 0.20  | 0.29  |
| 192 | UN-19                                                 | 0.07   | 0.026   | 0.20  | 0.29  |
| No. | Species Name                                          | R.D. % | R.D.m % | R.F % | IVI % |

|     |                                              |        |        |        |        |
|-----|----------------------------------------------|--------|--------|--------|--------|
| 193 | UN-7                                         | 0.07   | 0.024  | 0.20   | 0.29   |
| 194 | <i>Macarenga denticulata</i> Muell. Arg.     | 0.07   | 0.018  | 0.20   | 0.29   |
| 195 | UN-44                                        | 0.07   | 0.017  | 0.20   | 0.28   |
| 196 | <i>Callicarpa</i> sp.2                       | 0.07   | 0.016  | 0.20   | 0.28   |
| 197 | UN-27                                        | 0.07   | 0.016  | 0.20   | 0.28   |
| 198 | UN-29                                        | 0.07   | 0.016  | 0.20   | 0.28   |
| 199 | UN-21                                        | 0.07   | 0.015  | 0.20   | 0.28   |
| 200 | UN-37                                        | 0.07   | 0.014  | 0.20   | 0.28   |
| 201 | UN-11                                        | 0.07   | 0.012  | 0.20   | 0.28   |
| 202 | <i>Shorea assamica</i> Dyer                  | 0.07   | 0.012  | 0.20   | 0.28   |
| 203 | UN-41                                        | 0.07   | 0.011  | 0.20   | 0.28   |
| 204 | <i>Suregada multifolra</i> (A. Juss.) Baill. | 0.07   | 0.011  | 0.20   | 0.28   |
| 205 | <i>Celtis</i> sp.                            | 0.07   | 0.010  | 0.20   | 0.28   |
| 206 | <i>Dalbergia oliveri</i> Gamble              | 0.07   | 0.010  | 0.20   | 0.28   |
| 207 | <i>Acronychia</i> sp.                        | 0.07   | 0.008  | 0.20   | 0.27   |
| 208 | <i>Castanopsis</i> sp.3                      | 0.07   | 0.008  | 0.20   | 0.27   |
| 209 | <i>Engelhardtia spicata</i> Blume            | 0.07   | 0.007  | 0.20   | 0.27   |
| 210 | <i>Meliosma pinnata</i> Roxb.                | 0.07   | 0.007  | 0.20   | 0.27   |
| 211 | UN-35                                        | 0.07   | 0.006  | 0.20   | 0.27   |
| 212 | <i>Aporusa roxburghii</i> Baill.             | 0.07   | 0.006  | 0.20   | 0.27   |
| 213 | <i>Archidendron</i> sp.                      | 0.07   | 0.006  | 0.20   | 0.27   |
| 214 | <i>Bauhinia</i> sp.                          | 0.07   | 0.005  | 0.20   | 0.27   |
| 215 | <i>Rhus succedanea</i> L.                    | 0.07   | 0.005  | 0.20   | 0.27   |
| 216 | UN-34                                        | 0.07   | 0.005  | 0.20   | 0.27   |
| 217 | <i>Atalantia roxburghiana</i> Hk.f.          | 0.07   | 0.004  | 0.20   | 0.27   |
| 218 | UN-18                                        | 0.07   | 0.004  | 0.20   | 0.27   |
| 219 | UN-54                                        | 0.07   | 0.004  | 0.20   | 0.27   |
| 220 | <i>Magnolia</i> sp.                          | 0.07   | 0.003  | 0.20   | 0.27   |
| 221 | <i>Aglaia</i> sp.                            | 0.07   | 0.003  | 0.20   | 0.27   |
| 222 | <i>Carallia brachiata</i> (Lour.) Merr.      | 0.07   | 0.003  | 0.20   | 0.27   |
| 223 | <i>Emblica officinalis</i> Gaertn.           | 0.07   | 0.003  | 0.20   | 0.27   |
| 224 | <i>Neolitsea</i> sp.                         | 0.07   | 0.002  | 0.20   | 0.27   |
| 225 | <i>Morus</i> sp.                             | 0.07   | 0.002  | 0.20   | 0.27   |
| 226 | <i>Phoebe</i> sp.1                           | 0.07   | 0.001  | 0.20   | 0.27   |
| 227 | UN-31                                        | 0.07   | 0.001  | 0.20   | 0.27   |
| 228 | <i>Miliusa</i> sp.                           | 0.07   | 0.001  | 0.20   | 0.27   |
| 229 | UN-26                                        | 0.07   | 0.001  | 0.20   | 0.27   |
| 230 | UN-20                                        | 0.07   | 0.001  | 0.20   | 0.27   |
| 231 | UN-58                                        | 0.07   | 0.0003 | 0.20   | 0.27   |
|     | Total                                        | 100.00 | 100.00 | 100.00 | 300.00 |

## Chapter II

## 2. Yenam Dam

### 2.1. Study area

The location of Yenam area is '20"N, 97° 01'36"E and 27°48'18"N, 98° 98'97"E near Aliaung village on downstream confluence mouth of Mayhka river and Tarone stream. The study area lays WWF Eco-region of Northern Triangle Temperate forest. It is also located within the priority sites for conservation investment of Northern mountain forest complex. Its watershed area also comprises Hkakaborazi N.P and Hpongan Razi W.S. which are the biodiversity hot-spots and globally outstanding conservation areas. A detailed map of the study area is given in figure (1.1).

#### 2.1.1. Participants

Dr Myint Aung, Daw Thin Thin Su, Daw Khin Khin Soe, and U Tayzar Aung.

### 2.2. Results

#### 2.2.1. Forest composition

To clarify the tree species composition and their distribution, twelve quadrats (20x20 m each) were set up and observed in the flooded area of Yenam dam site. In the twelve sampling plots (.48 ha), total number of species with DBH  $\geq$  3cm was 113 species; of which 26 species are under identification. The dominant families of tree species were Lauraceae (12 species), Fagaceae (9 species), Rubiaceae (7 species), Mimosaceae (4 species), Moraceae (4 species), Myrtaceae (4 species), Symplocaceae (4 species), Aceraceae (3 species), Actinidiaceae (3 species), Myrsinaceae (3 species) and Araliaceae (3 species) Figure (2). The main vegetation types discovered in Yenam Dam site can be grouped into four formations, i.e. high land evergreen forest, oak forest, high land secondary forest, and bamboo forest. In some disturbed sites, there are wild banana and degraded forest patches. In the high land evergreen forest, *Exbucklandia populnea*, *Engelhardtia* sp. & *Eurya* sp. are found in tree layer. Shrub layer is dominated by *Oxyspora paniculata*, *Symplocos macrophylla* & *Maesa montana*. Herb layer is dominated by *Selaginella* sp. & *Dipteris chinensis*. In the oak forest, *Castanopsis* spp., *Lithocarpus* sp. associate with *Syzygium* sp. in tree layer. Shrub layer is dominated by *Oxyspora paniculata*, *Lasianthus* sp., *Symplocos macrophylla* & *Symplocos* sp.. The ground cover of Oak forest is dominated by *Selaginella* sp. In the high land secondary forest, *Syzygium* sp., *Acer* sp. occupied mostly in crown cover and in some places *Symplocos* sp., *Wendlandia tinctoria* DC. and *Eurya* sp. are mixed with them. The ground cover is dominated by *Selaginella* sp., *Adiantum* sp., *Asplenium* sp. and *Polypodium* sp. occupy in most places. In the bamboo forest *Dendrocalamus hamiltonii* Ness (Wabo Myatsan), *D. giganteus* Munro (Wabowa) mainly occur.

The species area curves of the investigated stands are shown in the figure (3). The species area curves, which express the number of species in relation to change in area of habitat, not only to consider the minimum representative area but also to detect the habitat diversity within the survey area (Fangliang He and Pierre Legendre, 1996). The trend of species area curve shows tendency towards flattening. Therefore the sample area can be said to be sufficient as a minimum representative area for the study.

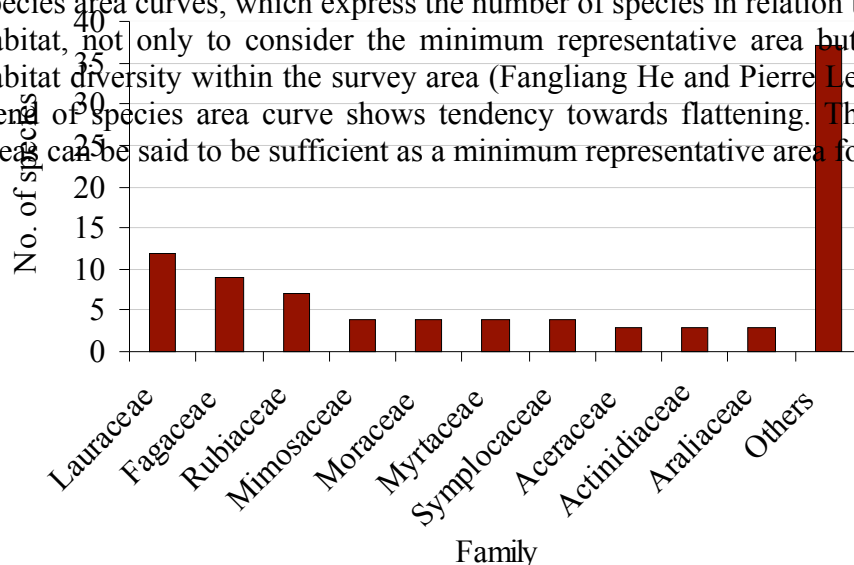


Figure (2) Ranking of dominant family by number of species composition

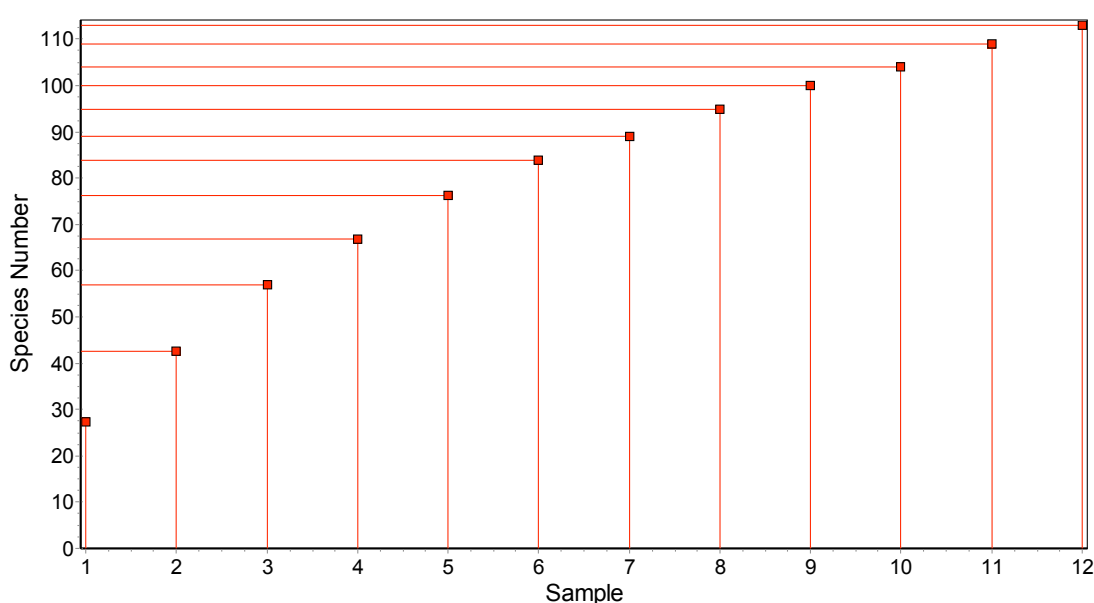


Figure (3) Plot of species accumulation in the Yenam Dam Site

### 2.2.2. Important Value Index (IVI)

Ranking of ecological significance by IVI of tree species in the study area is given in appendix (1). The tree layer in the study area is dominated by *Castanopsis tribuloides* A.DC. with the highest IVI of 22.02 %, the second most dominant species is *Sterculia* sp. (IVI = 20.81%) and *Symplocos* sp.1. (IVI= 20.72%) is third. The number of species greater than 5% IVI value was only fourteen species (Figure 4, Appendix 1). Those twelve species could be considered as ecological indicator species of Yenam area. Representation of 113 species and the high proportion of dominant species in the study area can directly be attributed to the favorable climatic and edaphic condition.

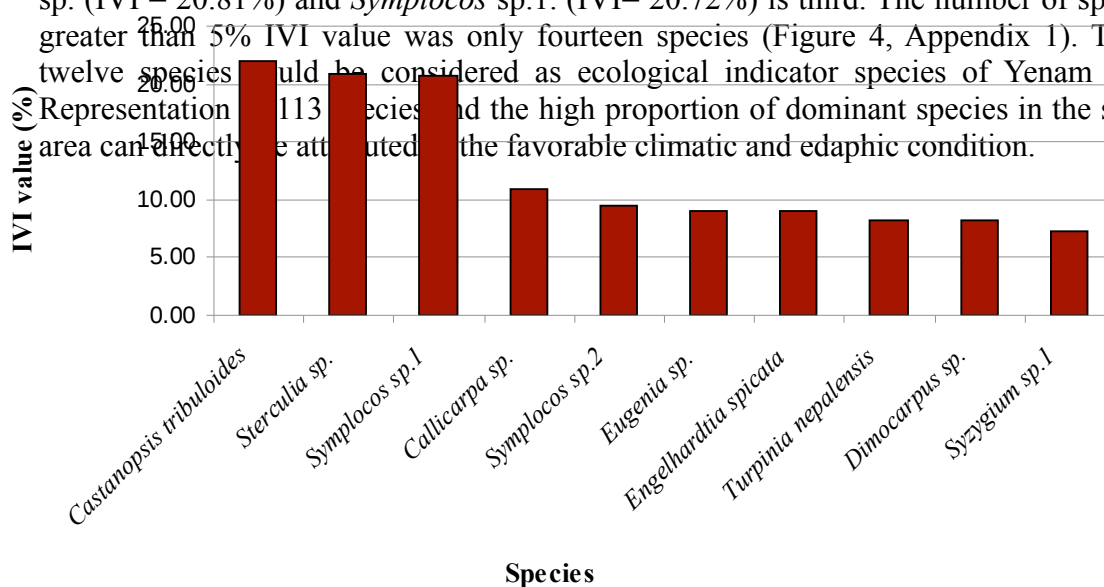


Figure (4) Important Value Index of top ten species in the Yenam Dam Site

### 2.2.3. Species distribution by frequency classes

In order to clarify the homogeneity or heterogeneity of the floristic distribution in the study area, species distribution by frequency classes was examined. According to the outcome of frequency chart, 74.34 % of the total number of species was in lower frequency classes, A and B, while low value was observed only in higher frequency class E (Table 1, Figure 5). It indicates that the forest in Yenam area is floristically heterogeneous, according to Lamprecht (1989). The species which fall in high frequency class E were UN-2 and *Cinnamomum* sp.2. The two species can be considered as the most common species in the Yenam area.

Table (1) Species distribution by frequency classes  $\geq 3\text{cm}$

| Frequency class | Frequency range | No. of species | % of total species frequency distribution |
|-----------------|-----------------|----------------|-------------------------------------------|
| A               | 1-20%           | 65             | 57.52                                     |
| B               | 21-40%          | 19             | 16.81                                     |
| C               | 41-60%          | 16             | 14.16                                     |
| D               | 61-80%          | 11             | 9.73                                      |
| E               | 81-100%         | 2              | 1.77                                      |

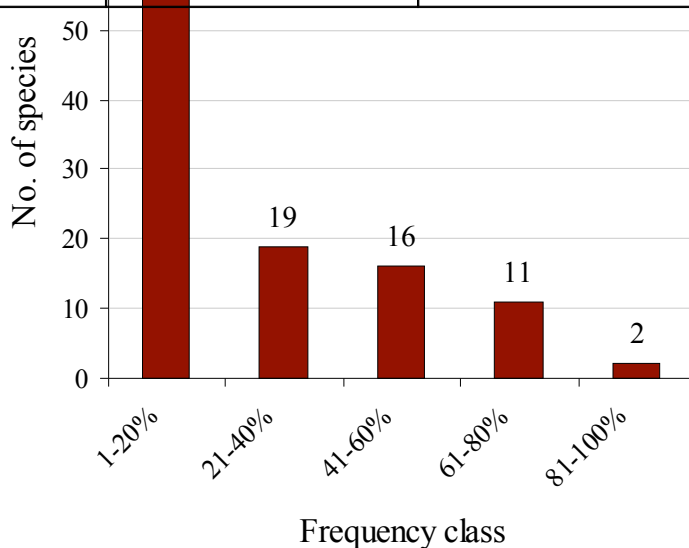


Figure (5) Species distribution by frequency classes  $\geq 3\text{cm}$

#### 2.2.4. Diversity indices and evenness

Among the different measurement of species diversity indices, the floristic diversity of the Yenam area was analyzed using the Shannon Wiener index (H), Simpsons index (D), Brillouin (D), Shannon Maximum and minimum evenness (E), Brillouin (E) because these indices not only take taxa richness into account but also depend on the relative distribution of individuals. The value of diversity indices and evenness indices of individual sample plot and all sample indices are shown in table (2) and (3). According to the result, though the diversity indices of individual sample plot are not too high, all sample indexes are relatively high.

Diversity value for all sample index of Shannon Wiener index (H) is 3.662, Simpsons index (D) is 18.910, and Brillouin (D) is 3.587. Presence of high species diversity and richness indicates uniqueness and potentiality of study area for conservation of ecosystem in totality.

Table (2) Species diversity indices in the Yenam Dam site

| <b>Sample</b>       | <b>Shonnon<br/>Wiener H</b> | <b>Variance H</b> | <b>Simpsons<br/>Index (D)</b> | <b>Brillouin (D)</b> |
|---------------------|-----------------------------|-------------------|-------------------------------|----------------------|
| PND 1               | 2.723                       | 0.006             | 12.400                        | 2.467                |
| PND 2               | 2.486                       | 0.010             | 8.638                         | 2.240                |
| PND 3               | 2.568                       | 0.003             | 10.220                        | 2.430                |
| PND 4               | 2.711                       | 0.004             | 11.540                        | 2.525                |
| PND 5               | 2.836                       | 0.004             | 11.430                        | 2.659                |
| PND 6               | 2.566                       | 0.012             | 9.101                         | 2.273                |
| PND 7               | 2.520                       | 0.011             | 6.549                         | 2.280                |
| PND 8               | 2.808                       | 0.005             | 9.856                         | 2.633                |
| PND 9               | 2.249                       | 0.005             | 3.781                         | 2.141                |
| PND 10              | 2.973                       | 0.004             | 15.130                        | 2.765                |
| PND 11              | 2.428                       | 0.005             | 6.300                         | 2.295                |
| PND 12              | 3.136                       | 0.006             | 19.320                        | 2.813                |
| All Sample Index    | 3.662                       |                   | 18.910                        | 3.587                |
| Jackknife Std Error | 0.228                       |                   | 9.487                         | 0.217                |

Table (3) Evenness indices in the Yenam Dam site

| Sample              | Shannon Wiener H | Variance H | Simpsons Index (D) | Brillouin (D) |
|---------------------|------------------|------------|--------------------|---------------|
| PND 1               | 3.178            | 1.003      | 0.517              | 0.858         |
| PND 2               | 3.178            | 1.034      | 0.360              | 0.781         |
| PND 3               | 3.091            | 0.509      | 0.464              | 0.830         |
| PND 4               | 3.178            | 0.697      | 0.481              | 0.853         |
| PND 5               | 3.584            | 0.762      | 0.317              | 0.792         |
| PND 6               | 3.135            | 1.188      | 0.396              | 0.817         |
| PND 7               | 3.219            | 0.959      | 0.262              | 0.777         |
| PND 8               | 3.611            | 0.736      | 0.266              | 0.776         |
| PND 9               | 3.738            | 0.480      | 0.090              | 0.596         |
| PND 10              | 3.497            | 0.840      | 0.459              | 0.851         |
| PND 11              | 3.296            | 0.523      | 0.233              | 0.733         |
| PND 12              | 3.555            | 1.349      | 0.522              | 0.884         |
| All Sample Index    | 4.727            | 0.337      | 0.167              | 0.775         |
| Jackknife Std Error | 0.053            | 0.062      | 0.088              | 0.047         |

### 2.2.5. Forest structure

Stem density of  $\geq 3\text{cm}$  was  $6227\text{ ha}^{-1}$  and basal area was  $73.3\text{ m}^2/\text{ha}$  in the Yenam dam site Table (4). Among the 12 sample plots studies, 113 tree species were recorded. Only one individual of 15 species were found and these species were considered as unique species.

The 10 most abundance species in terms of basal area occupied 63.63% of the total, of which *Sterculia* sp. was the most dominant species in the study area with 17.46%, followed by *Castanopsis tribuloides* A.DC. 11.27%, *Engelhardtia spicata* Blume 8.44 %, *Turpinia nepalensis* Wall. 6.10%, *Dimocarpus* sp. 4.67%, *Exbucklandia populnea* (R. Br. ex Griff.) R.W. Br. 3.44%, *Engelhardtia* sp. 3.07%, *Castanopsis diversifolia* King 2.89%, and *Symplocos* sp.2 2.86 %, of the total basal area Figure (6).

Table (4) Consolidated detail of species inventory in the Yenam Dam site

| Description                        | Results   |
|------------------------------------|-----------|
| No. of sample points               | 12        |
| No. of tree species                | 113       |
| Density (stem/ha)                  | 6227      |
| Basal area (m <sup>2</sup> /ha)    | 73.3      |
| <b>Total no. of unique species</b> | <b>15</b> |

The distribution of the basal area across DBH interval classes reveals the dominance of small stemmed individuals in the study area. The population structure by DBH class distinctly increases in lower DBH class, <30cm (83.1%). The population gradually decreases from class to class in higher DBH classes Figure (8) and Table (5). Out of total number of stems inventoried, 10.51% of stems were accumulated in the 30-60cm DBH class, 2.68% of stems in the 60-90cm, 1-61% in the 90-120cm. Other higher DBH classes are less than 1% of stem in each class interval. The highest DBH was measured in the case of *Sterculia* sp. (407cm), *Engelhardtia spicata* Blume (394cm), *Castanopsis* sp. (324cm), *Ficus roxburghii* Wall. (286cm).

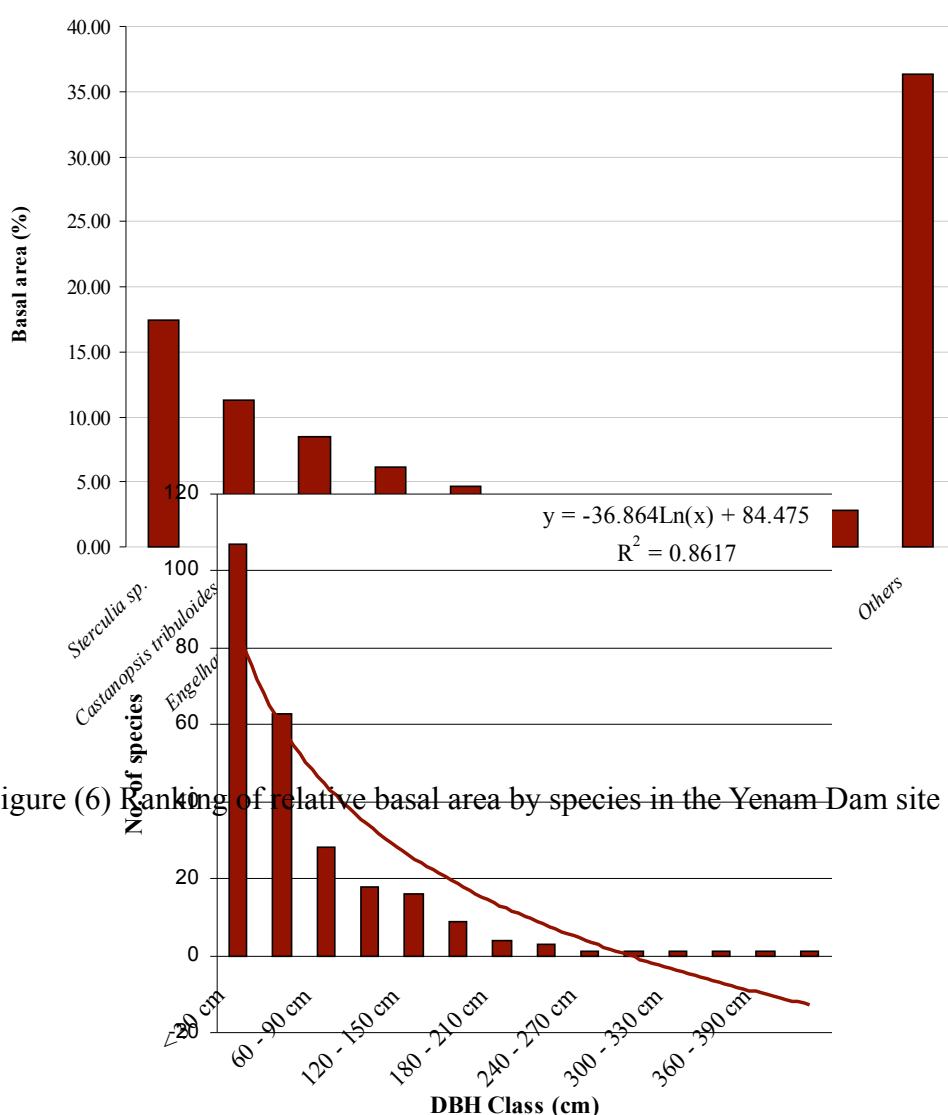


Figure (6) Ranking of relative basal area by species in the Yenam Dam site

Figure (7) Species distribution by DBH classes

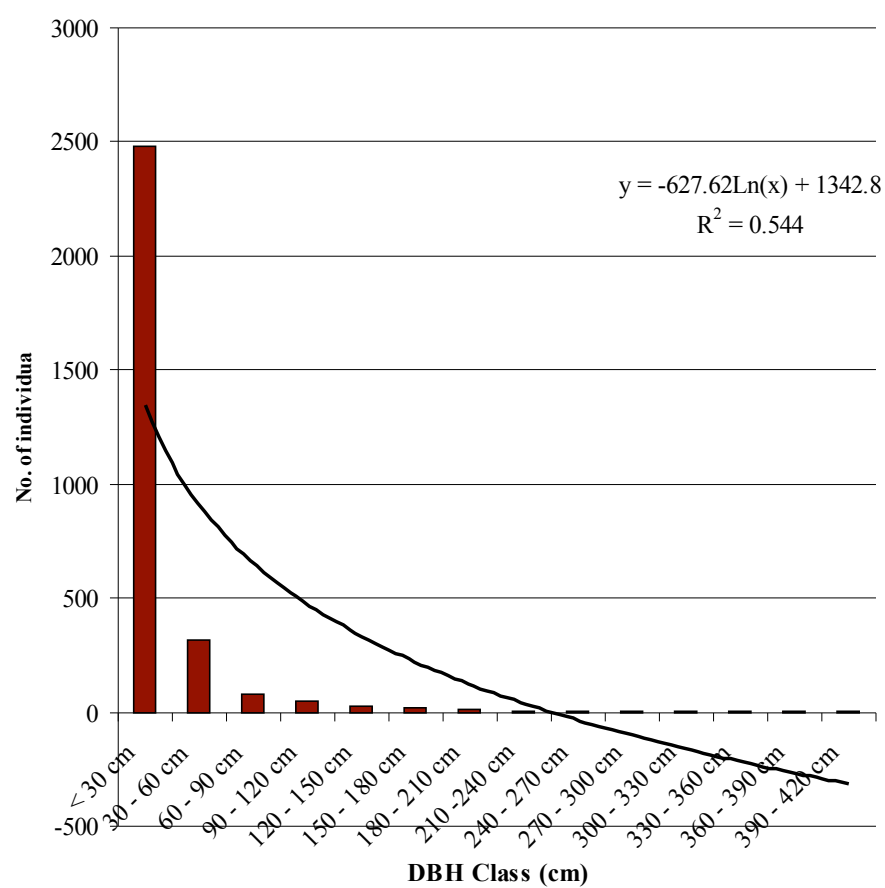


Figure (8) Population distribution by DBH classes

Table (5) Population density of tree species across DBH class interval

| DBH classes  | No. of species | Total number of individual | % of total species | % of total individual |
|--------------|----------------|----------------------------|--------------------|-----------------------|
| < 30 cm      | 107            | 2484                       | 42.13              | 83.10                 |
| 30-60 cm     | 63             | 314                        | 24.80              | 10.51                 |
| 60-90 cm     | 28             | 80                         | 11.02              | 2.68                  |
| 90-120 cm    | 18             | 48                         | 7.09               | 1.61                  |
| 120-150 cm   | 16             | 24                         | 6.30               | 0.80                  |
| 150-180 cm   | 9              | 17                         | 3.54               | 0.57                  |
| 180-210 cm   | 4              | 9                          | 1.57               | 0.30                  |
| 210-240 cm   | 3              | 4                          | 1.18               | 0.13                  |
| 240-270 cm   | 1              | 1                          | 0.39               | 0.03                  |
| 270-300 cm   | 1              | 2                          | 0.39               | 0.07                  |
| 300-330 cm   | 1              | 1                          | 0.39               | 0.03                  |
| 330-360 cm   | 1              | 1                          | 0.39               | 0.03                  |
| 360-390 cm   | 1              | 2                          | 0.39               | 0.07                  |
| 390-420 cm   | 1              | 2                          | 0.39               | 0.07                  |
| <b>Total</b> | <b>113</b>     | <b>2989</b>                | <b>100.00</b>      | <b>100.00</b>         |

Tree distribution by height intervals shows that among the total number of 2989 individual, 1747 individuals (58.45%) belong to 3-10m category, followed by 642 individuals (21.48%) in 10-17m, 287 individuals (9.6%) in 17-24m, and 102 individuals (3.41%) in 24-31m Table (6). Where as <3m high trees of 211 individuals (7.02%) infer natural regeneration is poor or frequent disturbance on ground cover plant. The population structure by height classes in the Yenam area is highest in 3-10m class and gradually decreases to higher class (Figure 10 and 11). The tallest individual trees were *Lithocarpus* sp.4 (28m), *Exbucklandia populnea* (R. Br. ex Griff.) R.W. Br. (28m), *Eugenia* sp. (28m), *Wendlandia tinctoria* DC. (27m), *Elaeocarpus* sp. (27m), and *Cinnamomum* sp. (27m). Total picture of height class shows that, 45.64% belong to <3-10m category, 44.25% in 10-24m, and 10.10% in 24-31m. The overall population structure indicates that study are represents mature stand.

Table (6) Population density of tree species across height class interval

| Height classes | No. of species | Total number of individual | % of total species | % of total individual |
|----------------|----------------|----------------------------|--------------------|-----------------------|
|----------------|----------------|----------------------------|--------------------|-----------------------|

|              |            |              |               |               |
|--------------|------------|--------------|---------------|---------------|
| < 3 m        | 38         | 211          | 13.24         | 7.06          |
| 3-10 m       | 93         | 1747         | 32.40         | 58.45         |
| 10-17 m      | 80         | 642          | 27.87         | 21.48         |
| 17-24 m      | 47         | 287          | 16.38         | 9.60          |
| 24-31 m      | 29         | 102          | 10.10         | 3.41          |
| <b>Total</b> | <b>113</b> | <b>29.89</b> | <b>100.00</b> | <b>100.00</b> |

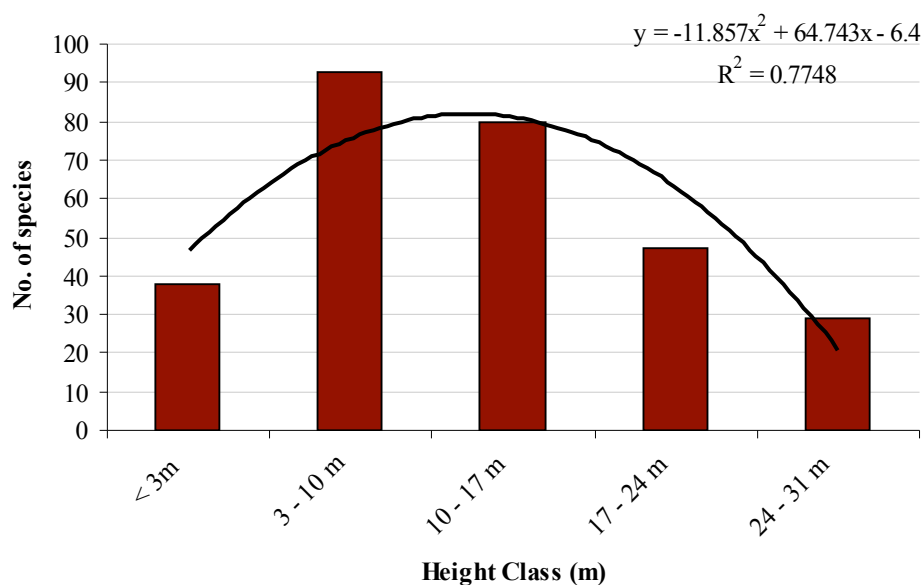


Figure (9) Species distribution by height classes

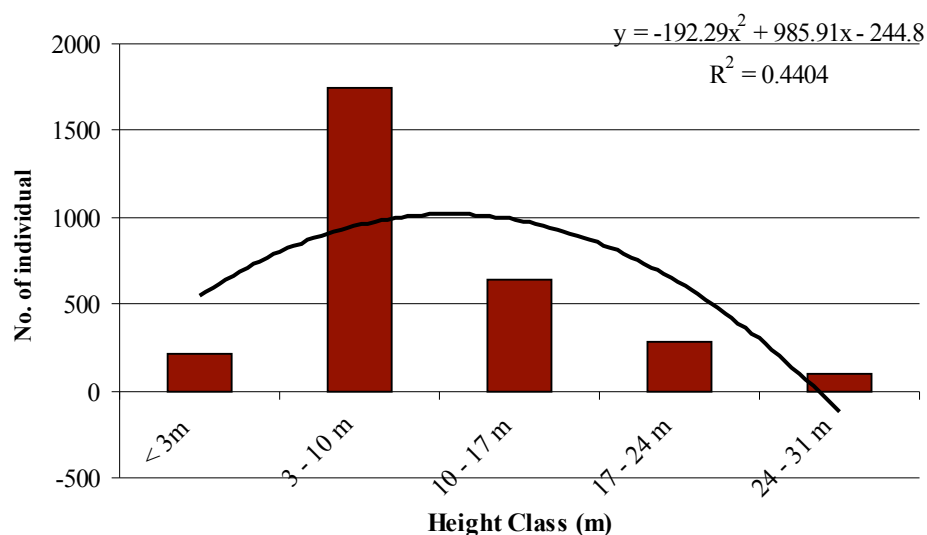


Figure (10) Population distribution by Height classes

## 2.4. Discussion and Conclusion

A total of 113 tree species representing 86 genera and 34 families were analyzed in the study area. The main vegetation types discovered in Yenam Dam site can be grouped

into four formations, i.e. highland evergreen forest, oak forest, highland secondary forest, and bamboo forest. In some disturbed sites, some bushy, degraded forest and wild banana can be seen in patches. The most dominant family in the study area are Lauraceae, Fagaceae, and Rubiaceae.

Accordingly, the ten leading dominants discovered in study area were *Castanopsis tribuloides* A.DC., *Sterculia* sp., *Symplocos* sp.1, *Callicarpa* sp., *Symplocos* sp.2, *Eugenia* sp, *Engelhardtia spicata* Blume., *Turpinia nepalensis*, *Dimocarpus* sp. and *Syzygium* sp.1 contributing highest IVI value (22.02, 20.81, 20.72, 10.94, 9.44, 9.02, 8.96, 8.27, 8.19, 7.23) respectively. Those tree species could be considered as ecological indicator species of the study area. In mature site, the largest trees can reach up to >31m in height while the main canopy is 24-31m with well developed understoreys. The canopy of the forest is more or less close, but in some disturbed sites, the canopy is open and the estimated height were probably not more than 15m, including stunted and cutover regrowth of the tree species.

Presence of relatively high species diversity and richness indicates uniqueness and potentiality of Yenam area for conservation of ecosystem in totality.

The forests in the study area show some types of disturbance such as, fire wood collection, shifting cultivation, and hunting. The forest in accessible area is more or less degraded and it indicates the influence of human impact on forest. Shifting cultivation was the major destructive force and one of the influencing factors for forest structure.

## 2.5. Recommendation

1. Infrastructure development as well as new access road from Rabbot to Panandim should be implemented cautiously and it should be least impacts on environment, since the forest along the way is primary condition in recently.
2. Though the lost of forest cover area by dam construction is small, one or more compensatory protected area should be established and managed under the project.
3. Since accessibility is one of the major reasons for biodiversity degradation, the remaining forest cover should be systematically managed and conserved after dam.

The catchments area of Yenam dam embrace Hkakaborazi N.P and Hpongan Razi W.S. which are the biodiversity hot-spots and globally outstanding areas. To substitute and minimize the biodiversity loss by dam, the protection and conservation of these areas should be extended.

## Appendix (1) Ranking of Important Value Index (IVI) in the Yenam Area

| No. | Species Name | R.D. % | R.D.m % | R.F % | IVI % |
|-----|--------------|--------|---------|-------|-------|
|-----|--------------|--------|---------|-------|-------|

| 1   | <i>Castanopsis tribuloides</i> A.DC.                     | 8.50   | 11.27   | 2.25  | 22.02 |
|-----|----------------------------------------------------------|--------|---------|-------|-------|
| 2   | <i>Sterculia</i> sp.                                     | 1.10   | 17.46   | 2.25  | 20.81 |
| 3   | <i>Symplocos</i> sp.1                                    | 17.30  | 1.18    | 2.25  | 20.72 |
| 4   | <i>Callicarpa</i> sp.                                    | 4.72   | 2.86    | 3.37  | 10.94 |
| 5   | <i>Symplocos</i> sp.2                                    | 4.05   | 2.86    | 2.53  | 9.44  |
| 6   | <i>Eugenia</i> sp.                                       | 3.35   | 3.43    | 2.25  | 9.02  |
| 7   | <i>Engelhardtia spicata</i> Blume.                       | 0.23   | 8.44    | 0.28  | 8.96  |
| 8   | <i>Turpinia nepalensis</i> Wall.                         | 1.04   | 6.10    | 1.12  | 8.27  |
| 9   | <i>Dimocarpus</i> sp.                                    | 1.27   | 4.67    | 2.25  | 8.19  |
| 10  | <i>Syzygium</i> sp.1                                     | 4.62   | 1.20    | 1.40  | 7.23  |
| 11  | <i>Syzygium</i> sp.2                                     | 3.78   | 1.11    | 2.25  | 7.14  |
| 12  | <i>Mallotus</i> sp.                                      | 3.98   | 0.27    | 2.53  | 6.78  |
| 13  | <i>Cinnamomum</i> sp.2                                   | 1.04   | 1.53    | 3.09  | 5.66  |
| 14  | <i>Lasianthus</i> sp.2                                   | 3.08   | 0.16    | 2.25  | 5.49  |
| 15  | UN-20                                                    | 1.10   | 2.14    | 1.69  | 4.93  |
| 16  | <i>Ilex</i> sp.2                                         | 1.37   | 1.00    | 2.53  | 4.90  |
| 17  | <i>Castanopsis</i> sp.4                                  | 1.00   | 2.44    | 1.12  | 4.56  |
| 18  | <i>Engelhardtia</i> sp.                                  | 0.33   | 3.07    | 1.12  | 4.53  |
| 19  | <i>Exbucklandia populnea</i> (R. Br. ex Griff.) R.W. Br. | 0.47   | 3.44    | 0.56  | 4.47  |
| 20  | <i>Eurya</i> sp.                                         | 2.14   | 0.88    | 1.40  | 4.42  |
| 21  | <i>Wendlandia tinctoria</i> DC.                          | 1.94   | 0.79    | 1.69  | 4.41  |
| 22  | <i>Eurya</i> sp.2                                        | 1.84   | 0.73    | 1.69  | 4.26  |
| 23  | UN-16                                                    | 1.20   | 1.04    | 1.97  | 4.21  |
| 24  | <i>Castanopsis diversifolia</i> King                     | 0.64   | 2.89    | 0.56  | 4.09  |
| 25  | <i>Acer</i> sp.2                                         | 1.51   | 0.99    | 1.40  | 3.90  |
| 26  | <i>Oxyspora paniculata</i> (D.Don)DC.                    | 2.07   | 0.13    | 1.69  | 3.89  |
| 27  | UN-22                                                    | 0.84   | 0.94    | 1.97  | 3.74  |
| 28  | <i>Aralia leschenaultii</i> (DC.) J. Wen                 | 1.00   | 0.44    | 2.25  | 3.69  |
| 29  | <i>Canthium</i> sp.                                      | 2.61   | 0.07    | 0.84  | 3.53  |
| 30  | <i>Schefflera</i> sp.1                                   | 0.30   | 1.77    | 1.12  | 3.20  |
| 31  | <i>Castanopsis</i> sp.2                                  | 0.10   | 2.68    | 0.28  | 3.06  |
| 32  | UN-18                                                    | 0.57   | 1.08    | 1.40  | 3.05  |
| 33  | <i>Rhamnus</i> sp.                                       | 0.77   | 0.28    | 1.97  | 3.02  |
| 34  | <i>Ficus roxburghii</i> Wall.                            | 0.17   | 2.28    | 0.56  | 3.01  |
| 35  | UN-17                                                    | 1.10   | 0.76    | 1.12  | 2.99  |
| 36  | <i>Sterculia</i> sp.1                                    | 0.54   | 0.26    | 1.69  | 2.48  |
| 37  | <i>Entada phaseoloides</i> Tamur.E.nepal                 | 0.74   | 0.28    | 1.40  | 2.42  |
| No. | Species Name                                             | R.D. % | R.D.m % | R.F % | IVI % |
| 38  | <i>Acer</i> sp.1                                         | 0.23   | 0.81    | 1.12  | 2.17  |
| 39  | <i>Cyathea gigantea</i> (Wall. ex Hook.) Holttum         | 0.60   | 0.71    | 0.84  | 2.16  |

| 40  | <i>Betula</i> sp.                                | 0.84   | 0.16    | 1.12  | 2.12  |
|-----|--------------------------------------------------|--------|---------|-------|-------|
| 41  | <i>Lithocarpus</i> sp.3                          | 0.64   | 0.21    | 1.12  | 1.97  |
| 42  | <i>Litsea</i> sp.2                               | 0.40   | 0.16    | 1.40  | 1.96  |
| 43  | <i>Fatsia japonica</i> (Thunb.) Decne. & Planch. | 0.40   | 0.14    | 1.40  | 1.95  |
| 44  | <i>Saurauia napaulensis</i> DC.                  | 1.34   | 0.18    | 0.28  | 1.80  |
| 45  | <i>Machilus</i> sp.2                             | 0.27   | 0.02    | 1.40  | 1.69  |
| 46  | <i>Symplocos microphylla</i> Wight.              | 0.60   | 0.19    | 0.84  | 1.63  |
| 47  | <i>Ficus hispida</i> Forsk.                      | 0.23   | 0.53    | 0.84  | 1.61  |
| 48  | <i>Diospyros</i> sp.                             | 0.87   | 0.12    | 0.56  | 1.55  |
| 49  | <i>Archidendron</i> sp.                          | 0.84   | 0.05    | 0.56  | 1.44  |
| 50  | <i>Archidendron clyperaria</i> (Jack) Nielsen    | 0.54   | 0.03    | 0.84  | 1.41  |
| 51  | <i>Sonerila</i> sp.                              | 0.54   | 0.02    | 0.84  | 1.40  |
| 52  | UN-9                                             | 0.27   | 0.19    | 0.84  | 1.30  |
| 53  | UN-8                                             | 0.23   | 0.14    | 0.84  | 1.21  |
| 54  | <i>Lasianthus</i> sp.1                           | 0.30   | 0.03    | 0.84  | 1.17  |
| 55  | UN-6                                             | 0.27   | 0.05    | 0.84  | 1.16  |
| 56  | UN-25                                            | 0.20   | 0.09    | 0.84  | 1.13  |
| 57  | <i>Maesa montana</i> A.DC.                       | 0.74   | 0.01    | 0.28  | 1.03  |
| 58  | <i>Machilus</i> sp.1                             | 0.43   | 0.03    | 0.56  | 1.02  |
| 59  | UN-15                                            | 0.03   | 0.65    | 0.28  | 0.97  |
| 60  | <i>Albizia odoratissima</i> (L.f.) Benth.        | 0.03   | 0.62    | 0.28  | 0.94  |
| 61  | <i>Castanopsis</i> sp.1                          | 0.23   | 0.12    | 0.56  | 0.92  |
| 62  | <i>Saurauia</i> sp.1                             | 0.57   | 0.07    | 0.28  | 0.92  |
| 63  | <i>Machilus thunbergii</i> Sieb. Et Zucc.        | 0.30   | 0.04    | 0.56  | 0.90  |
| 64  | <i>Alnus trabeculosa</i> Hand.-Mazz.             | 0.13   | 0.20    | 0.56  | 0.89  |
| 65  | <i>Eleocarpus</i> sp.                            | 0.13   | 0.19    | 0.56  | 0.89  |
| 66  | <i>Columnea</i> sp.                              | 0.13   | 0.16    | 0.56  | 0.86  |
| 67  | <i>Luculia</i> sp.                               | 0.27   | 0.01    | 0.56  | 0.84  |
| 68  | <i>Saurauia roxburghii</i> Wall.                 | 0.43   | 0.11    | 0.28  | 0.83  |
| 69  | <i>Litsea</i> sp.3                               | 0.23   | 0.03    | 0.56  | 0.83  |
| 70  | <i>Lindera</i> sp.                               | 0.20   | 0.05    | 0.56  | 0.81  |
| 71  | UN-4                                             | 0.17   | 0.08    | 0.56  | 0.81  |
| 72  | UN-26                                            | 0.40   | 0.11    | 0.28  | 0.79  |
| 73  | <i>Litsea</i> sp.4                               | 0.20   | 0.01    | 0.56  | 0.77  |
| 74  | UN-7                                             | 0.17   | 0.02    | 0.56  | 0.75  |
| 75  | UN-2                                             | 0.10   | 0.05    | 0.56  | 0.71  |
| 76  | <i>Persea</i> sp.                                | 0.10   | 0.01    | 0.56  | 0.67  |
| No. | Species Name                                     | R.D. % | R.D.m % | R.F % | IVI % |
| 77  | <i>Mussaenda</i> sp.                             | 0.10   | 0.01    | 0.56  | 0.67  |
| 78  | <i>Magnolia</i> sp.1                             | 0.07   | 0.01    | 0.56  | 0.64  |

|       |                                        |        |        |        |        |
|-------|----------------------------------------|--------|--------|--------|--------|
| 79    | UN-13                                  | 0.20   | 0.07   | 0.28   | 0.55   |
| 80    | <i>Litsea</i> sp.1                     | 0.17   | 0.06   | 0.28   | 0.50   |
| 81    | <i>Garcinia merguensis</i> Wight       | 0.17   | 0.05   | 0.28   | 0.49   |
| 82    | UN-5                                   | 0.10   | 0.09   | 0.28   | 0.47   |
| 83    | <i>Castanopsis</i> sp.3                | 0.17   | 0.02   | 0.28   | 0.47   |
| 84    | <i>Syzygium</i> sp.3                   | 0.17   | 0.02   | 0.28   | 0.47   |
| 85    | UN-11                                  | 0.17   | 0.01   | 0.28   | 0.46   |
| 86    | <i>Piper</i> sp.2                      | 0.17   | 0.00   | 0.28   | 0.45   |
| 87    | <i>Lithocarpus</i> sp.4                | 0.07   | 0.08   | 0.28   | 0.43   |
| 88    | <i>Meliosma</i> sp.                    | 0.13   | 0.00   | 0.28   | 0.42   |
| 89    | UN-23                                  | 0.10   | 0.01   | 0.28   | 0.39   |
| 90    | UN-14                                  | 0.10   | 0.01   | 0.28   | 0.39   |
| 91    | <i>Ficus</i> sp.                       | 0.07   | 0.04   | 0.28   | 0.39   |
| 92    | <i>Acer</i> sp.3                       | 0.07   | 0.03   | 0.28   | 0.38   |
| 93    | UN-12                                  | 0.07   | 0.02   | 0.28   | 0.37   |
| 94    | <i>Elaeocarpus lanceifolius</i> Roxb.  | 0.07   | 0.02   | 0.28   | 0.37   |
| 95    | <i>Acronychia</i> sp.                  | 0.07   | 0.01   | 0.28   | 0.36   |
| 96    | UN-21                                  | 0.07   | 0.01   | 0.28   | 0.35   |
| 97    | UN-19                                  | 0.07   | 0.01   | 0.28   | 0.35   |
| 98    | <i>Macaranga siamensis</i> S.J. Davies | 0.03   | 0.04   | 0.28   | 0.35   |
| 99    | UN-3                                   | 0.07   | 0.00   | 0.28   | 0.35   |
| 100   | <i>Dichroa febrifuga</i> Lour.         | 0.07   | 0.00   | 0.28   | 0.35   |
| 101   | <i>Maesa chisia</i> Godayari           | 0.07   | 0.00   | 0.28   | 0.35   |
| 102   | <i>Bauhinia</i> sp.                    | 0.03   | 0.02   | 0.28   | 0.33   |
| 103   | <i>Ardisia</i> sp.                     | 0.03   | 0.01   | 0.28   | 0.32   |
| 104   | UN-1                                   | 0.03   | 0.01   | 0.28   | 0.32   |
| 105   | UN-24                                  | 0.03   | 0.01   | 0.28   | 0.32   |
| 106   | <i>Streblus</i> sp.                    | 0.03   | 0.004  | 0.28   | 0.32   |
| 107   | <i>Chisocheton</i> sp.                 | 0.03   | 0.003  | 0.28   | 0.32   |
| 108   | <i>Symplocos</i> sp.                   | 0.03   | 0.002  | 0.28   | 0.32   |
| 109   | UN-10                                  | 0.03   | 0.002  | 0.28   | 0.32   |
| 110   | <i>Aglaia</i> sp.                      | 0.03   | 0.002  | 0.28   | 0.32   |
| 111   | <i>Sambucus</i> sp.                    | 0.03   | 0.002  | 0.28   | 0.32   |
| 112   | <i>Ixora</i> sp.                       | 0.03   | 0.001  | 0.28   | 0.32   |
| 113   | <i>Gmelina oblongifolia</i> Roxb.      | 0.03   | 0.001  | 0.28   | 0.31   |
| Total |                                        | 100.00 | 100.00 | 100.00 | 300.00 |

## Chapter III

### 3. Chibwe Dam

### 3.1. Study area

The location of Chibwe area lies between 25°58'N and 98° 09' E and reach about 20 kilometre on upstream confluence mouth of Myahka river and Chibwe Stream near Mandon Village. Dam site lies in the lowland area but Mayhka River flows in the narrow valley of High Mountain and has steep slope. The flooded area is long and narrow in upstream and a little broad near dam site. The study area lies WWF Eco-regions of Mizoram-Manipur-Kachin moist evergreen forest. The watershed area of Chibwe Dam area includes Bumphabum W.S and Emawbon Mountain forest and is one of the hotspots and outstanding area for conservation. A detailed map of the study area is given in figure (1.2).

#### 3.1.1. Participants

U Nyo Maung, Dr. Kalayar Lu, Dr. Kyaw Soe Naing, Daw Thin Thin Su, and U Tayzar Aung

### 3.2. Results

#### 3.2.1. Forest composition

To clarify the tree species composition and their distribution, eighteen quadrats (20x20 m each) were set up and observed in the flooded area of Chibwe dam site. In the eighteen sampling plots (0.72ha), total number of species with DBH  $\geq 3$ cm was 204 species; of which 5 species are under identification. The dominant families of tree species are Euphorbiaceae (19 species), Moraceae (19), Lauraceae (18 species), Fagaceae (11 species), Rubiaceae (8 species), Annonaceae (6 species), Araliaceae (6), Dipterocarpaceae (6 species), Sterculiaceae (6), Aquifoliaceae (5), Meliaceae (5 species), Verbenaceae (5 species) Figure (2). The main vegetation types discovered in Chibwe Dam site can be grouped into four formations, i.e. low land evergreen forest, oak forest, lowland secondary forest, and bamboo forest. In some disturbed sites, there are wild banana and degraded forest can be seen in patches. Low land evergreen forests mainly composed of *Schima wallichii*, *Duabanga grandiflora*, & *Pterospermum cinnamomum* in tree layer and *Knema furfuracea*, *Chisocheton siamensis* & *Polyalthia* sp. are mixed with them. Shrub layer is dominated by *Arenga triandra*, *Aglaia* sp., *Clausena* sp., *Calamus* sp., & *Phrynium capitatum*. Herb layer is dominated by *Begonia* sp., *Calanthe triplicata*, *Athyrium silvicola*, *Alphanamixis* sp., *Allantodia similis*, *Tectaria* sp., In the Oak forest, *Lithocarpus* sp., *Castanopsis* spp., *Fagus* sp. & *Quercus* sp. associate with *Schima wallichii*, & *Pterospermum cinnamomeum* in tree layer. Shrub layer is dominated by *Arenga triandra*, *Aglaia* sp.. Herb layer is dominated by *Elatostema* sp., *Calanthe triplicata*, *Phrynium capitatum* & *Stachyphrynium spicatum*. In the lowland secondary forest, *Saurauia* sp., *Ilex* sp., *Alnus nepaulensis*, and *Ficus fistulosa* are found in tree layer. Shrub layer is dominated by *Arenga triandra* & *Melastoma* sp.. Herb layer is dominated by *Alphanamixis silvicola*, *Begonia* sp. & *Neolepisorus* sp.. In the bamboo forest *Dendrocalamus hamiltonii* Ness ( Wabo Myatsan), and *D. giganteus* Munro(Wabowa) mainly occur.

The species area curves of the investigated stands are shown in the figure (4). The species area curves, which express the number of species in relation to change in area of habitat, not only to consider the minimum representative area but also to detect the habitat diversity within the survey area (Fangliang He and Pierre Legendre, 1996). The trend of species area curve shows tendency towards flattening. Therefore the sample areas can be said to be sufficient as a minimum representative area for the study.

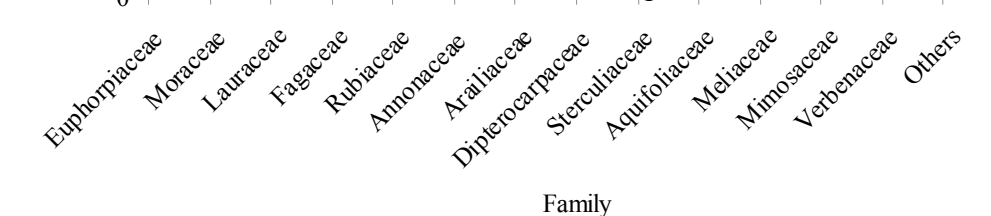


Figure (2) Ranking of dominant family by number of species composition

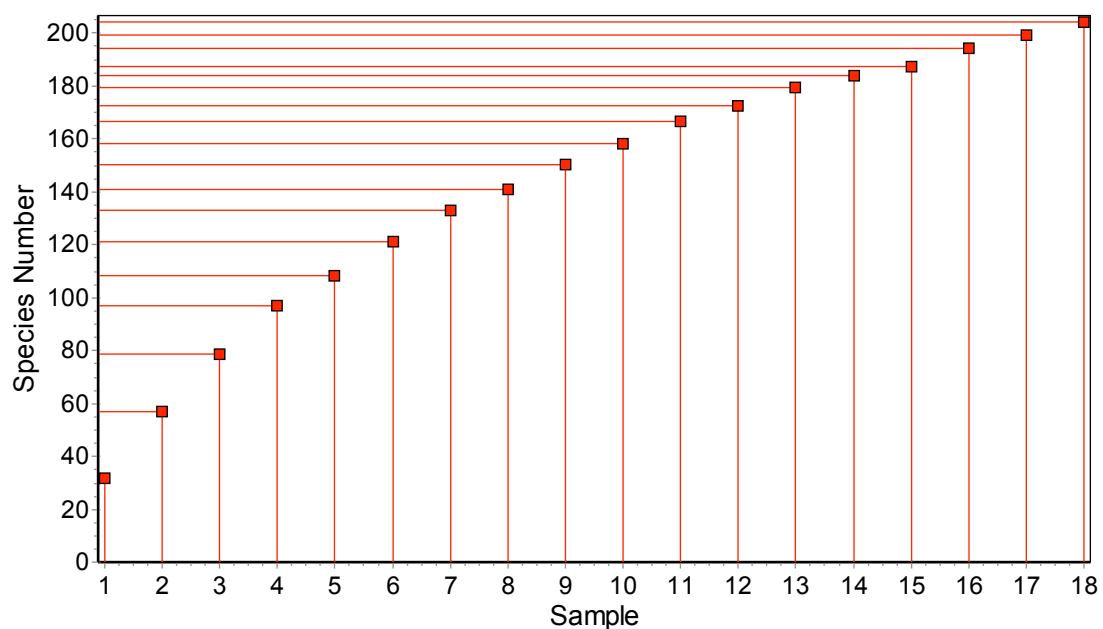
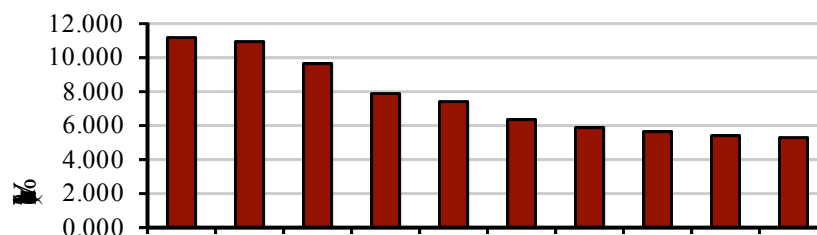


Figure (3) Plot of species accumulation in the Chibwe Dam Site



### 3.2.3. Important Value Index (IVI)

Ranking of ecological significance by IVI of tree species in the study area are given in appendix (1). The tree later in the study area is dominated by *Pterospermum*

*Pterospermum chinensis*  
*Duabanga sonchifolia*  
*Scleria pinnatifida*  
*Ficus sp.1*  
*Ficus sp.*  
*Albizia sp.*  
*Dipterocarpus*  
*Albizia*  
*Castanopsis acuminatissima*  
*Sterculia*  
*Albizia*

*cinnamomeum* with the highest IVI of 11.19%, the second most dominant species is *Duabanga grandiflora* (IVI = 10.95%) and *Schima wallichii* (IVI= 9.7%) is the third. The number of species greater than 5% IVI value was only six species (Figure 5). Those six species could be considered as ecological indicator species of Chibwe area. Representation of 204 species and the high proportion of dominant species in the study area can directly be attributed to the favorable climatic and edaphic condition.

Figure (4) Important Value Index of top ten species in the Chibwe Dam Site

### 3.2.4. Species distribution by frequency classes

In order to clarify the homogeneity or heterogeneity of the floristic distribution in the study area, species distribution by frequency classes was examined. According to the outcome of frequency chart, 89.71% of the total number of species was in lower frequency classes, A and B, while low value 10.29% was observed in higher frequency classes C and D (Table 1, Figure 5). It indicates that the forest in Chibwe area is floristically heterogeneous, according to Lamprecht (1989). The species which fall in high frequency class D was *Pterospermum cinnamomeum*, *Chisocheton siamensis*, *Duabanga grandiflora*, *Sterculia balanghas*, and *Polyalthia* sp. 1. These species can be considered as the most common species in the Chibwe area.

Table (1) Species distribution by frequency classes  $\geq 3\text{cm}$

| Frequency class | Frequency range | No. of species | % of total species frequency distribution |
|-----------------|-----------------|----------------|-------------------------------------------|
| A               | 1-20 %          | 141            | 69.12                                     |
| B               | 21-40 %         | 42             | 20.59                                     |
| C               | 41-60 %         | 15             | 7.35                                      |
| D               | 61-80%          | 6              | 2.94                                      |
| E               | 81-100%         | 0              | 0                                         |

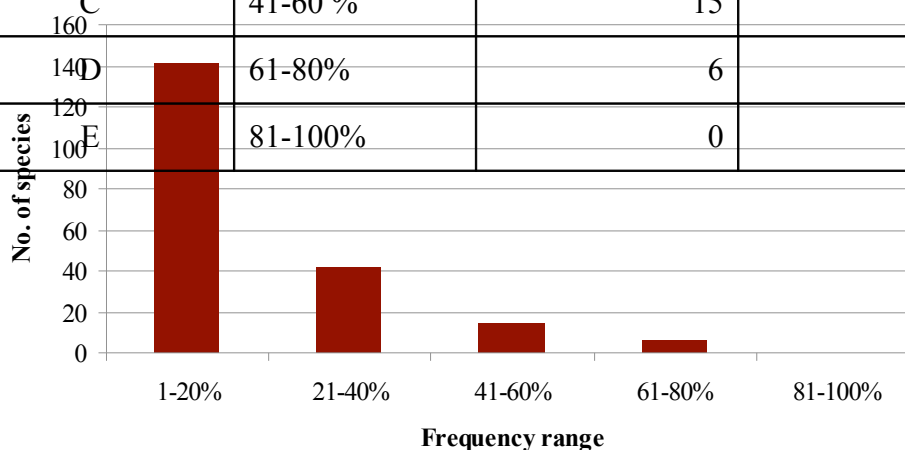


Figure (5) Species distribution by frequency classes  $\geq 3\text{cm}$

### 3.2.5. Diversity indices and evenness

Among the different measurement of species diversity indices, the floristic diversity of the Chibwe area was analyzed using the Shannon Wiener index (H), Simpsons index (D), Brillouin (D), Shannon Maximum and minimum evenness (E), Brillouin (E) because these indices not only take taxa richness into account but also depend on the relative distribution of individuals. The value of diversity indices and evenness indices of individual sample plot and all sample indices are shown in table (2) and (3). According to the result, though the diversity indices of individual sample plot are not too high, all sample index are relatively high. Diversity value for all sample index of Shannon Wiener index (H) is 4.605, Simpsons index (D) is 68.44, Brillouin (D) is 4.458. Presence of high species diversity and richness indicates uniqueness and potentiality of study area for conservation of ecosystem in totality.

Table (3) Species diversity indices in the Chibwe Dam site

| <b>Sample</b>       | <b>Shannon<br/>Wiener (H)</b> | <b>Variance H</b> | <b>Simpson<br/>Index (D)</b> | <b>Brillouin<br/>Index (D)</b> |
|---------------------|-------------------------------|-------------------|------------------------------|--------------------------------|
| Chibwe 1            | 2.167                         | 0.01298           | 5.955                        | 1.938                          |
| Chibwe 2            | 2.763                         | 0.01152           | 15.38                        | 2.344                          |
| Chibwe 3            | 2.104                         | 0.0247            | 4.062                        | 1.821                          |
| Chibwe 4            | 3.073                         | 0.008702          | 17.67                        | 2.689                          |
| Chibwe 5            | 2.928                         | 0.008571          | 12.97                        | 2.619                          |
| Chibwe 6            | 3.438                         | 0.005907          | 34.57                        | 2.961                          |
| Chibwe 7            | 2.965                         | 0.007367          | 11.89                        | 2.698                          |
| Chibwe 8            | 3.321                         | 0.006406          | 20.6                         | 2.968                          |
| Chibwe 9            | 3.727                         | 0.003837          | 38.45                        | 3.33                           |
| Chibwe 10           | 3.007                         | 0.008386          | 12.57                        | 2.702                          |
| Chibwe 11           | 3.214                         | 0.006515          | 19.26                        | 2.87                           |
| Chibwe 12           | 2.477                         | 0.01313           | 5.085                        | 2.235                          |
| Chibwe 13           | 3.254                         | 0.006649          | 22.48                        | 2.862                          |
| Chibwe 14           | 3.611                         | 0.004088          | 29.94                        | 3.262                          |
| Chibwe 15           | 3.367                         | 0.006884          | 26.17                        | 2.942                          |
| Chibwe 16           | 3.261                         | 0.009532          | 21.93                        | 2.814                          |
| Chibwe 17           | 2.608                         | 0.01431           | 8.983                        | 2.283                          |
| Chibwe 18           | 2.323                         | 0.01683           | 7                            | 2.023                          |
| All Sample Index    | 4.605                         |                   | 68.44                        | 4.458                          |
| Jackknife Std Error | 0.06397                       |                   | 5.227                        | 0.05909                        |

Table (3) Evenness indices in the Chibwe Dam site

| Sample              | Shannon<br>Maximum | Shannon<br>Minimum | Simpson<br>Evenness<br>(E) | Brillouin (E) |
|---------------------|--------------------|--------------------|----------------------------|---------------|
| Chibwe 1            | 2.89               | 0.9301             | 0.3308                     | 0.7465        |
| Chibwe 2            | 3.045              | 1.615              | 0.7323                     | 0.9088        |
| Chibwe 3            | 3.045              | 1.228              | 0.1934                     | 0.6795        |
| Chibwe 4            | 3.466              | 1.597              | 0.5521                     | 0.8891        |
| Chibwe 5            | 3.497              | 1.322              | 0.393                      | 0.8377        |
| Chibwe 6            | 3.664              | 2.015              | 0.8864                     | 0.9449        |
| Chibwe 7            | 3.738              | 1.214              | 0.283                      | 0.7919        |
| Chibwe 8            | 3.807              | 1.566              | 0.4578                     | 0.875         |
| Chibwe 9            | 4.06               | 1.779              | 0.6629                     | 0.9224        |
| Chibwe 10           | 3.611              | 1.313              | 0.3398                     | 0.8323        |
| Chibwe 11           | 3.664              | 1.472              | 0.4937                     | 0.8785        |
| Chibwe 12           | 3.584              | 1.104              | 0.1413                     | 0.6833        |
| Chibwe 13           | 3.584              | 1.63               | 0.6244                     | 0.9111        |
| Chibwe 14           | 4.025              | 1.558              | 0.5346                     | 0.8991        |
| Chibwe 15           | 3.714              | 1.842              | 0.6384                     | 0.9085        |
| Chibwe 16           | 3.664              | 1.971              | 0.5622                     | 0.8947        |
| Chibwe 17           | 3.296              | 1.431              | 0.3327                     | 0.7909        |
| Chibwe 18           | 2.944              | 1.207              | 0.3684                     | 0.7839        |
| All Sample Index    | 5.318              | 0.7307             | 0.3355                     | 0.8675        |
| Jackknife Std Error | 0.04382            | 0.06821            | 0.0194                     | 0.007935      |

### 3.2.6. Forest structure

Stem density of  $\geq 3\text{cm}$  was  $3378 \text{ ha}^{-1}$  and basal area was  $117.6 \text{ m}^2/\text{ha}$  in the Chibwe dam site (Table (4)). Among the 18 sample plots studies, 204 tree species were recorded.

Only one individual of 43 species were found and these species were considered as unique species.

The 10 most abundance species in terms of basal area occupied 43.81% of the total, of which *Pterospermum cinnamomeum* was the most dominant species in the study area with 7.05%, followed by *Duabanga grandiflora* 6.9%, *Schima wallichii* 5.26%, *Shorea assamica* 4.53%, *Fagus* sp. 4.44%, *Chukiasia* sp. 4.12%, *Albizia lucidior* 3.13%, *Castanopsis* sp. (1) 3.04%, *Dipterocarpus* sp. 2.68%, and *Ficus curtipes* 2.66% of the total basal area Figure (7).

Table (4) Consolidated detail of species inventory in the Chibwe Dam site

| Description                     | Results |
|---------------------------------|---------|
| No. of Sample points            | 18      |
| No. of tree species             | 204     |
| Density (stem/ha)               | 3378    |
| Basal area (m <sup>2</sup> /ha) | 117.6   |
| Total No. of unique species     | 43      |

The distribution of the basal area across DBH interval classes reveals the dominance of small stemmed individuals in the study area. The population structure by DBH class decreased from class to class with a steeper gradient in lower DBH classes and with a gentle slope in higher classes Figure (7, 8) and Table (5). Out of total number of stems inventoried, 79.69% of stems were accumulated in the 3-60cm DBH class, 15.79% of stems in the 60-150cm, 3.33% in the 150-240cm, 0.86% in the 240-330cm, 0.21% in 330-390cm, and only 0.12% in 480-580cm above. The highest DBH was measured in the case of *Shorea assamica* (607cm), *Pterospermum cinnamomeum* (501cm), *Duabanga grandiflora* (494cm), *Vitex* sp. (372cm).

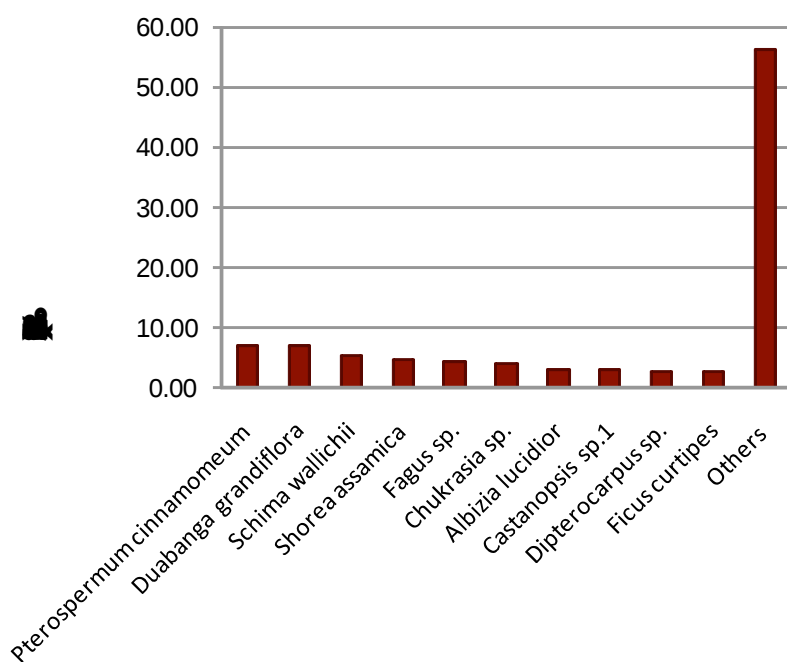


Figure (6) Ranking of relative basal area by species in the Chibwe Dam site

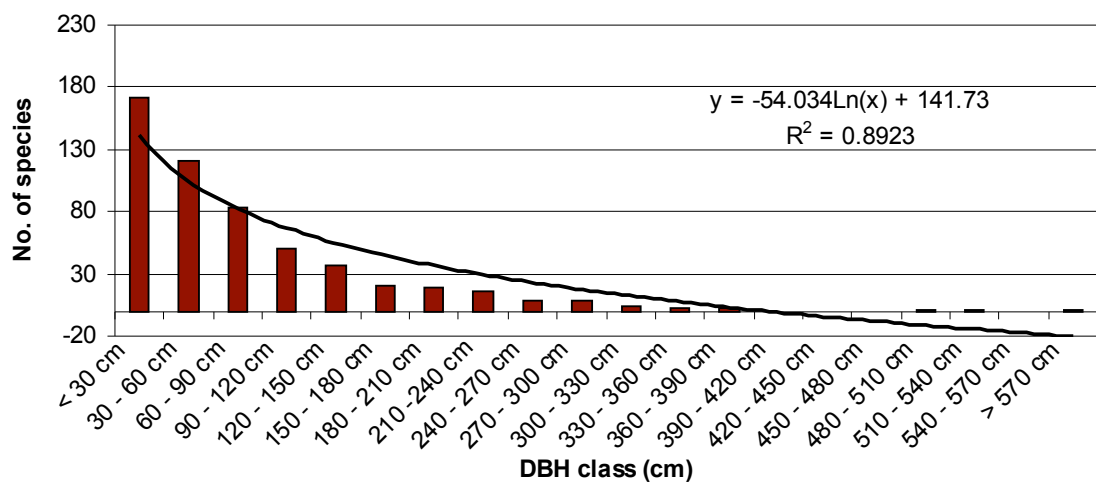


Figure (7) Species distribution by DBH classes

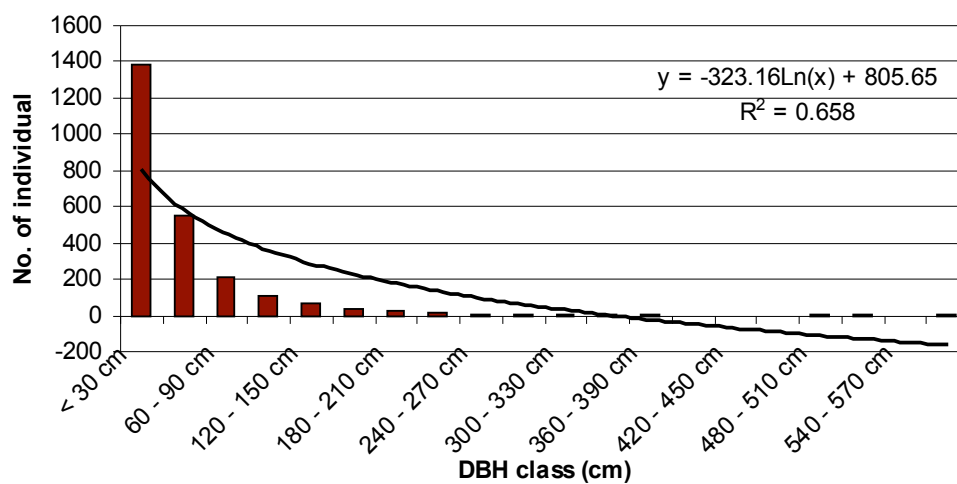


Figure (8) Population distribution by DBH classes

Table (5) Population density of tree species across DBH class interval

| DBH Classes | No. of species | Total number of individual | % of total species | % of total individual |
|-------------|----------------|----------------------------|--------------------|-----------------------|
| < 30 cm     | 171            | 1385                       | 31.26              | 56.95                 |
| 30-60 cm    | 121            | 553                        | 22.12              | 22.74                 |
| 60-90 cm    | 84             | 213                        | 15.36              | 8.76                  |
| 90-120 cm   | 50             | 106                        | 9.14               | 4.36                  |
| 120-150 cm  | 37             | 65                         | 6.76               | 2.67                  |
| 150-180 cm  | 21             | 37                         | 3.84               | 1.52                  |
| 180-210 cm  | 19             | 24                         | 3.47               | 0.99                  |
| 210-240 cm  | 16             | 20                         | 2.93               | 0.82                  |
| 240-270 cm  | 8              | 9                          | 1.46               | 0.37                  |
| 270-300 cm  | 8              | 8                          | 1.46               | 0.33                  |
| 300-330 cm  | 4              | 4                          | 0.73               | 0.16                  |
| 330-360 cm  | 3              | 3                          | 0.37               | 0.12                  |
| 360-390 cm  | 2              | 2                          | 0.55               | 0.08                  |
| 390-420 cm  | -              | -                          | -                  | -                     |
| 420-450 cm  | -              | -                          | -                  | -                     |
| 450-480 cm  | -              | -                          | -                  | -                     |
| 480-510 cm  | 1              | 1                          | 0.18               | 0.04                  |
| 510-540 cm  | 1              | 1                          | 0.18               | 0.04                  |
| 540-570 cm  | -              | -                          | 0.00               | -                     |
| > 570 cm    | 1              | 1                          | 0.18               | 0.04                  |
| Total       | 204            | 2432                       | 100.00             | 100.00                |

Tree distribution by height intervals shows that among the total number of 2432 individual, 1186 individuals (45.93%) belong to 3-10m category, followed by 769 individuals (31.62%) in 10-17m, 270 individuals (11.1%) in 17-24m, 189 individuals (7.77%) in 24-31m, and 17 individuals (0.7%) in 31-38m. The height class of >38m includes only (0.04%) of total individuals (Table (6)). <3m high trees of 69 individuals (2.84%) infer natural regeneration is relatively fair in study site. The population structure by height classes in the Chibwe area is highest in 3-10m class and gradually decreases to higher class (Figure 10 and 11). The tallest individual trees were *Styrax* sp. (43m), *Chukrasia* sp. (35m), *Dipterocarpus obtusifolius* (35m), *Dipterocarpus* spp. (35m), *Duabanga grandiflora* (35m), and *Fagus* sp.12 (35m), *Lithocarpus* sp.2 (35m), *Pterospermum cinnamomeum* (35m), *Vitex* sp. (35m). The overall population structure indicates that study area represents mature stand.

Table (6) Population density of tree species across height class interval

| Height Classes | No. of species | Total number of individual | % of total species | % of total individual |
|----------------|----------------|----------------------------|--------------------|-----------------------|
| < 3 m          | 32             | 69                         | 6.72               | 2.84                  |
| 3-10 m         | 162            | 1117                       | 34.03              | 45.93                 |
| 10-17 m        | 136            | 769                        | 28.57              | 31.62                 |
| 17-24 m        | 81             | 270                        | 17.02              | 11.10                 |
| 24-31 m        | 54             | 189                        | 11.34              | 7.77                  |
| 31-38 m        | 10             | 17                         | 2.10               | 0.70                  |
| > 38 m         | 1              | 1                          | 0.21               | 0.04                  |
| <b>Total</b>   | <b>204</b>     | <b>2432</b>                | <b>100.00</b>      | <b>100.00</b>         |

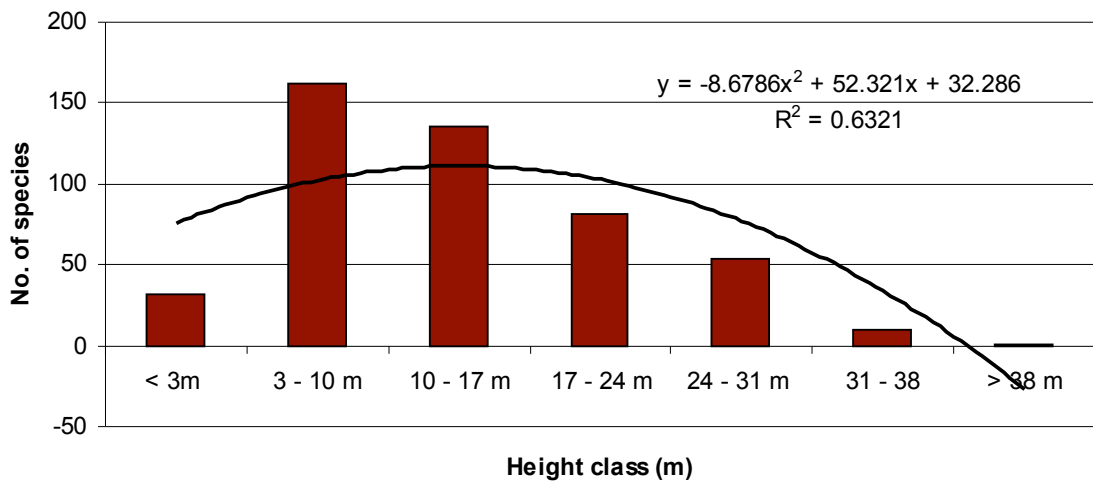


Figure (10) Species distribution by height classes

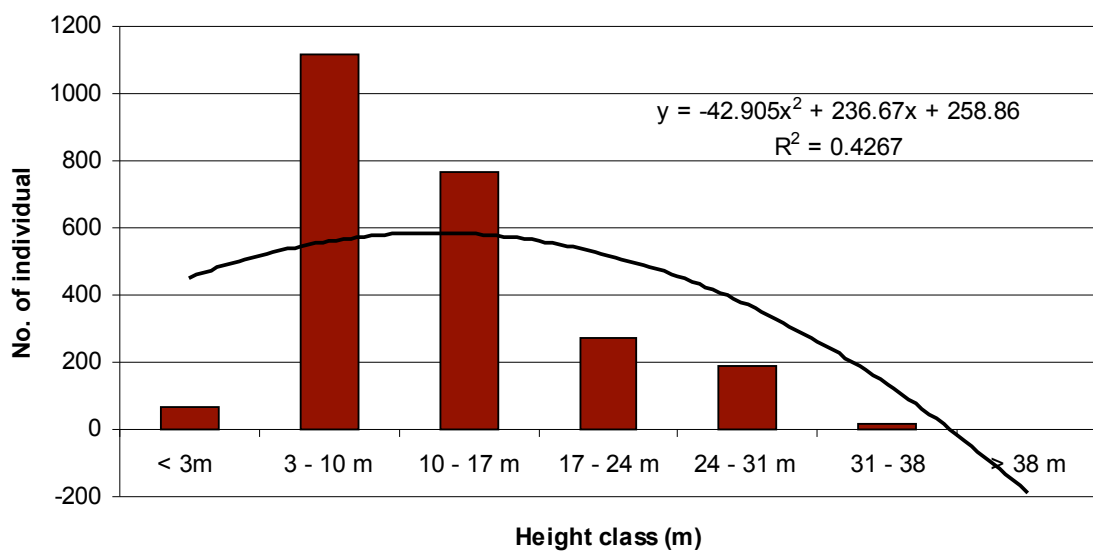


Figure (11) Population distribution by DBH classes

### 3.3. Discussion and Conclusion

A total of 204 tree species representing 128 genera and 60 families were analyzed in the study area. The main vegetation types discovered in Chibwe Dam site can be grouped into four; low land evergreen forest, oak forest, lowland secondary forest, and bamboo forest. Degraded forest occurs in some places especially in lowland area.

The ten leading dominants in study area were *Pterospermum cinnamomeum* Kurz, *Duabanga grandiflora* (Roxb. ex DC.) Walp., *Schima wallichii* (DC.) Korth., *Polyalthia* sp.1, *Chisocheton siamensis*, *Castanopsis indica*, *Gmelina arborea*, *Ostrya* sp., *Garcinia* sp.2, *Fagus* sp., *Chukrasia* sp., *Dipterocarpus obtusifolius* Teysm.ex.Mig., *Albizia lucidior* (Steud.) Nielsen, *Castanopsis acuminatissima* (Bl.) A. DC., *Sterculia balanghas* L. *Tetrameles nudiflora*, and *Baccaurea sapida* contributing highest IVI value. Those tree species could be considered as ecological indicator species of the study area. In mature site, the largest trees can reach up to >38m in height while the main canopy is 17-24m, and 24-31m with well developed understoreys. The canopy of the forest is 3 or 4 layers and generally close, but in some disturbed sites, the canopy is open and the estimated height were probably not more than 15m, including stunted and cutover regrowth of the tree species.

The watershed area of Chibwe Dam includes Bumphabum W.S and Emawbum Mountain forest and is one of the hotspots and outstanding area for conservation. The Chibwe area shows high species diversity and richness so planning for natural resource management and conservation should be carefully done.

Overexploitation of timber wood was noticed in Chibwe area. Due to the accessible road, the forest degradation is very rapid and noticeable. All the forest products are exported to China by motor road. The primary forests are found only in the area of high mountain region and non-accessible area. The rapid degradation of forest indicates the habitat loss for other organisms and lead to biodiversity lost and climate change as a long term impact. In addition, due to soil erosion of denuded site, speedy sedimentation may influence on water storage capacity of dam in a short time.

The following species that recorded in the study area assessed in IUCN Red list as follows;

| No. | Botanical Name                            | Family           | Red Lists   | Year      |
|-----|-------------------------------------------|------------------|-------------|-----------|
| 1.  | <i>Taiwania cryptomeriodes</i> Hayata     | Taxodiaceae      | VU Ald      | IUCN-2000 |
| 2.  | <i>Cephalotaxus griffithii</i> Hook.f.    | Cephalotaxaceae  | LR/nt       | IUCN-2000 |
| 3.  | <i>Dipterocarpus turbinatus</i> Gaertn.f. | Dipterocarpaceae | CR Alcd+2cd | IUCN-2000 |

### 3.4. Recommendation

1. The socioeconomic development and community awareness on environment should be planned and implemented under the project. It may support the conservation and maintenance of remaining forest.
2. Reforestation project should be introduced and implemented in degraded area.
3. One or more compensatory protected area should be established and managed under project, to offset the loss of natural habitat.

The flooded areas of dams are narrow and damage is minimal on terrestrial ecosystem since Chibwe dam is cascade, the cumulative impact assessment of hydrology should be carried out with special attention.

### Appendix (1) Ranking of Important Value Index (IVI) in the Chibwe Area

| No. | Species Name                                     | R.D. % | R.D.m % | R.F % | IVI % |
|-----|--------------------------------------------------|--------|---------|-------|-------|
| 1   | <i>Pterospermum cinnamonemum</i> Kurz            | 2.26   | 7.0509  | 1.88  | 11.19 |
| 2   | <i>Duabanga grandiflora</i> (Roxb. ex DC.) Walp. | 2.01   | 6.8999  | 2.03  | 10.95 |
| 3   | <i>Schima wallichii</i> (DC.) Korth.             | 3.50   | 5.2620  | 0.94  | 9.70  |
| 4   | <i>Polyalthia</i> sp.1                           | 3.95   | 1.7147  | 2.19  | 7.85  |
| 5   | <i>Fagus</i> sp.                                 | 1.69   | 4.4410  | 1.25  | 7.38  |
| 6   | <i>Chukrasia</i> sp.                             | 0.99   | 4.1235  | 1.25  | 6.36  |
| 7   | <i>Dipterocarpus obtusifolius</i> Teysm.ex.Mig.  | 3.82   | 1.7081  | 0.31  | 5.85  |
| 8   | <i>Albizia lucidior</i> (Steud.) Nielsen         | 1.11   | 3.1252  | 1.41  | 5.64  |
| 9   | <i>Castanopsis acuminatissima</i> (Bl.) A. DC.   | 2.67   | 1.7657  | 0.94  | 5.38  |
| 10  | <i>Sterculia balanghas</i> L.                    | 2.47   | 0.8201  | 2.03  | 5.32  |
| 11  | <i>Chisocheton siamensis</i> Craib               | 2.22   | 1.0518  | 2.03  | 5.31  |
| 12  | <i>Saurauia</i> sp.1                             | 3.29   | 0.6202  | 1.10  | 5.01  |
| 13  | <i>Shorea assamica</i> Dyer                      | 0.12   | 4.5281  | 0.31  | 4.96  |
| 14  | <i>Castanopsis</i> sp.1                          | 1.07   | 3.0379  | 0.63  | 4.73  |
| 15  | <i>Castanopsis diversifolia</i> (Kurz) King      | 1.07   | 2.3697  | 1.25  | 4.69  |
| 16  | <i>Cinnamomum</i> sp.                            | 2.01   | 1.3585  | 1.25  | 4.63  |
| 17  | <i>Lithocarpus</i> sp.1                          | 2.30   | 1.0440  | 1.25  | 4.60  |
| 18  | <i>Dipterocarpus</i> sp.                         | 1.27   | 2.6831  | 0.63  | 4.58  |
| 19  | <i>Syzygium</i> sp.1                             | 1.81   | 0.3759  | 1.72  | 3.91  |
| 20  | <i>Ficus auriculata</i> Lour.                    | 1.64   | 0.9863  | 1.25  | 3.88  |
| 21  | <i>Knema furfuracea</i> (HK. F.et Th.) Warb.     | 1.85   | 0.8053  | 0.94  | 3.59  |
| 22  | <i>Lithocarpus</i> sp.                           | 0.45   | 1.8891  | 1.25  | 3.59  |
| 23  | <i>Sapium</i> sp.                                | 2.10   | 0.7134  | 0.78  | 3.59  |
| 24  | <i>Streblus</i> sp.                              | 0.78   | 1.4635  | 1.25  | 3.50  |
| 25  | <i>Phoebe</i> sp.2                               | 1.56   | 0.9577  | 0.94  | 3.46  |
| 26  | <i>Castanopsis</i> sp.2                          | 0.45   | 2.2895  | 0.63  | 3.37  |
| 27  | <i>Ficus curtipes</i> Corn.                      | 0.25   | 2.6560  | 0.16  | 3.06  |
| 28  | <i>Caryota urens</i> L.                          | 0.86   | 0.5649  | 1.56  | 2.99  |
| 29  | <i>Leea</i> sp.                                  | 1.40   | 0.1622  | 1.41  | 2.97  |
| 30  | <i>Engelhardtia spicata</i> Blume                | 0.49   | 1.2774  | 1.10  | 2.87  |
| 31  | <i>Ostodes</i> sp.                               | 0.90   | 0.5726  | 1.25  | 2.73  |
| 32  | <i>Polyalthia</i> sp.2                           | 1.32   | 0.1399  | 1.25  | 2.71  |
| 33  | <i>Bischofia javanica</i> Blume                  | 0.25   | 1.8047  | 0.63  | 2.68  |
| 34  | <i>Garcinia</i> sp.                              | 1.11   | 0.1388  | 1.41  | 2.66  |
| 35  | <i>Ficus fistulosa</i> Reinw.                    | 1.15   | 0.2154  | 1.25  | 2.62  |
| 36  | <i>Machilus</i> sp.2                             | 0.99   | 0.4302  | 1.10  | 2.51  |
| 37  | <i>Toona ciliata</i> M. Roemer                   | 0.62   | 0.7760  | 1.10  | 2.49  |
| No. | Species Name                                     | R.D. % | R.D.m % | R.F % | IVI % |

|            |                                                       |               |                |              |              |
|------------|-------------------------------------------------------|---------------|----------------|--------------|--------------|
| 38         | <i>Lithocarpus</i> sp.2                               | 0.37          | 1.5523         | 0.47         | 2.39         |
| 39         | <i>Styrax</i> sp.                                     | 1.15          | 0.3850         | 0.78         | 2.32         |
| 40         | <i>Machilus</i> sp.3                                  | 1.48          | 0.2072         | 0.63         | 2.31         |
| 41         | <i>Atalantia roxburghiana</i> Hk.f.                   | 1.27          | 0.2137         | 0.78         | 2.27         |
| 42         | <i>Machilus</i> sp.1                                  | 1.11          | 0.3023         | 0.78         | 2.19         |
| 43         | <i>Actinodaphne</i> sp.                               | 0.70          | 0.3514         | 1.10         | 2.15         |
| 44         | <i>Sapindus</i> sp.                                   | 1.07          | 0.3538         | 0.63         | 2.05         |
| 45         | <i>Wendlandia</i> sp.                                 | 0.95          | 0.1526         | 0.94         | 2.04         |
| 46         | <i>Artocarpus</i> sp.                                 | 0.21          | 1.1908         | 0.63         | 2.02         |
| 47         | <i>Phoebe</i> sp.1                                    | 0.45          | 0.5947         | 0.94         | 1.99         |
| 48         | <i>Alnus nepalensis</i> D. Don                        | 0.53          | 0.9762         | 0.47         | 1.98         |
| 49         | <i>Syzygium megacarpum</i> (Craib) Rathakr.& N.C.Nair | 1.15          | 0.0767         | 0.63         | 1.85         |
| 50         | <i>Cleidion spiciflorum</i> Merr.                     | 0.82          | 0.1391         | 0.78         | 1.74         |
| 51         | <i>Alangium chinense</i> (Lour.) Harms                | 0.78          | 0.4775         | 0.47         | 1.73         |
| 52         | <i>Albizia</i> sp.                                    | 0.37          | 0.7162         | 0.63         | 1.71         |
| 53         | <i>Vitex</i> sp.                                      | 0.08          | 1.3030         | 0.31         | 1.70         |
| 54         | <i>Quercus</i> sp.1                                   | 0.16          | 1.3562         | 0.16         | 1.68         |
| 55         | <i>Goniothalamus</i> sp.                              | 0.49          | 0.0284         | 1.10         | 1.62         |
| 56         | <i>Ilex</i> sp.4                                      | 0.90          | 0.2302         | 0.47         | 1.60         |
| 57         | <i>Callicarpa arborea</i> Roxb.                       | 0.41          | 0.4083         | 0.78         | 1.60         |
| 58         | <i>Dalbergia</i> sp.                                  | 0.37          | 0.2783         | 0.94         | 1.59         |
| 59         | <i>Cotoneaster</i> sp.                                | 1.27          | 0.1467         | 0.16         | 1.58         |
| 60         | <i>Morus</i> sp.                                      | 0.29          | 0.6477         | 0.63         | 1.56         |
| 61         | <i>Quercus</i> sp.                                    | 0.62          | 0.0045         | 0.94         | 1.56         |
| 62         | <i>Aglaiia</i> sp.                                    | 0.82          | 0.1077         | 0.63         | 1.56         |
| 63         | <i>Baccaurea sapida</i> Muell.Arg.                    | 0.37          | 0.3928         | 0.78         | 1.55         |
| 64         | <i>Canthium</i> sp.                                   | 0.45          | 0.0380         | 0.94         | 1.43         |
| 65         | <i>Fagus</i> sp.12                                    | 0.12          | 1.1430         | 0.16         | 1.42         |
| 66         | <i>Dolichandrone serrulata</i> Seem.                  | 0.41          | 0.3582         | 0.63         | 1.40         |
| 67         | <i>Dipterocarpus</i> sp.2                             | 0.08          | 1.1387         | 0.16         | 1.38         |
| 68         | <i>Ficus hispida</i> Forsk.                           | 0.33          | 0.0638         | 0.94         | 1.33         |
| 69         | <i>Daphniphyllum</i> sp.                              | 1.03          | 0.1443         | 0.16         | 1.33         |
| 70         | <i>Machilus odoratissima</i> Nees.                    | 0.58          | 0.5786         | 0.16         | 1.31         |
| 71         | <i>Symplocos microphylla</i> Wight.                   | 0.74          | 0.0831         | 0.47         | 1.29         |
| 72         | <i>Micromelum minutum</i> (G. Forst.) Wight & Arn.    | 0.45          | 0.0564         | 0.78         | 1.29         |
| 73         | <i>Acer oblongum</i> Wall.                            | 0.37          | 0.7514         | 0.16         | 1.28         |
| 74         | <i>Mallotus</i> sp.3                                  | 0.66          | 0.4515         | 0.16         | 1.27         |
| 75         | <i>Syzygium cumini</i> (L.) Skeels                    | 0.25          | 0.3788         | 0.63         | 1.25         |
| <b>No.</b> | <b>Species Name</b>                                   | <b>R.D. %</b> | <b>R.D.m %</b> | <b>R.F %</b> | <b>IVI %</b> |

|            |                                                 |               |                |              |              |
|------------|-------------------------------------------------|---------------|----------------|--------------|--------------|
| 76         | <i>Ficus semicordata</i> Buch.-Ham. ex J.E. Sm. | 0.29          | 0.4918         | 0.47         | 1.25         |
| 77         | <i>Gnetum gnemon</i> L.                         | 0.53          | 0.0696         | 0.63         | 1.23         |
| 78         | <i>Turpinia</i> sp.                             | 0.37          | 0.0690         | 0.78         | 1.22         |
| 79         | <i>Litsea</i> sp.3                              | 0.37          | 0.2132         | 0.63         | 1.21         |
| 80         | <i>Cyathea</i> sp.                              | 0.62          | 0.2657         | 0.31         | 1.20         |
| 81         | <i>Mangifera indica</i> L.                      | 0.33          | 0.4664         | 0.31         | 1.11         |
| 82         | <i>Ficus</i> sp.7                               | 0.29          | 0.1563         | 0.63         | 1.07         |
| 83         | <i>Sterculia</i> sp.4                           | 0.49          | 0.2332         | 0.31         | 1.04         |
| 84         | <i>Alangium begoniifolia</i> (Roxb.) Baill.     | 0.25          | 0.4488         | 0.31         | 1.01         |
| 85         | <i>Litsea</i> sp.4                              | 0.25          | 0.2320         | 0.47         | 0.95         |
| 86         | <i>Rhus chinensis</i> Mill.                     | 0.49          | 0.1289         | 0.31         | 0.94         |
| 87         | <i>Dipterocarpus</i> sp.3                       | 0.16          | 0.5714         | 0.16         | 0.89         |
| 88         | <i>Eurya</i> sp.                                | 0.37          | 0.0488         | 0.47         | 0.89         |
| 89         | <i>Meliosma</i> sp.                             | 0.37          | 0.0398         | 0.47         | 0.88         |
| 90         | <i>Sterculia</i> sp.3                           | 0.33          | 0.0648         | 0.47         | 0.86         |
| 91         | <i>Lasianthus</i> sp.                           | 0.33          | 0.0522         | 0.47         | 0.85         |
| 92         | <i>Maesa montana</i> A.DC.                      | 0.37          | 0.0078         | 0.47         | 0.85         |
| 93         | <i>Glochidion</i> sp.                           | 0.21          | 0.0077         | 0.63         | 0.84         |
| 94         | <i>Ilex</i> sp.3                                | 0.29          | 0.0733         | 0.47         | 0.83         |
| 95         | <i>Acacia</i> sp.                               | 0.08          | 0.5635         | 0.16         | 0.80         |
| 96         | <i>Alstonia scholaris</i> (L.) R.Br.            | 0.25          | 0.0822         | 0.47         | 0.80         |
| 97         | <i>Aglaia lawii</i> (Wight) Sald.& Rama.        | 0.12          | 0.3505         | 0.31         | 0.79         |
| 98         | <i>Betula</i> sp.                               | 0.25          | 0.0668         | 0.47         | 0.78         |
| 99         | <i>Syzygium</i> sp.2                            | 0.21          | 0.1059         | 0.47         | 0.78         |
| 100        | <i>Cornus</i> sp.                               | 0.04          | 0.5785         | 0.16         | 0.78         |
| 101        | <i>Litsea cubeba</i> (Lour.) Pers.              | 0.25          | 0.0359         | 0.47         | 0.75         |
| 102        | <i>Swintonia floribunda</i> Griff.              | 0.25          | 0.3381         | 0.16         | 0.74         |
| 103        | <i>Mallotus</i> sp.1                            | 0.33          | 0.0728         | 0.31         | 0.71         |
| 104        | <i>Schefflera</i> sp.2                          | 0.16          | 0.0741         | 0.47         | 0.71         |
| 105        | <i>Hydrangea</i> sp.                            | 0.21          | 0.0167         | 0.47         | 0.69         |
| 106        | <i>Symplocos</i> sp.                            | 0.21          | 0.0070         | 0.47         | 0.68         |
| 107        | <i>Aporosa</i> sp.                              | 0.21          | 0.1496         | 0.31         | 0.67         |
| 108        | <i>Citrus</i> sp.                               | 0.29          | 0.0521         | 0.31         | 0.65         |
| 109        | <i>Rhododendron indicum</i> Sw.                 | 0.04          | 0.4552         | 0.16         | 0.65         |
| 110        | <i>Clausena</i> sp.                             | 0.16          | 0.0045         | 0.47         | 0.64         |
| 111        | <i>Archidendron clyperaria</i> (Jack) Nielsen   | 0.16          | 0.0027         | 0.47         | 0.64         |
| 112        | <i>Capparis</i> sp.                             | 0.45          | 0.0228         | 0.16         | 0.63         |
| 113        | <i>Euonymus</i> sp.                             | 0.21          | 0.1070         | 0.31         | 0.63         |
| 114        | <i>Irvingia</i> sp.                             | 0.33          | 0.1276         | 0.16         | 0.61         |
| <b>No.</b> | <b>Species Name</b>                             | <b>R.D. %</b> | <b>R.D.m %</b> | <b>R.F %</b> | <b>IVI %</b> |

| 115 | <i>Glochidion</i> sp.2                                   | 0.12   | 0.0150  | 0.47  | 0.61  |
|-----|----------------------------------------------------------|--------|---------|-------|-------|
| 116 | <i>Oroxylum indicum</i> (L.) Kurz                        | 0.16   | 0.1215  | 0.31  | 0.60  |
| 117 | <i>Ficus</i> sp.                                         | 0.04   | 0.3953  | 0.16  | 0.59  |
| 118 | <i>Saurauia</i> sp.2                                     | 0.21   | 0.2159  | 0.16  | 0.58  |
| 119 | <i>Cananga</i> sp.                                       | 0.25   | 0.0071  | 0.31  | 0.57  |
| 120 | <i>Betula utilis</i> D. Don                              | 0.21   | 0.1885  | 0.16  | 0.55  |
| 121 | <i>Trevesia</i> sp.                                      | 0.16   | 0.0718  | 0.31  | 0.55  |
| 122 | <i>Erythrina</i> sp.                                     | 0.04   | 0.3396  | 0.16  | 0.54  |
| 123 | <i>Ilex liukiensis</i> Loes.                             | 0.12   | 0.0929  | 0.31  | 0.53  |
| 124 | UN-4                                                     | 0.21   | 0.0077  | 0.31  | 0.53  |
| 125 | <i>Sauropus</i> sp.                                      | 0.16   | 0.0476  | 0.31  | 0.53  |
| 126 | <i>Spondias</i> sp.                                      | 0.08   | 0.1265  | 0.31  | 0.52  |
| 127 | <i>Clerodendron</i> sp.3                                 | 0.21   | 0.0026  | 0.31  | 0.52  |
| 128 | <i>Balakata baccata</i> (Roxb.) Esser                    | 0.16   | 0.0369  | 0.31  | 0.51  |
| 129 | <i>Mallotus paniculatus</i> Muell. Arg.                  | 0.12   | 0.0558  | 0.31  | 0.49  |
| 130 | <i>Litsea</i> sp.1                                       | 0.16   | 0.0118  | 0.31  | 0.49  |
| 131 | <i>Melastoma</i> sp.                                     | 0.16   | 0.0058  | 0.31  | 0.48  |
| 132 | <i>Litsea</i> sp.2                                       | 0.12   | 0.0405  | 0.31  | 0.48  |
| 133 | <i>Elaeocarpus</i> sp.                                   | 0.08   | 0.0760  | 0.31  | 0.47  |
| 134 | <i>Ostyra</i> sp.                                        | 0.12   | 0.0272  | 0.31  | 0.46  |
| 135 | <i>Clerodendron</i> sp.1                                 | 0.29   | 0.0079  | 0.16  | 0.45  |
| 136 | <i>Bridelia stipularis</i> (L.) Blume                    | 0.12   | 0.0139  | 0.31  | 0.45  |
| 137 | <i>Ficus variegata</i> Blume                             | 0.08   | 0.2050  | 0.16  | 0.44  |
| 138 | <i>Phoebe</i> sp.3                                       | 0.16   | 0.0958  | 0.16  | 0.42  |
| 139 | <i>Litsea monopetala</i> (Roxb.) Pers.                   | 0.08   | 0.0112  | 0.31  | 0.41  |
| 140 | <i>Diospyros</i> sp.                                     | 0.08   | 0.0109  | 0.31  | 0.41  |
| 141 | <i>Ficus</i> sp.6                                        | 0.16   | 0.0811  | 0.16  | 0.40  |
| 142 | <i>Exbucklandia populnea</i> (R. Br. ex Griff.) R.W. Br. | 0.08   | 0.0061  | 0.31  | 0.40  |
| 143 | <i>Mussaenda</i> sp.2                                    | 0.08   | 0.0046  | 0.31  | 0.40  |
| 144 | <i>Oxympora</i> sp.                                      | 0.08   | 0.0032  | 0.31  | 0.40  |
| 145 | <i>Tabernaemontana</i> sp.                               | 0.08   | 0.0028  | 0.31  | 0.40  |
| 146 | <i>Clerodendron</i> sp.2                                 | 0.08   | 0.0018  | 0.31  | 0.40  |
| 147 | <i>Celtis</i> sp.                                        | 0.08   | 0.1120  | 0.16  | 0.35  |
| 148 | <i>Albizia chinensis</i> (Osbeck.) Merr.                 | 0.08   | 0.0941  | 0.16  | 0.33  |
| 149 | <i>Ficus</i> sp.12                                       | 0.08   | 0.0935  | 0.16  | 0.33  |
| 150 | <i>Ilex</i> sp.2                                         | 0.08   | 0.0776  | 0.16  | 0.32  |
| 151 | <i>Dimocarpus</i> sp.                                    | 0.04   | 0.1077  | 0.16  | 0.31  |
| 152 | <i>Meliosma pinnata</i> Roxb.                            | 0.08   | 0.0622  | 0.16  | 0.30  |
| No. | Species Name                                             | R.D. % | R.D.m % | R.F % | IVI % |

| 153 | <i>Turpinia cochinchinensis</i> (Lour.) Merr.        | 0.12   | 0.0165  | 0.16  | 0.30  |
|-----|------------------------------------------------------|--------|---------|-------|-------|
| 154 | <i>Antidesma montanum</i> Bl.                        | 0.12   | 0.0164  | 0.16  | 0.30  |
| 155 | <i>Aralia montana</i> Bl.                            | 0.08   | 0.0540  | 0.16  | 0.29  |
| 156 | <i>Nephelium</i> sp.                                 | 0.12   | 0.0073  | 0.16  | 0.29  |
| 157 | <i>Carallia brachiata</i> (Lour.) Merr.              | 0.04   | 0.0762  | 0.16  | 0.27  |
| 158 | <i>Dipterocarpus</i> sp.1                            | 0.04   | 0.0728  | 0.16  | 0.27  |
| 159 | <i>Pterospermum grandiflorum</i> Craib               | 0.08   | 0.0306  | 0.16  | 0.27  |
| 160 | <i>Sterculia</i> sp.2                                | 0.08   | 0.0271  | 0.16  | 0.27  |
| 161 | <i>Ficus</i> sp.10                                   | 0.08   | 0.0237  | 0.16  | 0.26  |
| 162 | <i>Sterospermum</i> sp.                              | 0.08   | 0.0200  | 0.16  | 0.26  |
| 163 | <i>Ficus</i> sp.9                                    | 0.08   | 0.0120  | 0.16  | 0.25  |
| 164 | <i>Ficus</i> sp.5                                    | 0.08   | 0.0079  | 0.16  | 0.25  |
| 165 | <i>Mallotus</i> sp.2                                 | 0.08   | 0.0051  | 0.16  | 0.24  |
| 166 | <i>Zizyphus</i> sp.                                  | 0.08   | 0.0033  | 0.16  | 0.24  |
| 167 | <i>Xantolis</i> sp.                                  | 0.08   | 0.0032  | 0.16  | 0.24  |
| 168 | <i>Boehmeria platyphyllum</i> Buch. - Ham. ex D. don | 0.08   | 0.0026  | 0.16  | 0.24  |
| 169 | <i>Glochidion</i> sp.1                               | 0.04   | 0.0374  | 0.16  | 0.24  |
| 170 | <i>Memecylon</i> sp.                                 | 0.04   | 0.0350  | 0.16  | 0.23  |
| 171 | <i>Cleyera</i> sp.                                   | 0.04   | 0.0274  | 0.16  | 0.23  |
| 172 | <i>Ficus</i> sp.4                                    | 0.04   | 0.0245  | 0.16  | 0.22  |
| 173 | <i>Ficus</i> sp.8                                    | 0.04   | 0.0245  | 0.16  | 0.22  |
| 174 | <i>Gmelia arborea</i> Roxb                           | 0.04   | 0.0169  | 0.16  | 0.21  |
| 175 | <i>Schefflera</i> sp.1                               | 0.04   | 0.0136  | 0.16  | 0.21  |
| 176 | <i>Garcinia</i> sp.1                                 | 0.04   | 0.0109  | 0.16  | 0.21  |
| 177 | <i>Hibiscus macrophyllus</i> Roxb.                   | 0.04   | 0.0109  | 0.16  | 0.21  |
| 178 | <i>Macaranga</i> sp.                                 | 0.04   | 0.0102  | 0.16  | 0.21  |
| 179 | UN-2                                                 | 0.04   | 0.0102  | 0.16  | 0.21  |
| 180 | <i>Ficus</i> sp.11                                   | 0.04   | 0.0096  | 0.16  | 0.21  |
| 181 | <i>Ficus</i> sp.3                                    | 0.04   | 0.0074  | 0.16  | 0.20  |
| 182 | <i>Lindera</i> sp.                                   | 0.04   | 0.0059  | 0.16  | 0.20  |
| 183 | <i>Sterculia</i> sp.                                 | 0.04   | 0.0054  | 0.16  | 0.20  |
| 184 | <i>Vernonia</i> sp.                                  | 0.04   | 0.0041  | 0.16  | 0.20  |
| 185 | <i>Pavetta indica</i> L.                             | 0.04   | 0.0038  | 0.16  | 0.20  |
| 186 | <i>Holarrhena pubescens</i> Wall. ex G. Don          | 0.04   | 0.0027  | 0.16  | 0.20  |
| 187 | <i>Elatostema</i> sp.                                | 0.04   | 0.0026  | 0.16  | 0.20  |
| 188 | <i>Mussaenda</i> sp.                                 | 0.04   | 0.0024  | 0.16  | 0.20  |
| 189 | <i>Olea</i> sp.                                      | 0.04   | 0.0024  | 0.16  | 0.20  |
| 190 | <i>Antidesma</i> sp.                                 | 0.04   | 0.0021  | 0.16  | 0.20  |
| No. | Species Name                                         | R.D. % | R.D.m % | R.F % | IVI % |

|       |                                                                 |        |        |        |        |
|-------|-----------------------------------------------------------------|--------|--------|--------|--------|
| 191   | <i>Aralia</i> sp.1                                              | 0.04   | 0.0021 | 0.16   | 0.20   |
| 192   | <i>Meliosma simplicifolia</i> Walp.                             | 0.04   | 0.0021 | 0.16   | 0.20   |
| 193   | <i>Actinodaphne sesquipedalis</i> Hook. f. & Thoms. ex Meissner | 0.04   | 0.0018 | 0.16   | 0.20   |
| 194   | <i>Gnetum montanum</i> Markgraf                                 | 0.04   | 0.0018 | 0.16   | 0.20   |
| 195   | <i>Aralia</i> sp.2                                              | 0.04   | 0.0014 | 0.16   | 0.20   |
| 196   | <i>Ziziphus</i> sp.1                                            | 0.04   | 0.0014 | 0.16   | 0.20   |
| 197   | <i>Ilex micrococca</i> Maxim.                                   | 0.04   | 0.0011 | 0.16   | 0.20   |
| 198   | <i>Miliusa</i> sp.3                                             | 0.04   | 0.0011 | 0.16   | 0.20   |
| 199   | UN-1                                                            | 0.04   | 0.0011 | 0.16   | 0.20   |
| 200   | <i>Goniothalamus</i> sp.1                                       | 0.04   | 0.0009 | 0.16   | 0.20   |
| 201   | UN-5                                                            | 0.04   | 0.0009 | 0.16   | 0.20   |
| 202   | <i>Dracaena</i> sp.                                             | 0.04   | 0.0006 | 0.16   | 0.20   |
| 203   | <i>Ixora</i> sp.                                                | 0.04   | 0.0005 | 0.16   | 0.20   |
| 204   | UN-3                                                            | 0.04   | 0.0002 | 0.16   | 0.20   |
| Total |                                                                 | 100.00 | 100.00 | 100.00 | 300.00 |

## 4. Wusok and Pisa Dam

### 4.1. Study area

The Wusok Dam lies between 26°31'N and 98° 18' E and about 34.5 km away from Pisa Dam. The Pisa Hydropower Dam area is located between 26°44'N and 98° 22'E. Both Pisa and Wusok dam sites lie in the high mountain and riverine. These dam areas lie in WWF Eco-regions of Northern Triangle temperate forest and Mizoram-Manipur-Kachin moist evergreen forest. It is also located near the priority site for conservation investment of Northern mountain forest complex. The forests in the watershed areas of the dams are Hkakaborazi N.P Hponganrazi W.S and Emawbum mountain forests. So the areas are the biodiversity hot-spot areas and globally outstanding for conservation. A detailed map of the study area is given in figure (1.3).

#### 4.1.1. Participants

Dr Myint Aung, Dr. Kalayar Lu, Dr. Kyaw Soe Naing, Daw Thin Thin Su, Daw Khin Khin Soe, and U Tayzar Aung.

### 4.2. Results

#### 4.2.1. Forest composition

To clarify the tree species composition and their distribution, eleven quadrats (20x20 m each) were set up and observed in the flooded area of Wusok dam site. In the eleven sampling plots (.44ha), total number of species with DBH  $\geq 3$ cm was 110 species; of which 12 species are under identification. The dominant families of tree species are Lauraceae (11species), Fagaceae (8species), Moraceae (8species), Euphorbiaceae (6species), Sterculiaceae (5 species), Actinidiaceae (4 species), Myrsinaceae (4species), Verbenaceae (4 species) Figure (2). The main vegetation types discovered in Wusok Dam site can be grouped into four formations, i.e. low land evergreen forest, oak forest, low land secondary forest, and bamboo forest. In some disturbed sites, some bushes and degraded forest can be seen in patches. Low land evergreen forests can be typically distinguished by *Dipterocarpus obtusifolius*, *Ilex microcacca*, *Saurauia* sp., *Ficus* sp.3, and *Eleocarpus* sp. in tree layer. Shrub layer is dominated by *Schefflera* sp., *Canthium* sp., and *Oxyspora paniculata*. Herb layer is dominated by *Asplenium* sp., *Pronephrium* sp., *Pronephrium triphyllum*, and *Pseudocyclosourus* sp.. Oak forest is mainly composed of *Castanopsis* spp., *Quercus* sp., *Lithocarpus* sp., *Sterculia* sp.1, and *Saurauia* sp., in tree layer. Shrub layer is dominated by *Stachyphrynium spicatum*, and *Eurya* sp.. Herb layer is dominated by *Pteris* sp., *Piper* sp., *Arenga* sp., *Pronephrium* sp.. In the low land secondary forest, *Mallotus* sp., *Sterculia* sp.1, *Maesa* sp., *Callicarpa* sp. are found in tree layer. Shrub layer is dominated by *Gnetum* sp., *Wallichia siamensis*, *Stachyphrynium spicatum*, *Arenga triandra*, *Eurya* sp., and *Symplocos macrophylla*. Herb layer is dominated by *Pteris* sp., *Tectaria simonsii*, *Selaginella* sp., *Begonia* sp., *Piper* sp., *Pronephrium* sp. & *Commelina* sp. In the bamboo forest *Dendrocalamus hamiltonii* Ness ( Wabo Myatsan), *D. giganteus* Munro (Wabowa) mainly occur.

The species area curves of the investigated stands are shown in figure (3). The species area curves, which express the number of species in relation to change in area of habitat, not only consider the minimum representative area but also detect the habitat diversity within the survey area (Fangliang He and Pierre Legendre, 1996). The trend of species area curve shows tendency towards flattening. Therefore the sample areas can be said to be sufficient as a minimum representative area for the study.

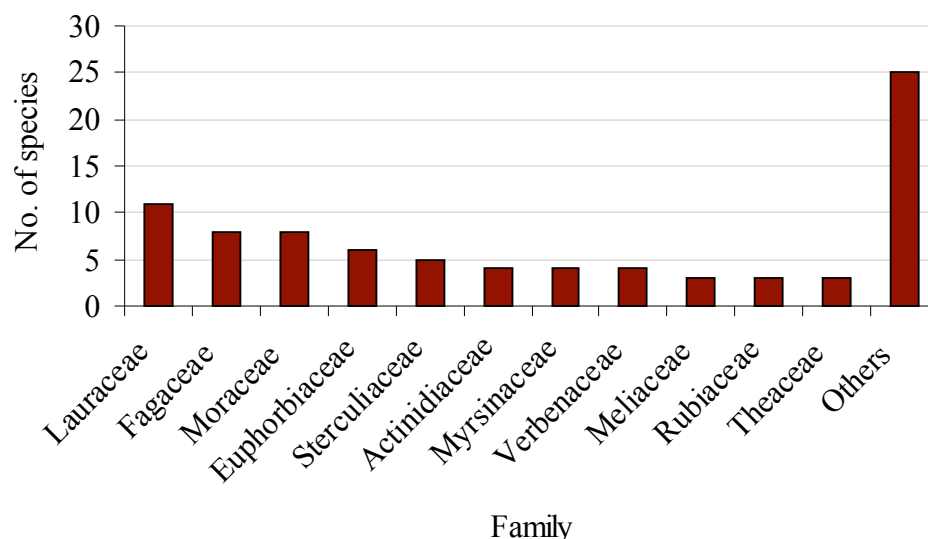


Figure (2) Ranking of dominant family by number of species composition

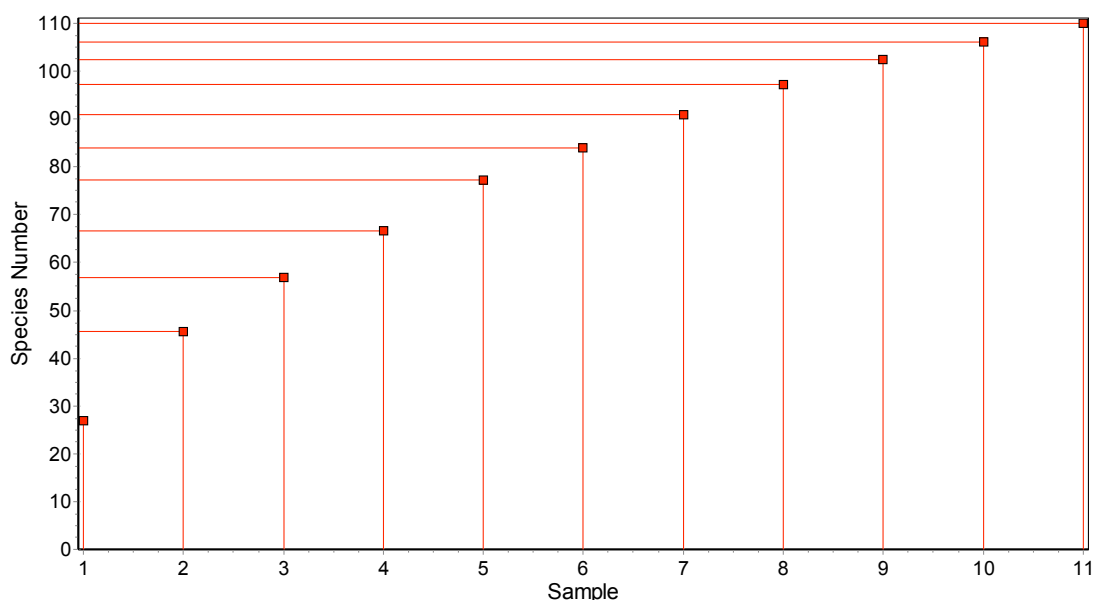


Figure (3) Plot of species accumulation in the Wusok Dam Site

#### 4.2.3. Important Value Index (IVI)

Ranking of ecological significance by IVI of tree species in the study area are given in appendix (4). The tree layer in the study area is dominated by *Dipterocarpus obtusifolius* Tey... with the highest IVI of 37.63%, the second most dominant species is *Sterculia* sp.1 (IVI = 14.23%) and *Ficus* sp.3 (IVI= 12.13%) is the third. Ecologically dominance of top ten species based on IVI value is shown in figure 4. Those species could be considered as ecological indicator species of Wusok area. The number of species greater than 5% IVI value was seventeen species (Appendix 1). Representation of 110 species and the high proportion of dominant species in the study area can directly be attributed to the favorable climatic and edaphic condition.

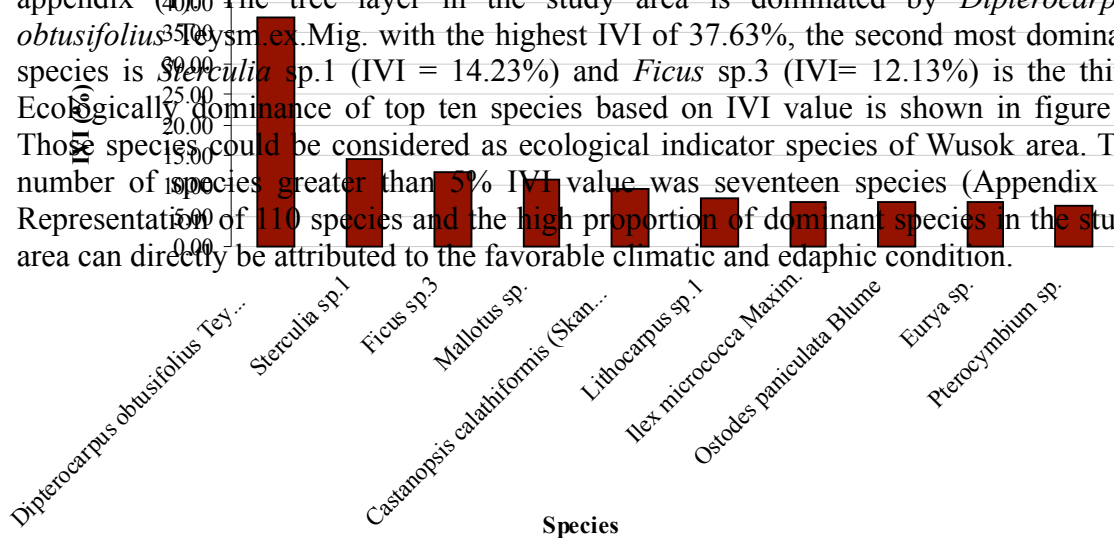


Figure (4) Important Value Index of top ten species in the Wusok Dam Site

#### 4.2.4. Species distribution by frequency classes

In order to clarify the homogeneity or heterogeneity of the floristic distribution in the study area, species distribution by frequency classes was examined. According to the outcome of frequency chart, 87.28% of the total number of species was in lower frequency classes, A and B, while low value was observed only in higher frequency class C, D, and E (Table 1, Figure 5). It indicates that the forest in Wusok area is floristically heterogeneous, according to Lamprecht (1989). The species which fall in high frequency class E was *Ostodes paniculata* Blume and *Sterculia* sp.1 These species can be considered as the most common species in the Wusok area.

Table (1) Species distribution by frequency classes  $\geq 3\text{cm}$

| Frequency Class | Frequency range | No. of species | % of total species frequency distribution |
|-----------------|-----------------|----------------|-------------------------------------------|
| A               | 1-20 %          | 70             | 63.64                                     |
| B               | 21-40 %         | 26             | 23.64                                     |
| C               | 41-60 %         | 9              | 8.18                                      |
| D               | 61-80 %         | 3              | 2.73                                      |
| E               | 81-100 %        | 2              | 1.82                                      |

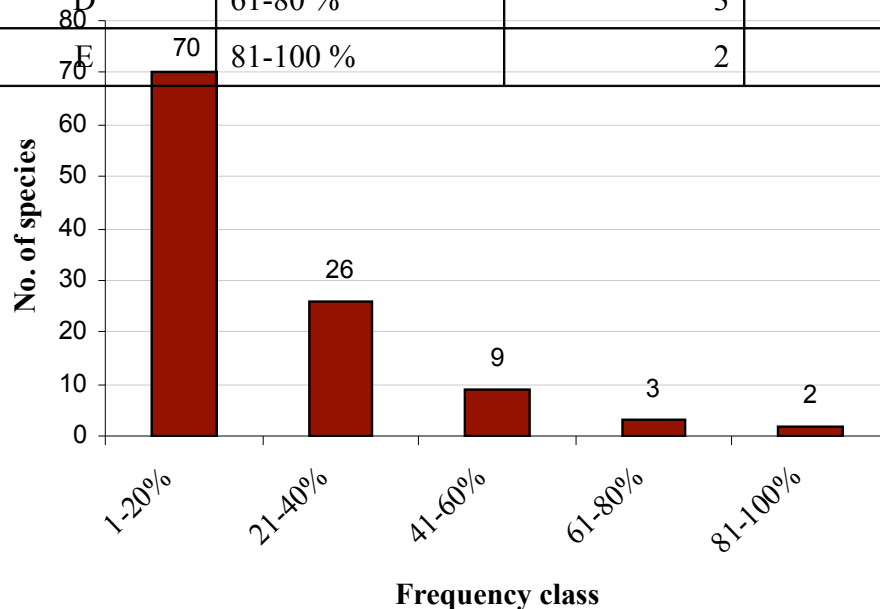


Figure (5) Species distribution by frequency classes  $\geq 3\text{cm}$

#### 4.2.5 Diversity indices and evenness

Among the different measurement of species diversity indices, the floristic diversity of the Wusok area was analyzed using the Shannon Wiener index (H), Simpsons index (D), Brillouin (D), Shannon Maximum and minimum evenness (E), Brillouin (E) because these indices not only take taxa richness into account but also depend on the relative distribution of individuals. The value of diversity indices and evenness indices of individual sample plot and all sample indices are shown in table (2) and (3). According to the result, though the diversity indices of individual sample plot are low, all sample indexes are fairly high. Diversity value for all sample index of Shannon Wiener index (H) is 4.021, Simpsons index (D) is 37.160, Brillouin (D) is 3.849.

Table (3) Species diversity indices in the Wusok Dam site

| <b>Sample</b>       | <b>Shannon Wiener H</b> | <b>Variance H</b> | <b>Simpsons Index (D)</b> | <b>Brillouin (D)</b> |
|---------------------|-------------------------|-------------------|---------------------------|----------------------|
| WS 1                | 2.666                   | 0.021             | 14.440                    | 2.152                |
| WS 2                | 2.653                   | 0.018             | 13.070                    | 2.195                |
| WS 3                | 2.869                   | 0.013             | 18.800                    | 2.388                |
| WS 4                | 2.826                   | 0.014             | 16.450                    | 2.351                |
| WS 5                | 3.156                   | 0.009             | 26.960                    | 2.644                |
| WS 6                | 2.824                   | 0.006             | 15.580                    | 2.522                |
| WS 7                | 2.679                   | 0.009             | 12.720                    | 2.352                |
| WS 8                | 2.325                   | 0.007             | 6.967                     | 2.15                 |
| WS 9                | 2.746                   | 0.009             | 9.677                     | 2.481                |
| WS 10               | 2.712                   | 0.11              | 9.250                     | 2.423                |
| WS 11               | 2.969                   | 0.88              | 13.910                    | 2.645                |
| All Sample Index    | 4.021                   |                   | 37.160                    | 3.849                |
| Jackknife Std Error | 0.138                   |                   | 10.59                     | 0.1206               |

Table (3) Evenness indices in the Wutsok Dam site

| <b>Sample</b>       | <b>Shannon Maximum</b> | <b>Shannon Minimum</b> | <b>Simpson evenness (E)</b> | <b>Brillouin (E)</b> |
|---------------------|------------------------|------------------------|-----------------------------|----------------------|
| WS 1                | 2.944                  | 1.989                  | 0.7602                      | 0.9066               |
| WS 2                | 2.996                  | 1.809                  | 0.6533                      | 0.89                 |
| WS 3                | 3.135                  | 1.909                  | 0.8173                      | 0.9217               |
| WS 4                | 3.091                  | 1.852                  | 0.7476                      | 0.9192               |
| WS 5                | 3.367                  | 2.072                  | 0.9298                      | 0.9436               |
| WS 6                | 3.135                  | 1.144                  | 0.6774                      | 0.9025               |
| WS 7                | 3.091                  | 1.288                  | 0.5784                      | 0.8666               |
| WS 8                | 3.258                  | 0.7727                 | 0.268                       | 0.7114               |
| WS 9                | 3.434                  | 1.126                  | 0.3122                      | 0.7971               |
| WS 10               | 3.296                  | 1.174                  | 0.3426                      | 0.8201               |
| WS 11               | 3.434                  | 1.325                  | 0.4486                      | 0.864                |
| All Sample Index    | 4.700                  | 0.8025                 | 0.3379                      | 0.8567               |
| Jackknife Std Error | 0.041                  | 0.1414                 | 0.09503                     | 0.02792              |

#### 4.2.6. Forest structure

Stem density of  $\geq 3\text{cm}$  was  $2448\text{ ha}^{-1}$  and basal area was  $67.3\text{ m}^2/\text{ha}$  in the Wusok dam site Table (4). Among the 11 sample plots studies, 110 tree species were recorded. Only one individual of 23 species were found only and these species were considered as unique species.

The 10 most abundance species in terms of basal area occupied 69.53% of the total, of which *Dipterocarpus obtusifolius* Teysm.ex.Mig. was the most dominant species in the study area with 33.11%, followed by *Ficus* sp.3 9.54%, *Elaeocarpus* sp. 5.23%, *Castanopsis calathiformis* (Skan) Resd &Wils 4.19%, *Caryota gigas* Hahn ex hodel 3.48%, *Sterculia* sp. 3.13%, *Lithocarpus* sp.1 2.98%, *Quercus* sp. 2.91%, *Pterocymbium* sp. 2.70%, and *Syzygium* sp.1 2.27% of the total basal area Figure (6).

Table (4) Consolidated detail of species inventory in the Wusok Dam site

| Description                     | Results |
|---------------------------------|---------|
| No. of sample points            | 11      |
| No. of tree species             | 110     |
| Density (stem/ha)               | 2448    |
| Basal area (m <sup>2</sup> /ha) | 67.3    |
| Total no. of unique species     | 23      |

The distribution of the basal area across DBH interval classes reveals the dominance of small stemmed individuals in the study area. The population structure by DBH class decreased from class to class with a steeper gradient in lower DBH classes and with a gentle slope in higher classes Figure (7) and Table (5). Out of total number of stems inventoried, 89.09% of stems were accumulated in the 3-60cm DBH class, 9.00% of stems in the 60-150cm, 2.78% in the 150-240cm, 0.55% in the 240-330cm and 330-480cm. The highest DBH was measured in the case of *Dipterocarpus obtusifolius* Teysm.ex.Mig. (460cm), *Ficus* sp.3 (345cm), *Elaeocarpus* sp. (340cm), *Castanopsis calathiformis* (Skan) Resd &Wils (290cm).

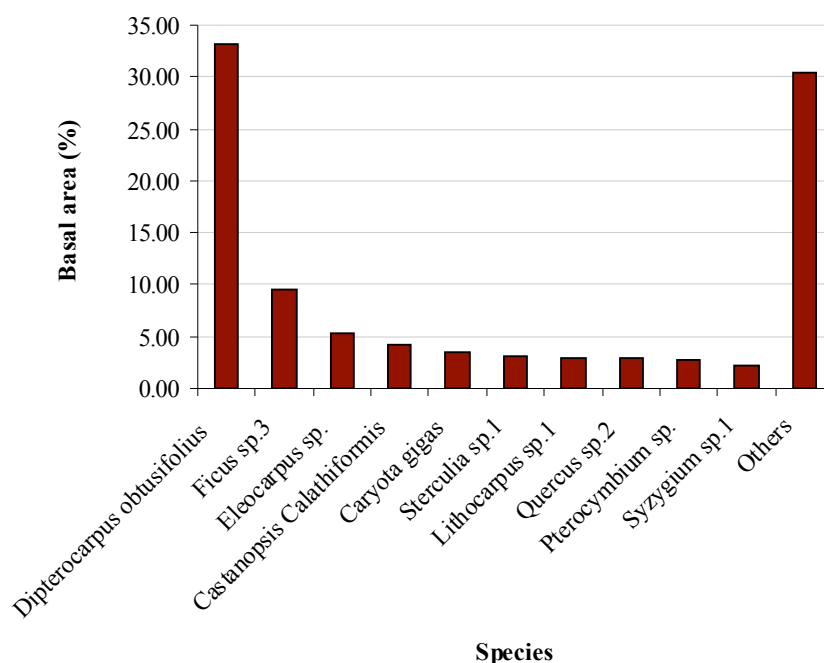


Figure (6) Ranking of relative basal area by species in the Wusok Dam site

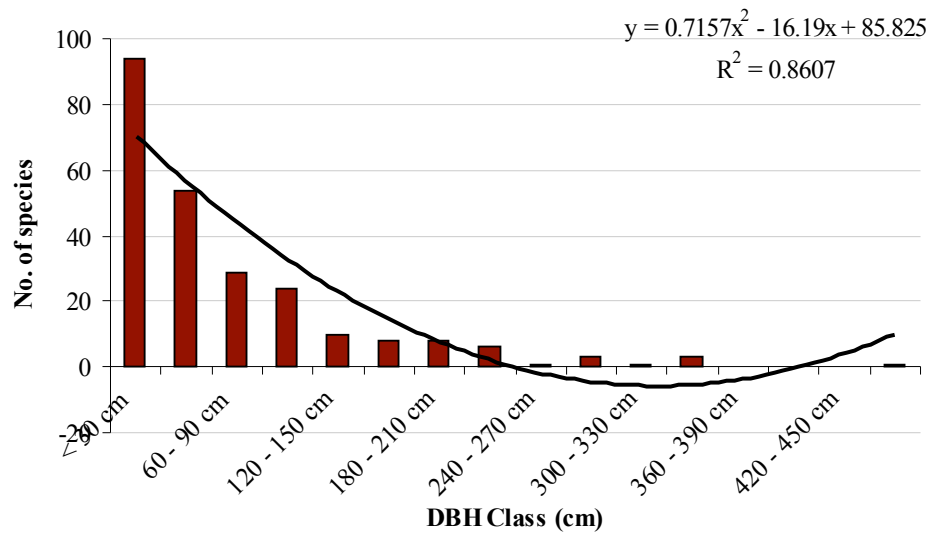


Figure (7) Species distribution by DBH classes

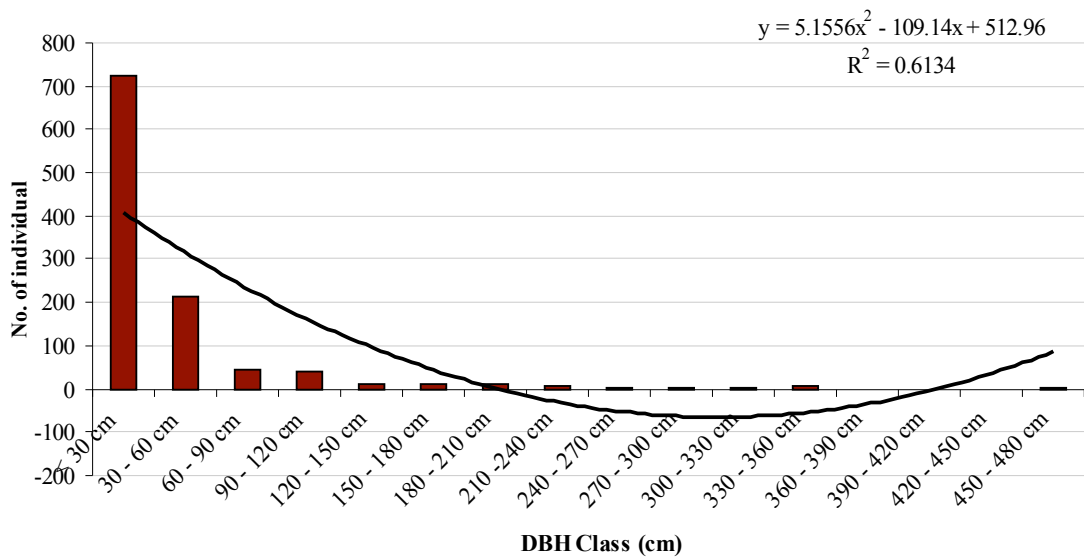


Figure (8) Population distribution by DBH classes

Table (5) Population density of tree species across DBH class interval

| DBH Classes  | No. of species | Total number of individual | % of total species | % of total individual |
|--------------|----------------|----------------------------|--------------------|-----------------------|
| < 30 cm      | 94             | 726                        | 38.84              | 67.41                 |
| 30-60 cm     | 54             | 212                        | 22.31              | 19.68                 |
| 60-90 cm     | 29             | 45                         | 11.98              | 4.18                  |
| 90-120 cm    | 24             | 39                         | 9.92               | 3.62                  |
| 120-150 cm   | 10             | 13                         | 4.13               | 1.21                  |
| 150-180 cm   | 8              | 11                         | 3.31               | 1.02                  |
| 180-210 cm   | 8              | 13                         | 3.31               | 1.21                  |
| 210-240 cm   | 6              | 6                          | 2.48               | 0.56                  |
| 240-270 cm   | 1              | 2                          | 0.41               | 0.19                  |
| 270-300 cm   | 3              | 3                          | 1.24               | 0.28                  |
| 300-330 cm   | 1              | 1                          | 0.41               | 0.09                  |
| 330-360 cm   | 3              | 5                          | 1.24               | 0.46                  |
| 360-390 cm   | -              | -                          | 0.00               | 0.00                  |
| 390-420 cm   | -              | -                          | 0.00               | 0.00                  |
| 420-450 cm   | -              | -                          | 0.00               | 0.00                  |
| 450-480 cm   | 1              | 1                          | 0.41               | 0.09                  |
| <b>Total</b> | <b>110</b>     | <b>1077</b>                | <b>100.00</b>      | <b>100.00</b>         |

Tree distribution by height intervals shows that among the total number of 1077 individuals, 429 individuals (39.83%) belong to 3-10m category, followed by 425 individuals (39.46%) in 10-17m, 91 individuals (8.45%) in 17-24m, and 97 individuals (9.01%) in 24-31m, 1 individual (0.09%) in 31-38m. The height class of >38m includes (0.19%) of total individuals Table (6). <3m height trees of 32 individuals (2.97%) infer natural regeneration is poor or frequent disturbance on ground cover plant. The population structure by height classes in the Wusok area, 3-10m class is highest and gradually decreases to higher classes (Figure 9 and 10). The tallest individual trees were *Mallotus* sp. (43m), UN-6 (40m), *Ilex micrococca* Maxim. (34m), *Dipterocarpus obtusifolius* Teysm.ex.Mig. (30m), *Sterculia* sp.1 (30m), and *Ficus* sp.3 (30m), Total picture of height class shows that, 42.8% belong to <3-10m category, 47.91% in 10-24m, and 9.29% in 24->38m. The overall population structure indicates that study area represents mature stand.

Table (6) Population density of tree species across height class interval

| Height Classes | No. of species | Total number of individual | % of total species | % of total individual |
|----------------|----------------|----------------------------|--------------------|-----------------------|
| < 3 m          | 8              | 32                         | 3.32               | 2.97                  |
| 3-10 m         | 81             | 429                        | 33.61              | 39.83                 |
| 10-17 m        | 81             | 425                        | 33.61              | 39.46                 |
| 17-24 m        | 33             | 91                         | 13.69              | 8.45                  |
| 24-31 m        | 35             | 97                         | 14.52              | 9.01                  |
| 31-38 m        | 1              | 1                          | 0.41               | 0.09                  |
| > 38 m         | 2              | 2                          | 0.83               | 0.19                  |
| Total          | 110            | 1077                       | 100.00             | 100.00                |

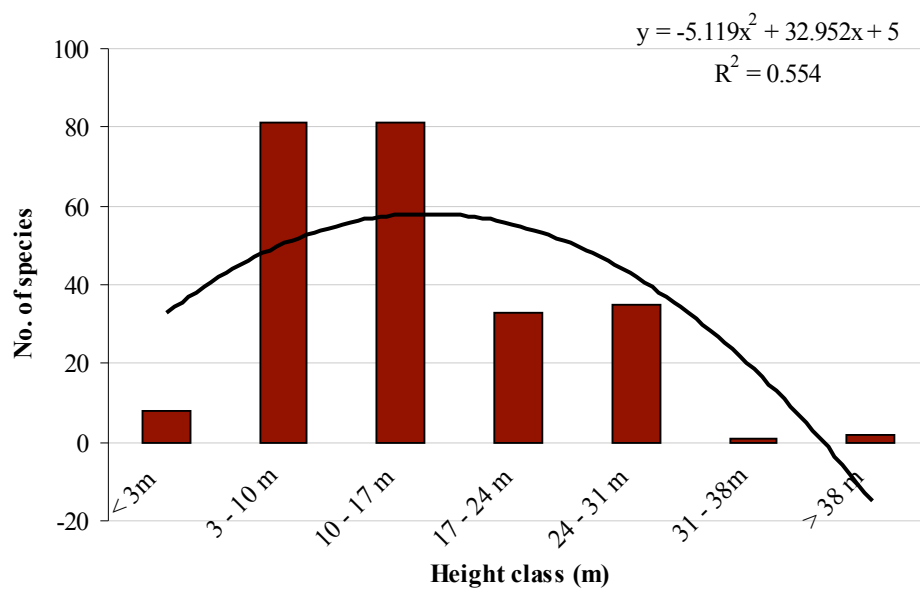


Figure (9) Species distribution by height classes

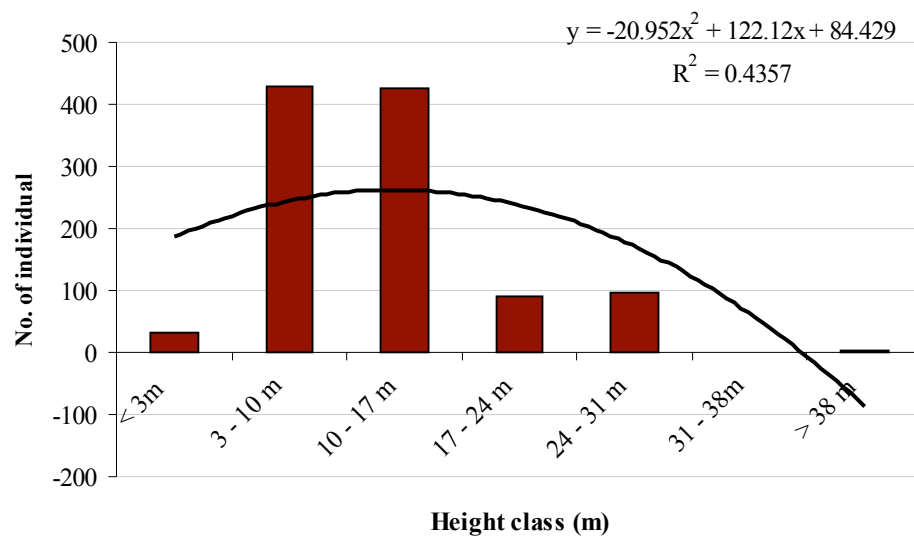


Figure (10) Population distribution by DBH classes

#### 4.3. Discussion and Conclusion

A total of 110 tree species representing 79 genera and 43 families were analyzed in the study area. The main vegetation types discovered in Wusok and Pisa Dam sites can be grouped into four formations, i.e. low land evergreen forest, oak forest, lowland secondary forest, and bamboo forest. In some disturbed site, degraded forests are occurred.

The ten leading dominants by important value index in study area were *Dipterocarpus obtusifolius* Teysm.ex.Mig., *Sterculia* sp.1, *Ficus* sp.3, *Mallotus* sp., *Castanopsis calathiformis* (Skan) Resd & Wils, *Lithocarpus* sp.1, *Ilex micrococca* Maxim., *Ostodes paniculata* Blume, *Eurya* sp., and *Pterocymbium* sp. contributing highest IVI value (37.65, 14.23, 12.13, 11.01, 9.45, 7.96, 7.37, 7.26, 7.21, 6.76 ) respectively. Those tree species could be considered as ecological indicator species of the study area.

In mature site, the largest trees can reach up to >31m in height while the main canopy is 24-31m with well developed understoreys. The canopy of the forest is more or less close, but in some disturbed site the canopy is open and the estimated height is probably not more than 15m, including stunted and cutover regrowth of the tree species.

Presence of high species diversity and richness indicates uniqueness and potentiality of Wusok area for conservation of ecosystem in totality.

The forest structures in the study area show all types of disturbance. The surrounding Wusok area has an insufficient protection status and so allows the exploitation of natural resources; such as firewood collection, logging, shifting cultivation, and hunting. Logging was the major destructive force and one of the influencing factors for forest structure.

#### **4.4. Recommendation**

4. The new access road to Wusok and Pisa should be implemented with great care and it should have minimal impacts on environment.
5. The socioeconomic development and community awareness on environment should be planned and implemented under the project. It may support the conservation and maintenance of remaining forest.
6. Reforestation project should be introduced and implemented in degraded area.

The flooded areas of dams are narrow and damage is minimal on terrestrial ecosystem since both dams are cascade, the cumulative impact assessment of hydrology should be carried out with special attention.

### Ranking of Important Value Index (IVI) in the Wutsok Area

| No. | Species Name                                        | R.D. % | R.D.m % | R.F % | IVI % |
|-----|-----------------------------------------------------|--------|---------|-------|-------|
| 1   | <i>Dipterocarpus obtusifolius</i> Teysm.ex.Mig.     | 3.44   | 33.112  | 1.10  | 37.65 |
| 2   | <i>Sterculia</i> sp.1                               | 7.80   | 3.135   | 3.30  | 14.23 |
| 3   | <i>Ficus</i> sp.3                                   | 1.49   | 9.544   | 1.10  | 12.13 |
| 4   | <i>Mallotus</i> sp.                                 | 6.96   | 2.210   | 1.83  | 11.01 |
| 5   | <i>Castanopsis calathiformis</i> (Skan) Resd & Wils | 3.44   | 4.188   | 1.83  | 9.45  |
| 6   | <i>Lithocarpus</i> sp.1                             | 2.41   | 2.981   | 2.56  | 7.96  |
| 7   | <i>Ilex micrococca</i> Maxim.                       | 3.90   | 2.010   | 1.47  | 7.37  |
| 8   | <i>Ostodes paniculata</i> Blume                     | 2.79   | 1.182   | 3.30  | 7.26  |
| 9   | <i>Eurya</i> sp.                                    | 4.18   | 1.567   | 1.47  | 7.21  |
| 10  | <i>Pterocymbium</i> sp.                             | 2.23   | 2.696   | 1.83  | 6.76  |
| 11  | <i>Saurauia</i> sp.1                                | 3.44   | 0.722   | 2.56  | 6.72  |
| 12  | <i>Elaeocarpus</i> sp.                              | 0.74   | 5.229   | 0.73  | 6.70  |
| 13  | <i>Caryota gigas</i> Hahn ex hodel                  | 0.84   | 3.480   | 2.20  | 6.51  |
| 14  | <i>Quercus</i> sp.2                                 | 1.95   | 2.908   | 1.47  | 6.32  |
| 15  | <i>Saurauia</i> sp.2                                | 4.18   | 0.467   | 1.10  | 5.74  |
| 16  | <i>Quercus</i> sp.1                                 | 1.67   | 1.755   | 2.20  | 5.62  |
| 17  | <i>Syzygium</i> sp.1                                | 1.39   | 2.266   | 1.47  | 5.12  |
| 18  | <i>Callicarpa</i> sp.                               | 2.41   | 0.715   | 1.47  | 4.59  |
| 19  | <i>Diphanimorpha</i> sp.                            | 3.16   | 0.166   | 1.10  | 4.42  |
| 20  | <i>Canthium</i> sp.                                 | 1.67   | 0.141   | 2.56  | 4.38  |
| 21  | <i>Ficus</i> sp.1                                   | 1.21   | 0.766   | 2.20  | 4.17  |
| 22  | <i>Chisocheton siamensis</i> Craib                  | 0.93   | 0.889   | 1.83  | 3.65  |
| 23  | <i>Litsea</i> sp.1                                  | 0.84   | 0.562   | 2.20  | 3.60  |
| 24  | <i>Boehmeria</i> sp.                                | 1.49   | 0.151   | 1.83  | 3.47  |
| 25  | <i>Maesasp.</i>                                     | 2.41   | 0.038   | 0.73  | 3.18  |
| 26  | <i>Knema furfuracea</i> (HK. F.et Th.) Warb.        | 1.39   | 0.682   | 1.10  | 3.17  |
| 27  | <i>Bischofia</i> sp.                                | 1.21   | 0.327   | 1.47  | 3.00  |
| 28  | <i>Macaranga</i> sp.                                | 1.30   | 0.216   | 1.10  | 2.61  |
| 29  | <i>Saurauia napaulensis</i> DC.                     | 1.30   | 0.557   | 0.73  | 2.59  |
| 30  | <i>Castanopsis tribuloides</i> A.DC.                | 0.46   | 0.611   | 1.47  | 2.54  |
| 31  | <i>Ficus semicordata</i> Buch.- Ham ex. J. E. Sm.   | 0.74   | 0.609   | 1.10  | 2.45  |
| 32  | <i>Sterculia</i> sp.2                               | 1.02   | 0.316   | 1.10  | 2.44  |
| 33  | UN-9                                                | 0.65   | 0.207   | 1.47  | 2.32  |
| 34  | <i>Lasianthus</i> sp.                               | 0.74   | 0.015   | 1.47  | 2.22  |
| 35  | <i>Myrica</i> sp.                                   | 0.37   | 1.099   | 0.73  | 2.20  |
| No. | Species Name                                        | R.D. % | R.D.m % | R.F % | IVI % |

|            |                                                  |               |                |              |              |
|------------|--------------------------------------------------|---------------|----------------|--------------|--------------|
| 36         | <i>Mitrephora</i> sp.                            | 0.19          | 1.586          | 0.37         | 2.14         |
| 37         | <i>Oxyspara paniculata</i> (D.Don.) DC.          | 1.30          | 0.090          | 0.73         | 2.12         |
| 38         | <i>Nothaphoebe</i> sp.1                          | 0.19          | 1.179          | 0.73         | 2.10         |
| 39         | <i>Leea</i> sp.                                  | 1.30          | 0.056          | 0.73         | 2.09         |
| 40         | <i>Pterospermum cinnamonemum</i> Kurz            | 0.46          | 0.138          | 1.47         | 2.07         |
| 41         | <i>Ficus hispida</i> Forsk.                      | 1.11          | 0.138          | 0.73         | 1.98         |
| 42         | <i>Polyalthia</i> sp.                            | 0.74          | 0.022          | 1.10         | 1.86         |
| 43         | <i>Castanopsis</i> sp1                           | 0.37          | 0.370          | 1.10         | 1.84         |
| 44         | <i>Arenga triandra</i> Roxb.                     | 1.02          | 0.018          | 0.73         | 1.77         |
| 45         | <i>Engelhardtia spicata</i> Blume                | 0.09          | 1.302          | 0.37         | 1.76         |
| 46         | <i>Schefflera</i> sp.                            | 0.56          | 0.062          | 1.10         | 1.72         |
| 47         | <i>Ficus roxburghii</i> Wall.                    | 0.19          | 0.799          | 0.73         | 1.72         |
| 48         | <i>Phoebe</i> sp.2                               | 0.56          | 0.045          | 1.10         | 1.70         |
| 49         | UN-12                                            | 0.19          | 1.143          | 0.37         | 1.70         |
| 50         | <i>Cinnamomum</i> sp.1                           | 0.56          | 0.008          | 1.10         | 1.66         |
| 51         | <i>Machilus</i> sp.                              | 0.46          | 0.055          | 1.10         | 1.62         |
| 52         | <i>Aralia</i> sp.                                | 0.46          | 0.054          | 1.10         | 1.62         |
| 53         | <i>Ilex</i> sp.                                  | 0.65          | 0.139          | 0.73         | 1.52         |
| 54         | <i>Litsea</i> sp.2                               | 0.28          | 0.072          | 1.10         | 1.45         |
| 55         | <i>Diospyros</i> sp.                             | 0.46          | 0.236          | 0.73         | 1.43         |
| 56         | <i>Symplocos</i> sp.                             | 0.65          | 0.018          | 0.73         | 1.40         |
| 57         | <i>Ardisia</i> sp.                               | 0.84          | 0.144          | 0.37         | 1.35         |
| 58         | UN-4                                             | 0.46          | 0.095          | 0.73         | 1.29         |
| 59         | <i>Symplocos microphylla</i> Wight.              | 0.46          | 0.048          | 0.73         | 1.24         |
| 60         | <i>Wendlandia</i> sp.                            | 0.28          | 0.229          | 0.73         | 1.24         |
| 61         | <i>Agalia</i> sp.                                | 0.46          | 0.015          | 0.73         | 1.21         |
| 62         | <i>Litsea cubeba</i> (Lour.) Pers.               | 0.19          | 0.232          | 0.73         | 1.15         |
| 63         | <i>Pteris</i> sp.                                | 0.09          | 0.689          | 0.37         | 1.15         |
| 64         | <i>Betula</i> sp.                                | 0.28          | 0.074          | 0.73         | 1.09         |
| 65         | <i>Cyathea gigantea</i> (Wall. Ex Hook.) Holttum | 0.28          | 0.072          | 0.73         | 1.08         |
| 66         | UN-11                                            | 0.19          | 0.527          | 0.37         | 1.08         |
| 67         | <i>Callicarpa arborea</i> Roxb.                  | 0.65          | 0.045          | 0.37         | 1.06         |
| 68         | <i>Cinnamomum</i> sp.2                           | 0.09          | 0.597          | 0.37         | 1.06         |
| 69         | <i>Myristica angustifolia</i> Roxb.              | 0.19          | 0.128          | 0.73         | 1.05         |
| 70         | UN-8                                             | 0.28          | 0.027          | 0.73         | 1.04         |
| 71         | <i>Maesa montana</i> A.DC.                       | 0.65          | 0.021          | 0.37         | 1.04         |
| 72         | <i>Garcinia</i> sp.                              | 0.28          | 0.020          | 0.73         | 1.03         |
| 73         | <i>Alnus nepalensis</i> D. Don                   | 0.19          | 0.457          | 0.37         | 1.01         |
| 74         | <i>Eurya</i> sp.1                                | 0.19          | 0.045          | 0.73         | 0.96         |
| <b>No.</b> | <b>Species Name</b>                              | <b>R.D. %</b> | <b>R.D.m %</b> | <b>R.F %</b> | <b>IVI %</b> |

|     |                                              |       |       |       |        |
|-----|----------------------------------------------|-------|-------|-------|--------|
| 75  | <i>Castanopsis argyrophylla</i> King.        | 0.37  | 0.213 | 0.37  | 0.95   |
| 76  | <i>Meliosma</i> sp.                          | 0.19  | 0.030 | 0.73  | 0.95   |
| 77  | <i>Glochidion</i> sp.                        | 0.19  | 0.030 | 0.73  | 0.95   |
| 78  | <i>Phoebe</i> sp.1                           | 0.19  | 0.017 | 0.73  | 0.94   |
| 79  | <i>Gmelina</i> sp.                           | 0.46  | 0.034 | 0.37  | 0.86   |
| 80  | UN-2                                         | 0.46  | 0.032 | 0.37  | 0.86   |
| 81  | <i>Lithocarpus</i> sp.2                      | 0.09  | 0.331 | 0.37  | 0.79   |
| 82  | <i>Indigofera</i> sp.                        | 0.19  | 0.147 | 0.37  | 0.70   |
| 83  | <i>Lannea</i> sp.                            | 0.28  | 0.043 | 0.37  | 0.69   |
| 84  | <i>Bischofia javanica</i> Blume              | 0.28  | 0.027 | 0.37  | 0.67   |
| 85  | UN-7                                         | 0.28  | 0.008 | 0.37  | 0.65   |
| 86  | <i>Clerodendrum</i> sp.                      | 0.28  | 0.002 | 0.37  | 0.65   |
| 87  | <i>Limnophila</i> sp.                        | 0.19  | 0.081 | 0.37  | 0.63   |
| 88  | <i>Flacourtia</i> sp.                        | 0.09  | 0.143 | 0.37  | 0.60   |
| 89  | <i>Archidendron clypearia</i> (Jack) Nielsen | 0.19  | 0.024 | 0.37  | 0.58   |
| 90  | <i>Ziziphus</i> sp.                          | 0.19  | 0.015 | 0.37  | 0.57   |
| 91  | UN-5                                         | 0.19  | 0.013 | 0.37  | 0.56   |
| 92  | <i>Nothaphoebe</i> sp.2                      | 0.19  | 0.005 | 0.37  | 0.56   |
| 93  | <i>Dichroa</i> sp.                           | 0.19  | 0.002 | 0.37  | 0.55   |
| 94  | <i>Meliosma</i> sp.2                         | 0.09  | 0.073 | 0.37  | 0.53   |
| 95  | UN-3                                         | 0.09  | 0.041 | 0.37  | 0.50   |
| 96  | <i>Saurauia benghalensis</i>                 | 0.09  | 0.031 | 0.37  | 0.49   |
| 97  | <i>Streblus</i> sp.                          | 0.09  | 0.031 | 0.37  | 0.49   |
| 98  | UN-6                                         | 0.09  | 0.029 | 0.37  | 0.49   |
| 99  | <i>Chesocheton</i> sp.                       | 0.09  | 0.024 | 0.37  | 0.48   |
| 100 | <i>Ficus</i> sp.2                            | 0.09  | 0.011 | 0.37  | 0.47   |
| 101 | <i>Syzygium</i> sp.2                         | 0.09  | 0.011 | 0.37  | 0.47   |
| 102 | <i>Litsea monopetala</i> (Roxb.) Pers.       | 0.09  | 0.009 | 0.37  | 0.47   |
| 103 | UN-10                                        | 0.09  | 0.007 | 0.37  | 0.47   |
| 104 | <i>Arenga saccharifera</i> Labill.           | 0.09  | 0.004 | 0.37  | 0.46   |
| 105 | <i>Dolichandron</i> sp.                      | 0.09  | 0.004 | 0.37  | 0.46   |
| 106 | <i>Schima</i> sp.                            | 0.09  | 0.003 | 0.37  | 0.46   |
| 107 | UN-1                                         | 0.09  | 0.003 | 0.37  | 0.46   |
| 108 | <i>Maesa chisia</i> Godayari                 | 0.09  | 0.002 | 0.37  | 0.46   |
| 109 | <i>Morus</i> sp.                             | 0.09  | 0.002 | 0.37  | 0.46   |
| 110 | <i>Sterculia</i> sp.3                        | 0.09  | 0.002 | 0.37  | 0.46   |
|     | Total                                        | 56.36 | 27.94 | 74.73 | 159.03 |

## Chapter V

## 5. Khaunglanphu Dam

### 5.1. Study area

The location of Khaunglanphu area is between 26°30'N, 98° 00'E and 27°30'N, 98° 40' E near Sangn hkun Hkyet village on downstream confluence mouth of Mayhka River and Achanhti stream. The dam site lies between high mountains and riverine. From biodiversity standpoint, the study area lies WWF Eco-region of Northern Triangle Temperate forest. It is also located within the priority site for conservation investment of Northern mountain forest complex. The Hkakaborizi NP, Hponganrazi W.S and Emawbum mountain forest are its watershed area. So the area is the biodiversity hot-spot area and globally outstanding for conservation. A detailed map of the study area is given in figure (1.4).

#### 5.1.1. Participants

Dr Win Myint, Daw Khin Swe Lwin, Daw Ei Ei Phyto, and U Nay Phyto Aung.

### 5.2. Results

#### 5.2.1. Forest composition

To clarify the tree species composition and their distribution, fourteen quadrats (20x20 m each) were set up and observed in the flooded area of Khaunglanphu dam site. In the fourteen sampling plots (.56ha), total number of species with DBH  $\geq 3$ cm was 56 species; of which 7 species are under identification. The dominant families of tree species were Fagaceae (8 species), Euphorbiaceae (6 species), Lauraceae (5 species), Verbenaceae (3 species) Figure (3). The main vegetation types encountered in Khaunglanphu Dam site can be grouped into four formations; high land evergreen forest, oak forest, highland secondary forest, and bamboo forest. Due to the human impact, degraded forest occurs in most of the places. In some disturbed sites, wild banana and bushes can be seen in patches. Highland evergreen forests can be typically distinguished by *Saurauia* sp., *Spondias* sp., *Cinnamomum* sp., *Litsea cubeba*., *Macaranga diversifolia*, associated with *Ficus* sp., *Elaeocarpus* sp. are found in tree layer. Shrub layer is dominated by *Maesa* sp., *Polygonum* sp., *Phlogacanthus pubinervius*, and *Buddleja* sp.. Herb layer is dominated by *Oxalis* sp., *Begonia* sp., *Commelina* sp., and *Viola* sp.. Oak forest can be typically distinguished by *Castanopsis tribuloides*, *Castanopsis diversifolia*, *Castanopsis* sp., *Lithocarpus* sp. associated with *Macaranga denticulata*, *Spondias* sp. and *Cinnamomum* sp. are found in tree layer. Shrub layer is dominated by *Osbeckia* sp., and *Rubus* sp.. The ground cover of dominated by *Commelina* sp., *Polygonum* sp., and *Plantago* sp.. In the high land secondary forest, *Michelia champaca*., *Schefflera* sp., *Cinnamomum* sp. and *Saurauia napaulensis* are found in tree layer. Herb layer is dominated by *Begonia semperflorens*., *Adiantum* sp. and *Polygonum* sp.. In the bamboo forest *Dendrocalamus hamiltonii* Ness (Wabo Myatsan), *D. giganteus* Munro(Wabowa), and *Melocalamus compactiflorus* (Kurz) Benth.(Wa-nwe) mainly occur.

The species area curves of the investigated stands are shown in the figure (4). The species area curves, which express the number of species in relation to change in area of habitat, not only consider the minimum representative area but also detect the habitat diversity within the survey area (Fangliang He and Pierre Legendre, 1996). The trend of species area curve shows tendency towards flattening. Therefore the sample areas can be said to be sufficient as a minimum representative area for the study.

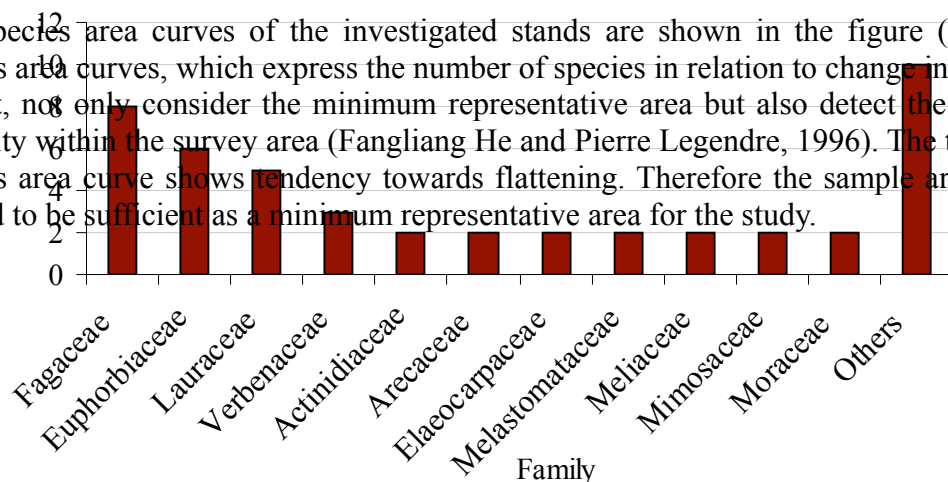


Figure (2) Ranking of dominant family by number of species composition

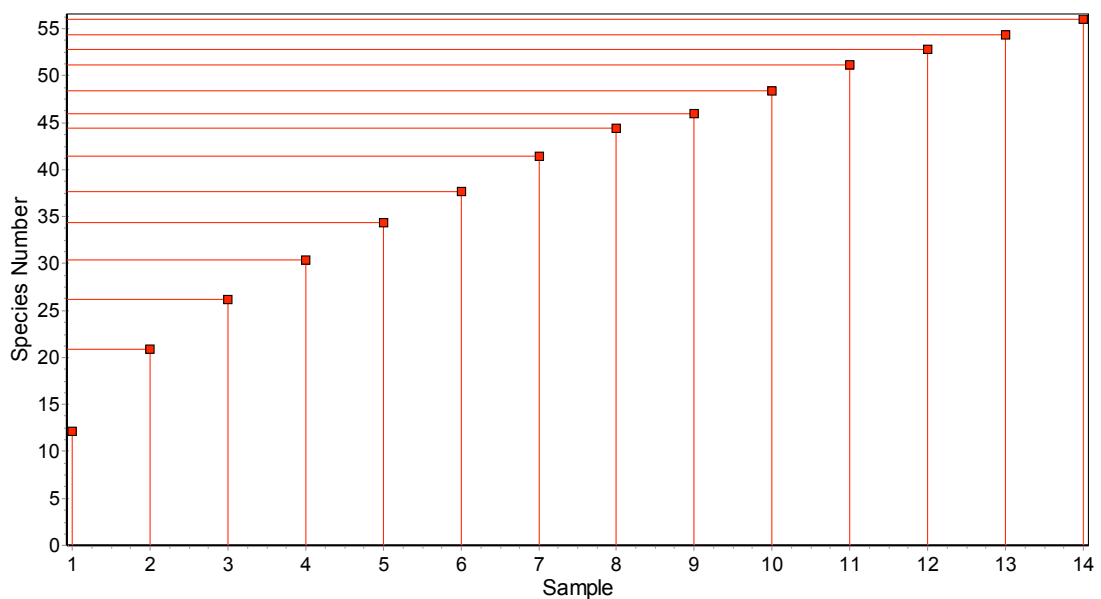


Figure (3) Plot of species accumulation in the Khaunglanhpu Dam Site

### 5.2.2. Important Value Index (IVI)

Ranking of ecological significance by IVI of tree species in the study area is given in appendix (1). The tree layer in the study area is dominated by *Alnus nepalensis* D. Don with the highest IVI of 33.76 %, the second most dominant species is *Castanopsis diversifolia* (Kurz) King (IVI = 21.51%) and *Castanopsis acuminatissima* (Bl.) A. DC. (IVI= 19.57 %) is the third. Ecologically dominance of top ten species based on IVI value is shown in figure 4. Those species could be considered as ecological indicator species of Khaunglanhpu area. The number of species greater than 5% IVI value was only sixteen species (Appendix 1).

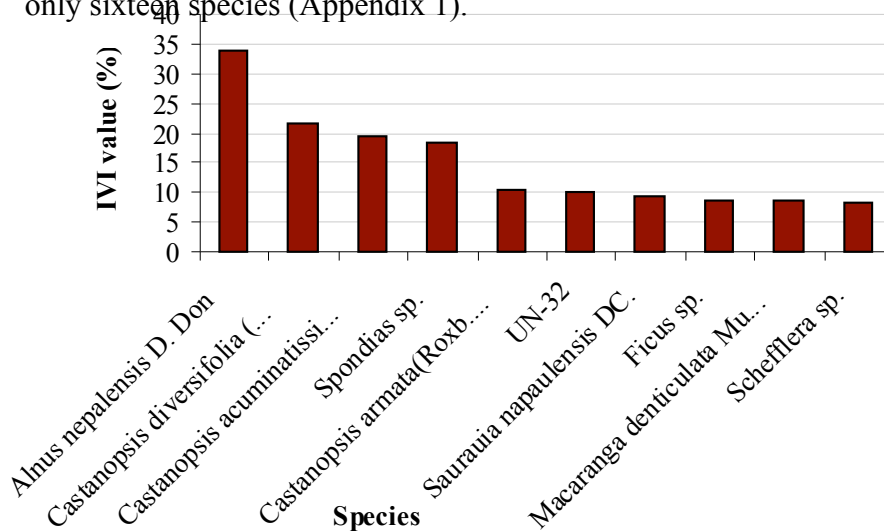


Figure (4) Important Value Index of top ten species in the Khaunglanhpu Dam Site

### 5.2.3. Species distribution by frequency classes

In order to clarify the homogeneity or heterogeneity of the floristic distribution in the study area, species distribution by frequency classes was examined. According to the outcome of frequency chart, 82.14 % of the total number of species was in lower frequency classes, A and B, while low value was observed only in higher frequency class D (Table 1, Figure 5). It indicates that the forest in Khaunglanhpu area is floristically heterogeneous, according to Lamprecht (1989). The species which fall in high frequency class D was *Castanopsis acuminatissima* (Bl.) A. DC. *Macaranga diversifolia* and *Castanopsis diversifolia* (Kurz) King,. These species can be considered as the most common species in the Khaunglanhpu area.

Table (1) Species distribution by frequency classes  $\geq 3\text{cm}$

| Frequency Class | Frequency range | No. of species | % of total species frequency distribution |
|-----------------|-----------------|----------------|-------------------------------------------|
| A               | 1-20 %          | 35             | 62.50                                     |
| B               | 21-40 %         | 11             | 19.64                                     |
| C               | 41-60 %         | 7              | 12.50                                     |
| D               | 61-80 %         | 3              | 5.36                                      |
| E               | 81-100 %        | -              | -                                         |

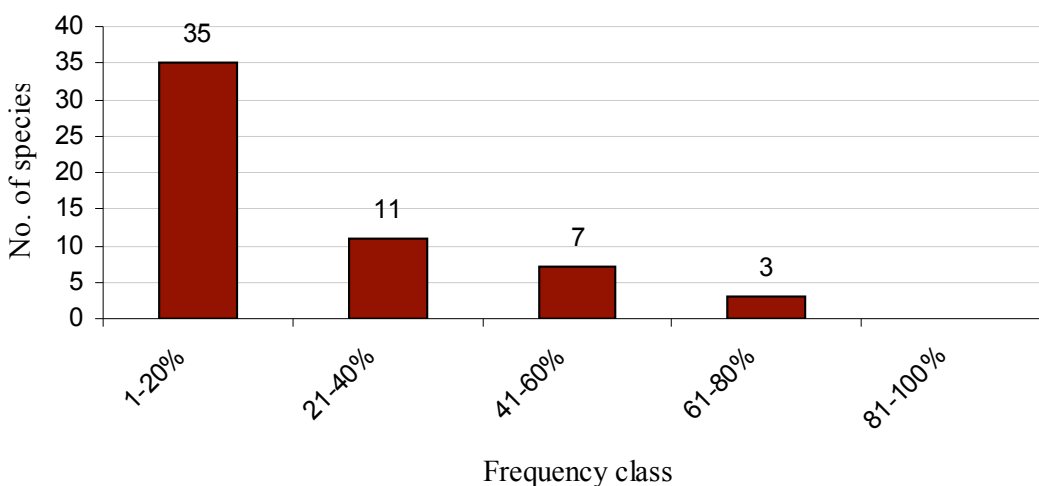


Figure (5) Species distribution by frequency classes  $\geq 3\text{cm}$

#### 5.2.4. Diversity indices and evenness

Among the different measurement of species diversity indices, the floristic diversity of the Khaunglanhpu area was analyzed using the Shannon Wiener index (H), Simpsons index (D), Brillouin (D), Shannon Maximum and minimum evenness (E), Brillouin (E) because these indices not only take taxa richness into account but also depend on the relative distribution of individuals. The value of diversity indices and evenness indices of individual sample plot and all sample indices are shown in table (2) and (3). According to the result, the diversity indices of individual sample plot and all sample indexes are relatively low. Diversity value for all sample index of Shannon Wiener index (H) is 3.527, Simpsons index (D) is 25.5, Brillouin (D) is 3.318.

Table (2) Species diversity indices in the Khaunglanhpu Dam site

| <b>Sample</b>       | <b>Shannon<br/>Wiener H</b> | <b>Variance H</b> | <b>Simpsons<br/>Index (D)</b> | <b>Brillouin (D)</b> |
|---------------------|-----------------------------|-------------------|-------------------------------|----------------------|
| KLP 1               | 2.463                       | 0.019             | 18.400                        | 1.902                |
| KLP 2               | 2.602                       | 0.016             | 20.300                        | 2.047                |
| KLP 3               | 2.719                       | 0.012             | 27.190                        | 2.138                |
| KLP 4               | 2.372                       | 0.007             | 15.540                        | 1.932                |
| KLP 5               | 2.076                       | 0.022             | 7.808                         | 1.687                |
| KLP 6               | 2.306                       | 0.008             | 12.350                        | 1.926                |
| KLP 7               | 1.746                       | 0.015             | 5.293                         | 1.499                |
| KLP 8               | 1.942                       | 0.028             | 6.522                         | 1.554                |
| KLP 9               | 2.397                       | 0.016             | 13.680                        | 1.932                |
| KLP 10              | 2.372                       | 0.007             | 15.540                        | 1.932                |
| KLP 11              | 2.023                       | 0.027             | 7.131                         | 1.639                |
| KLP 12              | 1.701                       | 0.012             | 4.598                         | 1.507                |
| KLP 13              | 2.315                       | 0.023             | 13.14                         | 1.801                |
| KLP 14              | 2.362                       | 0.01645           | 14.04                         | 1.876                |
| All Sample Index    | 3.527                       |                   | 25.5                          | 3.318                |
| Jackknife Std Error | 0.08919                     |                   | 3.092                         | 0.07386              |

Table (3) Evenness indices in the Khaunglanhpu Dam site

| Sample              | Shannon Maximum | Shannon Minimum | Simpson Evenness (E) | Brillouin (E) |
|---------------------|-----------------|-----------------|----------------------|---------------|
| KLP 1               | 2.565           | 1.936           | 1.415                | 0.9681        |
| KLP 2               | 2.708           | 1.967           | 1.353                | 0.9643        |
| KLP 3               | 2.773           | 2.047           | 1.699                | 0.9875        |
| KLP 4               | 2.398           | 1.404           | 1.412                | 0.9951        |
| KLP 5               | 2.303           | 1.301           | 0.7808               | 0.8987        |
| KLP 6               | 2.398           | 1.23            | 1.123                | 0.965         |
| KLP 7               | 2.079           | 0.8199          | 0.6616               | 0.8357        |
| KLP 8               | 2.197           | 1.292           | 0.7246               | 0.8814        |
| KLP 9               | 2.565           | 1.629           | 1.052                | 0.942         |
| KLP 10              | 2.398           | 1.404           | 1.412                | 0.9951        |
| KLP 11              | 2.398           | 1.404           | 0.6483               | 0.8442        |
| KLP 12              | 2.079           | 0.6288          | 0.5747               | 0.812         |
| KLP 13              | 2.485           | 1.789           | 1.095                | 0.9305        |
| KLP 14              | 2.485           | 1.653           | 1.17                 | 0.9565        |
| All Sample Index    | 4.025           | 0.8794          | 0.4554               | 0.8769        |
| Jackknife Std Error | 0.094           | 0.1089          | 0.06093              | 0.01819       |

### 5.2.5. Forest structure

Stem density of  $\geq 3\text{cm}$  was  $784 \text{ ha}^{-1}$  and basal area was  $53.3 \text{ m}^2/\text{ha}$  in the Khaunglanhpu dam site Table (4). Among the 14 sample plots studies, 56 tree species were recorded, only one individual of 9 species were found and these species were considered as unique species. The 10 most abundance species in terms of basal area occupied 72.17% of the total, of which *Alnus nepalensis* D. Don was the most dominant species in the study area with 20.50%, followed by UN-5 9.25%, *Castanopsis diversifolia* (Kurz) King 8.14%, *Castanopsis acuminatissima* (Bl.) A. DC. 8.02%, *Spondias* sp. 5.81%, *Alseodaphne nigrescens* (Gamble) Kosterm. 5.29%, *Castanopsis armata* Spach 4.84%, *Osbeckia* sp. 4.14%, *Castanopsis argyrophylla* King. 3.22%, and *Ficus* sp. 2.96% of the total basal area Figure (6).

Table (4) Consolidated detail of species inventory in the Khaunglanhpu Dam site

| Description                           | Results |
|---------------------------------------|---------|
| No. of sample points                  | 14      |
| No. of tree species                   | 56      |
| Density (stem/ha)                     | 784     |
| Basal area ( $\text{m}^2/\text{ha}$ ) | 55.3    |
| Total No. of unique species           | 9       |

The distribution of the basal area across DBH interval classes reveals the dominance of small stemmed individuals in the study area. The population structure by DBH class

decreased from class to class with a steeper gradient in lower DBH classes and with a gentle slope in higher classes Figure (7) and Table (5). Out of total number of stems inventoried, 44.87% of stems were accumulated in the 3-60cm DBH class, 44.88% of stems in the 60-150cm, 9.34% in the 150-240cm, 0.68% in the 240-330cm, only 0.23% occurs in >570cm. The highest DBH was measured in the case of UN-5 (600cm), *Alseodaphne nigrescens* (Gamble) Kosterm (250cm), *Alnus nepalensis* D. Don (250cm), *Spondias* sp. (230cm).

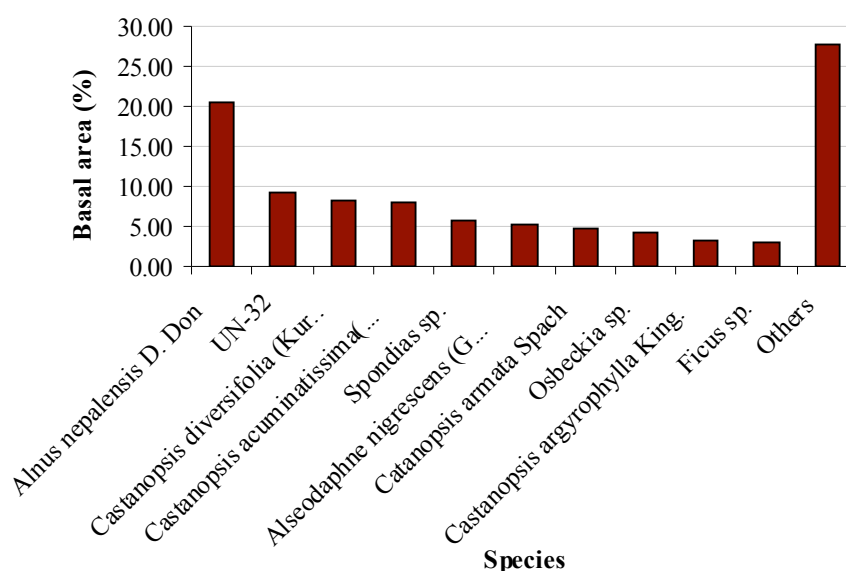


Figure (6) Ranking of relative basal area by species in the Khaunglanhpu Dam site

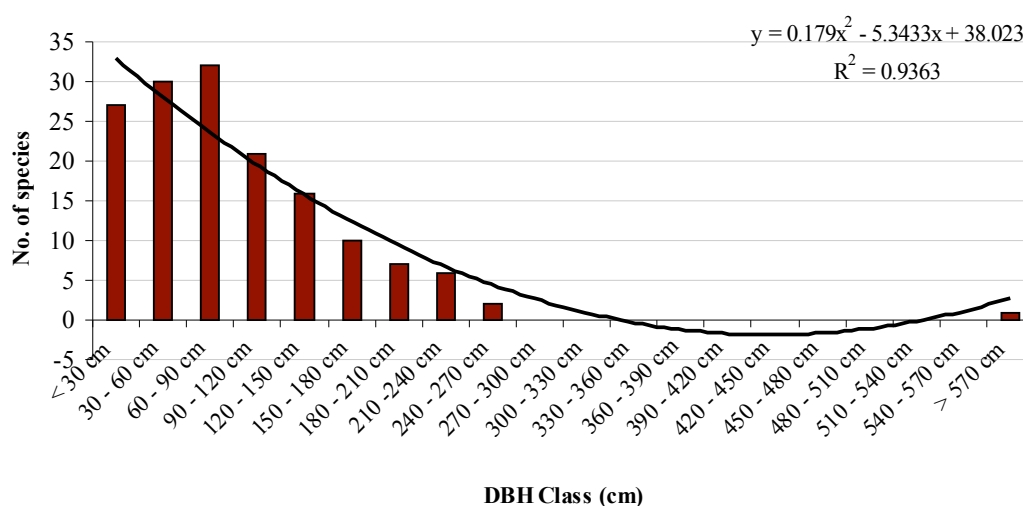


Figure (7) Species distribution by DBH classes

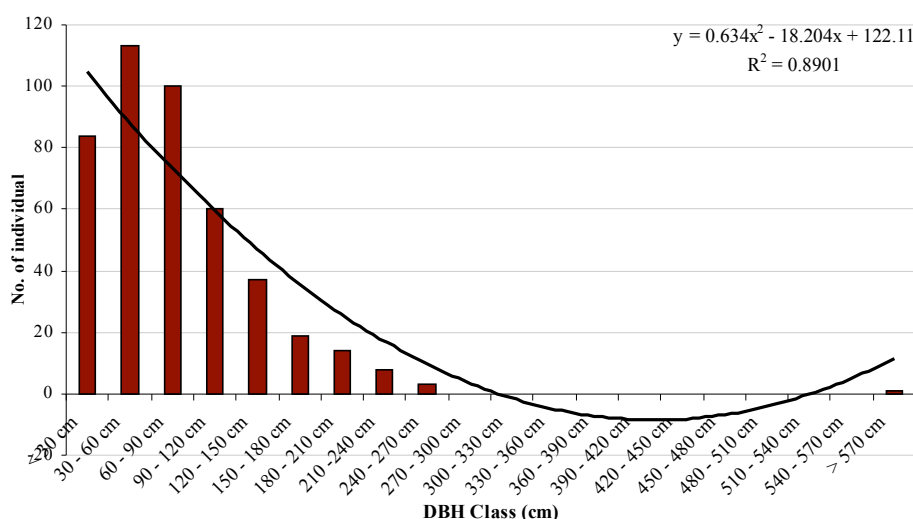


Figure (8) Population distribution by DBH classes

Table (5) Population density of tree species across DBH class interval

| DBH Classes | No. of species | Total number of individual | % of total species | % of total individual |
|-------------|----------------|----------------------------|--------------------|-----------------------|
| < 30 cm     | 27             | 84                         | 17.76              | 19.13                 |
| 30-60 cm    | 30             | 113                        | 19.74              | 25.74                 |
| 60-90 cm    | 32             | 100                        | 21.05              | 22.78                 |
| 90-120 cm   | 21             | 60                         | 13.82              | 13.67                 |
| 120-150 cm  | 16             | 37                         | 10.53              | 8.43                  |
| 150-180 cm  | 10             | 19                         | 6.58               | 4.33                  |
| 180-210 cm  | 7              | 14                         | 4.61               | 3.19                  |
| 210-240 cm  | 6              | 8                          | 3.95               | 1.82                  |
| 240-270 cm  | 2              | 3                          | 1.32               | 0.68                  |
| 270-300 cm  | -              | 0                          | 0.00               | 0.00                  |
| 300-330 cm  | -              | 0                          | 0.00               | 0.00                  |
| 330-360 cm  | -              | 0                          | 0.00               | 0.00                  |
| 360-390 cm  | -              | 0                          | 0.00               | 0.00                  |
| 390-420 cm  | -              | 0                          | 0.00               | 0.00                  |
| 420-450 cm  | -              | 0                          | 0.00               | 0.00                  |
| 450-480 cm  | -              | 0                          | 0.00               | 0.00                  |
| 480-510 cm  | -              | 0                          | 0.00               | 0.00                  |
| 510-540 cm  | -              | 0                          | 0.00               | 0.00                  |
| 540-570 cm  | -              | 0                          | 0.00               | 0.00                  |
| > 570 cm    | 1              | 1                          | 0.66               | 0.23                  |
| Total       | 56             | 439                        | 100.00             | 100.00                |

Tree distribution by height intervals shows that among the 439 total number of individual, 151 individuals (34.40%) belong to 3-10m category, followed by 158 individuals (35.99%) in 10-17m, 97 individuals (22.10%) in 17-24m, 31 individuals (7.06%) in 24-31m. The height class of 31-38m includes only (0.46%) of total individuals Table (6). The population structure by height classes in the Khaunglanhpu area, 3-10m class is the highest and gradually decreases to higher classes (Figure 10 and 11). The tallest individual trees were UN-5 (36m), *Alnus nepalensis* D. Don (35m), *Osbeckia* sp. (30m), *Spondias* sp. (30m), *Lithocarpus* sp. (30m), and *Castanopsis argyrophylla* King. (30m). Total picture of height class shows that, 34.40% belong to <3-10m category, 58.09% in 10-24m, and 7.52% in 24->31m. The overall population structure indicates that study area represents mature stand.

Table (6) Population density of tree species across height class interval

| Height Classes | No. of species | Total number of individual | % of total species | % of total individual |
|----------------|----------------|----------------------------|--------------------|-----------------------|
| < 3 m          | 0              | 0                          | 0.0                | 0.0                   |
| 3-10 m         | 38             | 151                        | 36.2               | 34.40                 |
| 10-17 m        | 35             | 158                        | 33.3               | 35.99                 |
| 17-24 m        | 19             | 97                         | 18.1               | 22.10                 |
| 24-31 m        | 11             | 31                         | 10.5               | 7.06                  |
| 31-38 m        | 2              | 2                          | 1.9                | 0.46                  |
| Total          | 56             | 439                        | 100.00             | 100.00                |

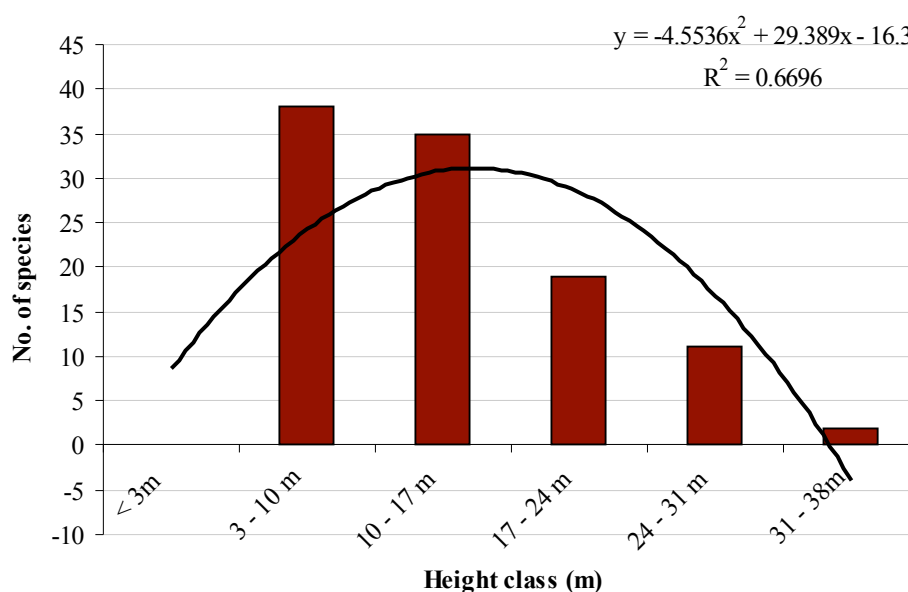


Figure (9) Species distribution by height classes

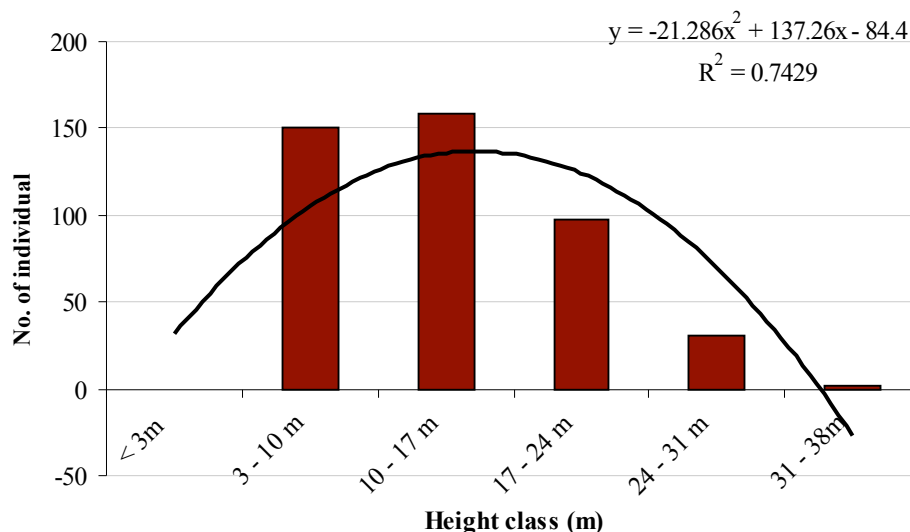


Figure (10) Population distribution by DBH classes

### 5.3. Discussion and Conclusion

A total of 56 tree species representing 41 genera and 25 families were analyzed in the study area. The main vegetation types discovered in Khaunglanphu Dam sites can be grouped into four formations, i.e. highland evergreen forest, highland secondary forest, oak forest, and bamboo forest. In some disturbed sites, degraded forests occur.

The ten leading dominants by important value index in study area were *Alnus nepalensis* D. Don, *Castanopsis diversifolia* (Kurz) King, *Castanopsis acuminatissima* (Bl.) A. DC., *Spondias* sp., *Castanopsis armata* (Roxb.) Spach. Prodr., UN-5, *Saurauia napaulensis* DC., *Ficus* sp., *Macaranga denticulata* Muell. Arg., and *Schefflera* sp. contributing highest IVI value (33.76, 21.51, 19.57, 18.38, 10.47, 10.11, 9.38, 8.76, 8.56, 8.16) respectively. Those tree species could be considered as ecological indicator species of the study area.

In some sites, the largest trees can reach up to >31m in height while the main canopy is 17-24m. The canopy of the forest is more or less sparse and in some disturbed site the canopy is open and the estimated height is probably 12 m and ground cover is dominated by *Oxalis* sp., *Begonia* sp., *Commelina* sp., and *Viola* sp..

The forest structure in the study area illustrates some types of disturbance. The surrounding of Khaunglanphu area has insufficient protection status and so shifting cultivation, firewood collection and hunting occur as common practices. Shifting cultivation is one of the main factors for habitat loss and deforestation. So the species diversity in the area is low.

The following species that recorded in the study area is assessing in IUCN Red list as follows;

| No. | Botanical Name                        | Family      | Red Lists | Year      |
|-----|---------------------------------------|-------------|-----------|-----------|
| 1.  | <i>Taiwania cryptomeriodes</i> Hayata | Taxodiaceae | VU Ald    | IUCN-2000 |

## Recommendation

1. The flooded areas of dams are narrow and damage is minimal on terrestrial ecosystem since both dams are cascade, the cumulative impact assessment of hydrology should be carried out with special attention.
2. The socioeconomic development and community awareness on environment should be planned and implemented under the project. It may support the conservation and maintenance of remaining forest.
3. To substitute the inundated forest cover by dam construction, reforestation project should be implemented.
4. Resettlement area for inundated villages should be selected in environmentally least impact area.

## Appendix (1) Ranking of Important Value Index (IVI) in the Khaunglanhpu Area

| No. | Species Name                                    | R.D. % | R.D.m % | R.F % | IVI % |
|-----|-------------------------------------------------|--------|---------|-------|-------|
| 1   | <i>Alnus nepalensis</i> D. Don                  | 8.88   | 20.50   | 4.38  | 33.76 |
| 2   | <i>Castanopsis diversifolia</i> (Kurz) King     | 7.74   | 8.14    | 5.63  | 21.51 |
| 3   | <i>Castanopsis acuminatissima</i> (Bl.) A. DC.  | 5.92   | 8.02    | 5.63  | 19.57 |
| 4   | <i>Spondias</i> sp.                             | 8.20   | 5.81    | 4.38  | 18.38 |
| 5   | <i>Castanopsis armata</i> (Roxb.) Spach. Prodr. | 2.51   | 4.84    | 3.13  | 10.47 |
| 6   | UN-5                                            | 0.23   | 9.25    | 0.63  | 10.11 |
| 7   | <i>Saurauia napaulensis</i> DC.                 | 2.96   | 2.67    | 3.75  | 9.38  |
| 8   | <i>Ficus</i> sp.                                | 4.56   | 2.96    | 1.25  | 8.76  |
| 9   | <i>Macaranga denticulata</i> Muell. Arg.        | 5.92   | 1.38    | 1.25  | 8.56  |
| 10  | <i>Schefflera</i> sp.                           | 3.64   | 0.77    | 3.75  | 8.16  |
| 11  | <i>Ficus roxburghii</i> Wall.                   | 2.05   | 1.05    | 5.00  | 8.10  |
| 12  | <i>Alseodaphne nigrescens</i> (Gamble) Kosterm. | 1.37   | 5.29    | 1.25  | 7.91  |
| 13  | <i>Osbeckia</i> sp.1                            | 2.73   | 4.14    | 0.63  | 7.50  |
| 14  | <i>Saurauia roxburghii</i> Wall.                | 2.28   | 2.71    | 2.50  | 7.48  |
| 15  | <i>Chisocheton siamensis</i> Craib              | 1.37   | 1.81    | 3.75  | 6.93  |
| 16  | <i>Grewia</i> sp.                               | 4.56   | 0.45    | 1.25  | 6.25  |
| 17  | <i>Macaranga diversifolia</i>                   | 0.46   | 0.15    | 5.63  | 6.23  |
| 18  | <i>Castanopsis argyrophylla</i> King.           | 1.37   | 3.22    | 1.25  | 5.84  |
| 19  | <i>Lithocarpus</i> sp.                          | 2.05   | 2.38    | 0.63  | 5.06  |
| 20  | <i>Engelhardtia spicata</i> Blume               | 0.68   | 1.06    | 3.13  | 4.86  |
| 21  | <i>Caryota gigas</i> Hahn ex hodel              | 0.91   | 1.96    | 1.88  | 4.74  |
| 22  | <i>Glochidion</i> sp.                           | 0.91   | 0.06    | 3.75  | 4.72  |
| 23  | <i>Lithocarpus craibianus</i> barn.             | 0.46   | 1.58    | 2.50  | 4.53  |
| 24  | <i>Macaranga kurzii</i> (O.k.) Pax & Hoffm.     | 3.19   | 0.55    | 0.63  | 4.36  |
| 25  | <i>Litsea cubeba</i> (Lour.) Pers.              | 1.82   | 0.64    | 1.88  | 4.34  |
| 26  | <i>Albizia odoratissima</i> (L.f.) Benth.       | 0.91   | 2.10    | 1.25  | 4.26  |

| No.   | Species Name                                        | R.D. % | R.D.m % | R.F %  | IVI %  |
|-------|-----------------------------------------------------|--------|---------|--------|--------|
| 27    | UN-2                                                | 1.82   | 0.27    | 1.88   | 3.97   |
| 28    | <i>Amoora rohituka</i> W.& A.                       | 1.37   | 0.52    | 1.88   | 3.77   |
| 29    | <i>Cinnamomum</i> sp.                               | 1.82   | 0.45    | 1.25   | 3.53   |
| 30    | <i>Trema orientalis</i> (L.) Blume                  | 1.14   | 0.28    | 1.88   | 3.29   |
| 31    | <i>Callicarpa</i> sp.                               | 0.91   | 0.23    | 1.88   | 3.02   |
| 32    | <i>Cinnamomum</i> sp.2                              | 1.82   | 0.23    | 0.63   | 2.68   |
| 33    | <i>Elaeocarpus</i> sp.1                             | 1.14   | 0.21    | 1.25   | 2.60   |
| 34    | <i>Caryota urens</i> L.                             | 1.14   | 0.15    | 1.25   | 2.54   |
| 35    | <i>Symplocos macrophylla</i> Wight.                 | 1.14   | 0.02    | 1.25   | 2.41   |
| 36    | <i>Hydrangea aspera</i> D. Don                      | 0.91   | 0.07    | 1.25   | 2.23   |
| 37    | <i>Macaranga</i> sp.                                | 0.23   | 0.13    | 1.88   | 2.23   |
| 38    | <i>Michelia champaca</i> L.                         | 0.91   | 0.61    | 0.63   | 2.15   |
| 39    | UN-6                                                | 0.68   | 0.70    | 0.63   | 2.01   |
| 40    | <i>Elaeagnus montana</i> Makino                     | 0.68   | 0.02    | 1.25   | 1.96   |
| 41    | <i>Albizia</i> sp.                                  | 0.68   | 0.63    | 0.63   | 1.94   |
| 42    | <i>Quercus</i> sp.                                  | 0.68   | 0.58    | 0.63   | 1.89   |
| 43    | <i>Machilus</i> sp.                                 | 0.68   | 0.45    | 0.63   | 1.76   |
| 44    | UN-7                                                | 0.46   | 0.02    | 1.25   | 1.73   |
| 45    | <i>Elaeocarpus</i> sp.2                             | 0.46   | 0.33    | 0.63   | 1.41   |
| 46    | UN-3                                                | 0.68   | 0.03    | 0.63   | 1.34   |
| 47    | <i>Agave sisalana</i> Perr.                         | 0.46   | 0.15    | 0.63   | 1.23   |
| 48    | UN-1                                                | 0.46   | 0.10    | 0.63   | 1.18   |
| 49    | <i>Alstonia angustifolia</i> Wall.                  | 0.46   | 0.00    | 0.63   | 1.08   |
| 50    | <i>Vitex</i> sp.                                    | 0.23   | 0.13    | 0.63   | 0.98   |
| 51    | <i>Antidesma</i> sp.                                | 0.23   | 0.05    | 0.63   | 0.90   |
| 52    | <i>Cordia myxa</i> L.                               | 0.23   | 0.04    | 0.63   | 0.89   |
| 53    | <i>Castanopsis calathiformis</i> (Skan) Resd & Wils | 0.23   | 0.04    | 0.63   | 0.89   |
| 54    | UN-4                                                | 0.23   | 0.02    | 0.63   | 0.87   |
| 55    | <i>Osbeckia</i> sp.2                                | 0.23   | 0.01    | 0.63   | 0.86   |
| 56    | <i>Clerodendrum</i> sp.                             | 0.23   | 0.00    | 0.63   | 0.85   |
| Total |                                                     | 100.00 | 100.00  | 100.00 | 300.00 |

## Chapter VI

### 6. Lasa Dam

#### 6.1. Study area

The location of Lasa area is 26° 28' N and 97° 49' E and 144.2 km away from the confluence at Myitsone. From biodiversity standpoint, the study area lies in WWF Eco-regions of Mizoram-Manipur-Kachin moist evergreen forest and Northern Triangle Subtropical forest-Myanmar. The watershed areas of Lasa Dam are Hukaung Valley W.S and its extension and Bumphabum W.S., which are biodiversity hotspot and outstanding area of conservation. A detailed map of the study area is given in figure (1.5).

**6.1.1. Participants:** Dr Win Myint, Daw Khin Swe Lwin, and Daw Ei Ei Phyto, and U Nay Phyto Aung.

#### 6.2. Results

##### 6.2.1. Forest composition

To clarify the tree species composition and their distribution, eight quadrats (20x20 m each) were set up and observed in the flooded area of Lasa dam site. In the eight sampling plots (.32ha), total number of species with DBH  $\geq 3$ cm was 77 species; of which 26 species are under identification. The dominant families of tree species were Euphorbiaceae (11 species), Fagaceae (5 species), Dipterocarpaceae (4 species), Moraceae (4 species) Figure (3). The main vegetation types discovered in Lasa Dam site can be grouped into four formations; low land evergreen forest, oak forest, low land secondary forest, and bamboo forest. Due to the human impact degraded forest occurs in most of the places. In some disturbed sites, wild banana and bushes can be seen in patches. Low land evergreen forests typically distinguished by *Itea macrophyll.*, *Dipterocarpus sp.*, *Litsea sp.*, *Mallotus paniculatus*, *Spondias sp.* are mainly found in tree layer. Ground layer is dominated by *Urena sp.*, *Commelina sp.*, *Gnetum sp.*, *Molineria capitulata.*, *Begonia sp.*, *Phrynium capitatum*. Oak forest mainly composed of *Lithocarpus sp.*, *Quercus sp.*, *Castanopsis sp.*, associate with *Garcinia sp.*, *Chisocheton siamensis* are found in tree layer. Ground layer is dominated by *Melastoma sp.*, *Smilax sp.*, *Lepidagathis sp.*, and *Urena sp.* In the low land secondary forest, *Cinnamomum sp.*, *Myristica angustifolia*, *Chisocheton siamensis* and *Macaranga kurzii*, *Mallotus sp.* are mainly found in tree layer. Ground layer is dominated by *Dracaena sp.*, *Wallichia siamensis*, *Clerodendrum sp.*, *Piper sp.*, and *Commelina sp.* In the bamboo forest *Dendrocalamus hamiltonii* Ness (Wabo Myatsan), *D. giganteus* Munro (Wabowa), and *Bambusa sp.* mainly occur.

The species area curves of the investigated stands are shown in the figure (4). The species area curves, which express the number of species in relation to change in area of habitat, not only to consider the minimum representative area but also to detect the habitat diversity within the survey area (Fangliang He and Pierre Legendre, 1996). The trend of species area curve shows tendency towards flattening. Therefore the sample areas can be said to be sufficient as a minimum representative area for the study.

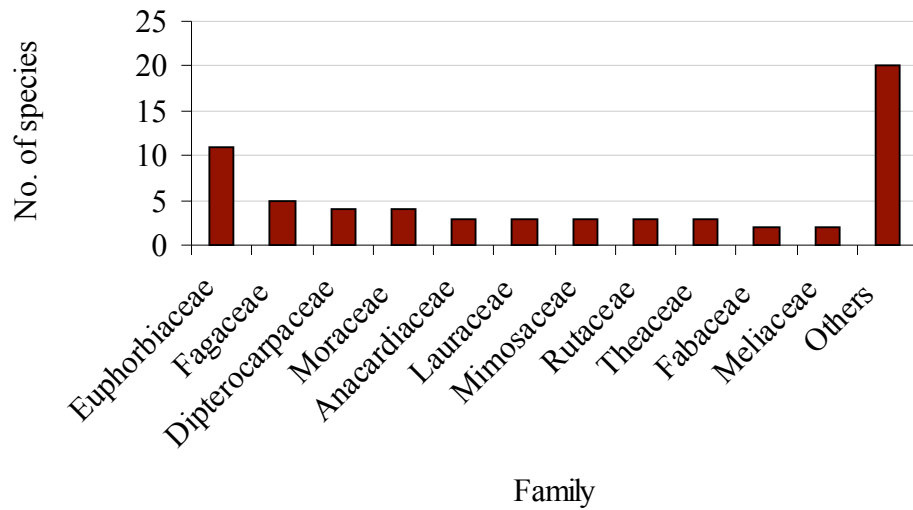


Figure (2) Ranking of dominant family by number of species composition

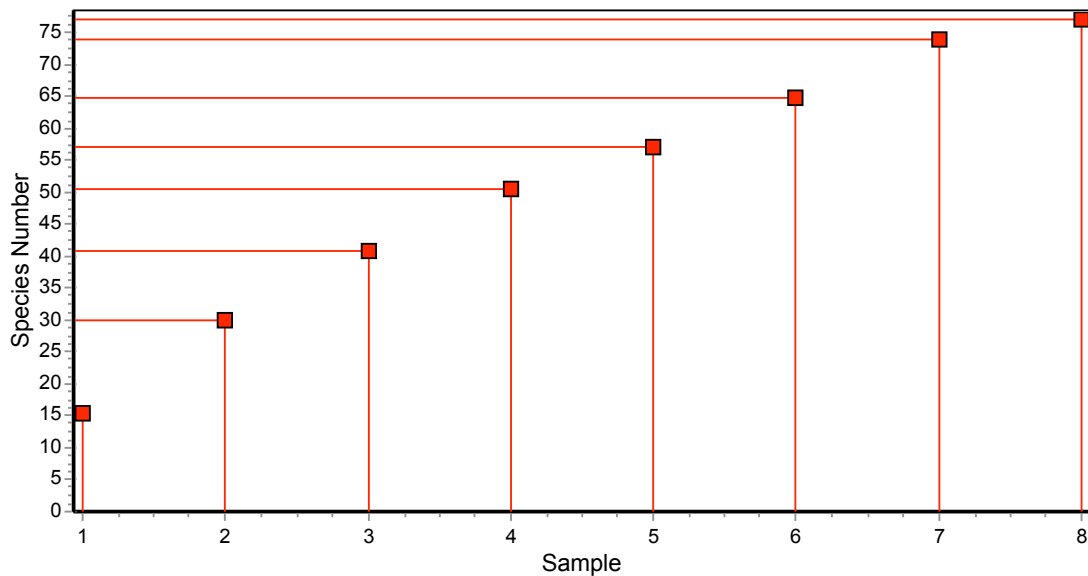


Figure (3) Plot of species accumulation in the Lasar Dam Site

### 6.2.2. Important Value Index (IVI)

Ranking of ecological significance by IVI of tree species in the study area are given in appendix (1). The tree layer in the study area is dominated by *Castanopsis* sp. with the highest IVI of 25.88%, the second most dominant species is *Schima wallichii* (DC.) Korth. (IVI = 16.21%) and *Cinnamomum* sp. (IVI= 14.88%) is third. Ecologically dominance of top ten species based on IVI value is shown in figure 4. Those species could be considered as ecological indicator species of Lasa area. The number of species greater than 5% IVI value was only sixteen species (Appendix 1).

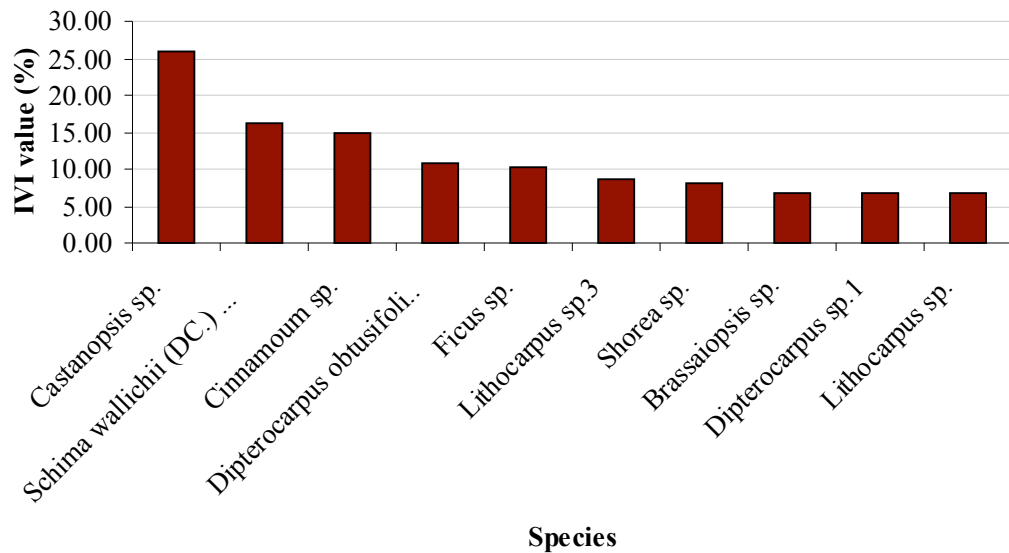


Figure (4) Important Value Index of top ten species in the Lasar Dam Site

### 6.2.3. Species distribution by frequency classes

In order to clarify the homogeneity or heterogeneity of the floristic distribution in the study area, species distribution by frequency classes was examined. According to the outcome of frequency chart, 94.8% of the total number of species was in lower frequency classes, A and B, while low value was observed only in higher frequency classes C and D (Table 1, Figure 5). It indicates that the forest in Lasa area is floristically heterogeneous, according to Lamprecht (1989). The species which fall in high frequency class D was *Ficus* sp., *Castanopsis* sp., and *Cinnamomum* sp.. These species can be considered as the most common species in the Lasa area.

Table (1) Species distribution by frequency classes  $\geq 3\text{cm}$

| Frequency Class | Frequency range | No. of species | % of total species frequency distribution |
|-----------------|-----------------|----------------|-------------------------------------------|
| A               | 1 – 20 %        | 43             | 55.84                                     |
| B               | 21 – 40 %       | 30             | 38.96                                     |
| C               | 41 – 60 %       | 1              | 1.30                                      |
| D               | 61 – 80 %       | 3              | 3.90                                      |
| E               | 81 – 100 %      | 0              | 0.00                                      |

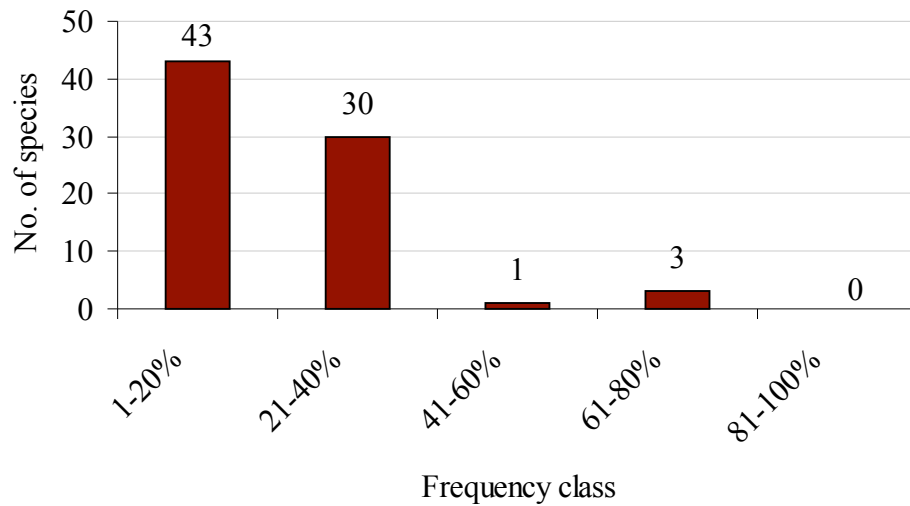


Figure (5) Species distribution by frequency classes  $\geq 3\text{cm}$

#### 6.2.4. Diversity indices and evenness

Among the different measurement of species diversity indices, the floristic diversity of the Lasa area was analyzed using the Shannon Wiener index (H), Simpsons index (D), Brillouin (D), Shannon Maximum and minimum evenness (E), Brillouin (E) because these indices not only take taxa richness into account but also depend on the relative distribution of individuals. The value of diversity indices and evenness indices of individual sample plot and all sample indices are shown in table (2) and (3). According to the result, though the diversity indices of individual sample plot are not too high, all sample index are relatively high. Diversity value for all sample index of Shannon Wiener index (H) is 4.049, Simpsons index (D) is 51.95, and Brillouin (D) is 3.687.

Table (2) Species diversity indices in the Lasa Dam site

| Sample              | Shannon Wiener H | Variance H | Simpsons Index (D) | Brillouin (D) |
|---------------------|------------------|------------|--------------------|---------------|
| LSR 1               | 2.631            | 0.011      | 21.57              | 2.104         |
| LSR 2               | 2.770            | 0.013      | 23.33              | 2.217         |
| LSR 3               | 2.526            | 0.008      | 13.67              | 2.157         |
| LSR 4               | 2.654            | 0.007      | 20.58              | 2.186         |
| LSR 5               | 1.791            | 0.013      | 6.407              | 1.495         |
| LSR 6               | 2.770            | 0.010      | 25.2               | 2.229         |
| LSR 7               | 3.102            | 0.012      | 37.43              | 2.466         |
| LSR 8               | 2.881            | 0.010      | 25.08              | 2.345         |
| All Sample Index    | 4.049            |            | 51.95              | 3.687         |
| Jackknife Std Error | 0.146            |            | 9.377              | 0.1127        |

Table (3) Evenness indices in the Lasa Dam site

| Sample              | Shannon Maximum | Shannon Minimum | Simpson Evenness (E) | Brillouin (E) |
|---------------------|-----------------|-----------------|----------------------|---------------|
| LSR 1               | 2.708           | 1.84            | 1.438                | 0.9765        |
| LSR 2               | 2.89            | 2.03            | 1.296                | 0.959         |
| LSR 3               | 2.708           | 1.293           | 0.9113               | 0.9364        |
| LSR 4               | 2.708           | 1.6             | 1.372                | 0.9873        |
| LSR 5               | 1.946           | 0.9035          | 0.9153               | 0.9172        |
| LSR 6               | 2.833           | 1.919           | 1.482                | 0.9816        |
| LSR 7               | 3.219           | 2.499           | 1.497                | 0.977         |
| LSR 8               | 2.996           | 1.987           | 1.254                | 0.9663        |
| All Sample Index    | 4.344           | 1.627           | 0.6747               | 0.9338        |
| Jackknife Std Error | 0.133           | 0.217           | 0.0742               | 0.013         |

### 6.2.5. Forest structure

Stem density of  $\geq 3\text{cm}$  was  $963\text{ha}^{-1}$  and basal area was  $44.5\text{ m}^2/\text{ha}$  in the Lasa dam site Table (4). Among the 8 sample plots studies, 77 tree species were recorded. Only one individual of 15 species were found and these species were considered as unique species.

The 10 most abundance species in terms of basal area occupied 62.15% of the total, of which *Castanopsis* sp. was the most dominant species in the study area with 15.81%, followed by *Schima wallichii* (DC.) Korth 11.66 %, *Dipterocarpus obtusifolius* Teysm.ex.Mig. 8.03%, *Dipterocarpus* sp.1 5.43%, *Cinnamomum* sp. 4.81%, *Lithocarpus* sp.3 4.13%, *Lithocarpus* sp. 2.76%, *Lithocarpus* sp.1 2.47%, and *Dipterocarpus* sp.2 2.36%, of the total basal area (Figure (6)).

Table (4) Consolidated detail of species inventory in the Lasa Dam site

| Description                           | Results |
|---------------------------------------|---------|
| No. of sample points                  | 8       |
| No. of tree species                   | 77      |
| Density (stem/ha)                     | 963     |
| Basal area ( $\text{m}^2/\text{ha}$ ) | 44.5    |
| Total No. of unique species           | 15      |

The distribution of the basal area across DBH interval classes reveals the dominance of small stemmed individuals in the study area. The population structure by DBH class decreased from class to class with a steeper gradient in lower DBH classes and with a gentle slope in higher classes Figure (8) and Table (5). Out of total number of stems inventoried, 52.92% of stems were accumulated in the 3-60cm DBH class, 39.28% of stems in the 60-150cm, and 7.8% in the 150-240cm. The highest DBH was measured in the case of *Dipterocarpus* sp.1 (230cm), *Knema* sp. (200cm), *Dipterocarpus obtusifolius* Teysm.ex.Mig. (200cm), *Castanopsis* sp. (200cm).

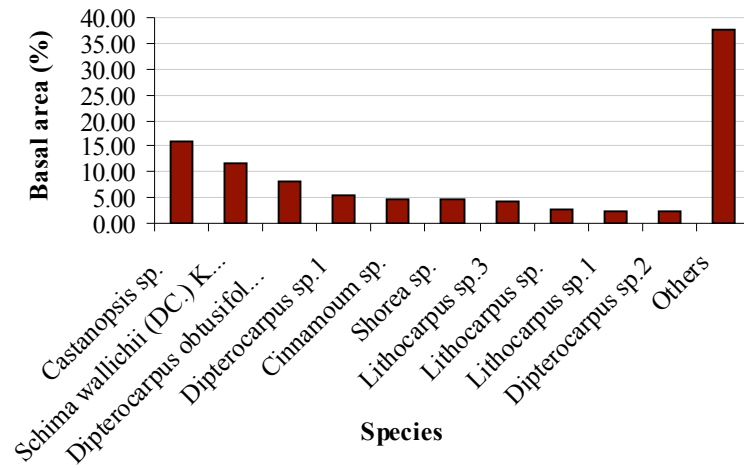


Figure (6) Ranking of relative basal area by species in the Lasa Dam site

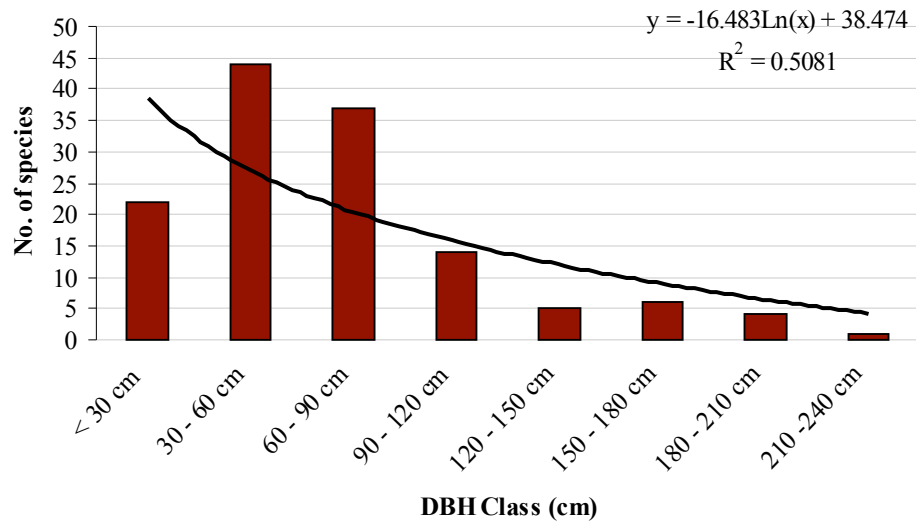


Figure (7) Species distribution by DBH classes

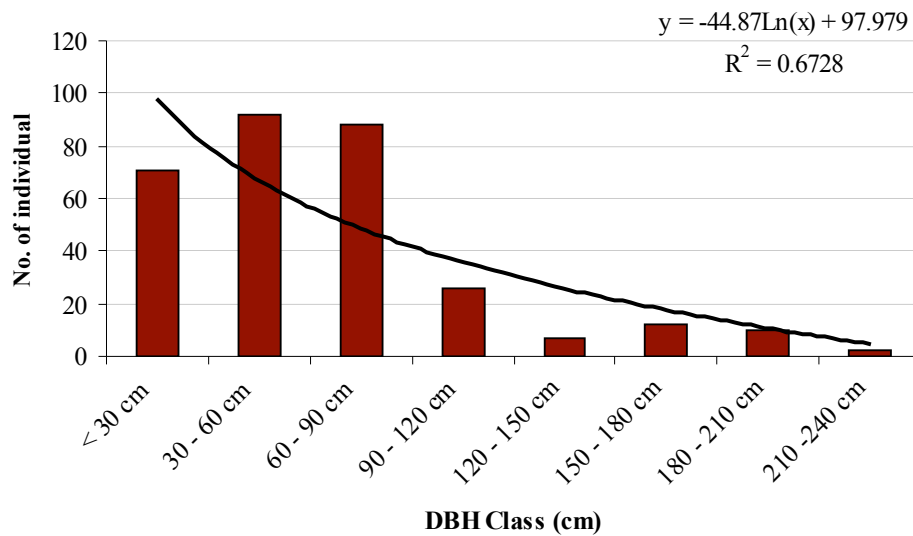


Figure (8) Population distribution by DBH classes

Table (5) Population density of tree species across DBH class interval

| DBH Classes | No. of species | Total number of individual | % of total species | % of total individual |
|-------------|----------------|----------------------------|--------------------|-----------------------|
| < 30 cm     | 22             | 71                         | 16.54              | 23.05                 |
| 30-60 cm    | 44             | 92                         | 33.08              | 29.87                 |
| 60-90 cm    | 37             | 88                         | 27.82              | 28.57                 |
| 90-120 cm   | 14             | 26                         | 10.53              | 8.44                  |
| 120-150 cm  | 5              | 7                          | 3.76               | 2.27                  |
| 150-180 cm  | 6              | 12                         | 4.51               | 3.90                  |
| 180-210 cm  | 4              | 10                         | 3.01               | 3.25                  |
| 210-240 cm  | 1              | 2                          | 0.75               | 0.65                  |
| Total       | 77             | 308                        | 100.00             | 100.00                |

Tree distribution by height intervals shows that among the total number of 308 individuals, 160 individuals (51.30%) belong to 3-10m category, followed by 89 individuals (28.90%) in 10-17m, and 52 individuals (16.88%) in 17-24m. The height class of 24-31m includes only (2.27%) of total individuals (Table (6)). <3m high trees of 2 individuals (0.65%) infer natural regeneration is poor or frequent disturbance on ground cover plant. The population structure by height classes in the Lasa area is highest in 3-10m class and gradually decreases to higher classes (Figure 9 and 10). The tallest individual trees were *Schima wallichii* (DC.) Korth. (25m), *Lithocarpus* sp. (25m), *Dipterocarpus* sp.1(25m), *Dipterocarpus* sp.2 (25m), *Castanopsis* sp. (25m), and *terminalia* sp. (20m). Total picture of height class shows that, 51.95% belong to <3-10m category, 45.78% in 10-24m, and 0.65% in 24-31m. The overall population structure indicates that study area was strongly influenced by human impact.

Table (6) Population density of tree species across height class interval

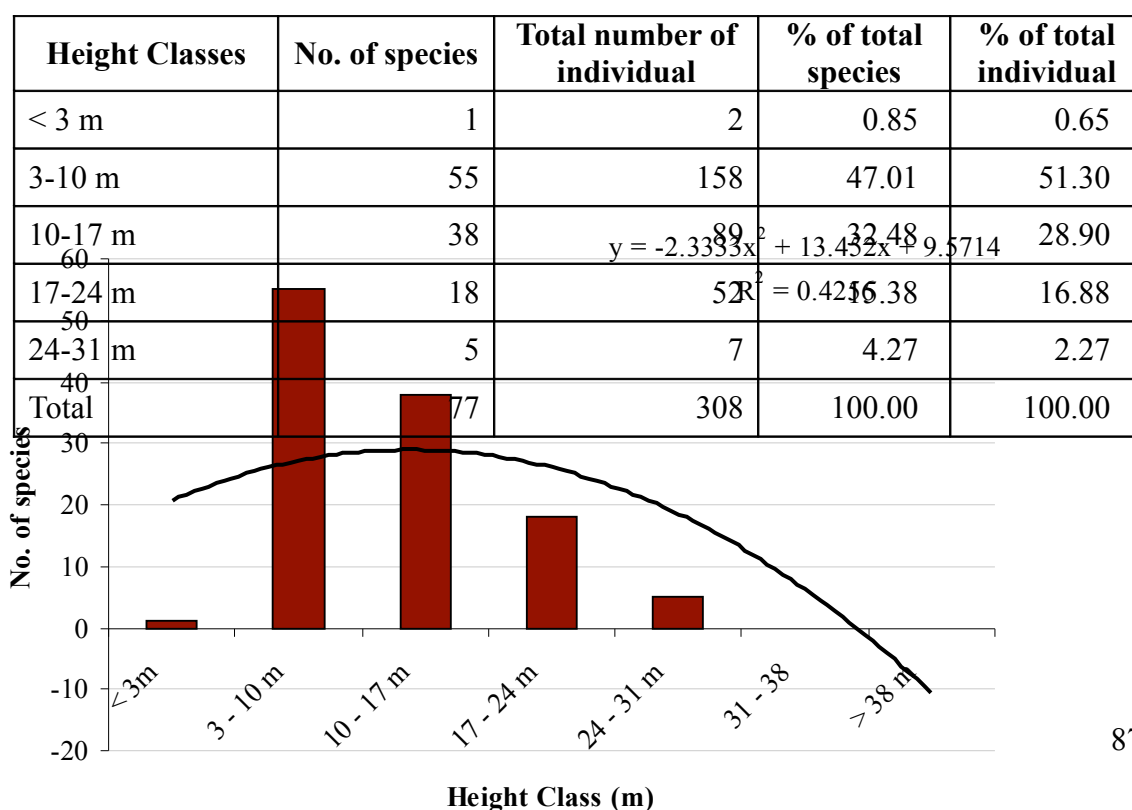


Figure (9) Species distribution by height classes

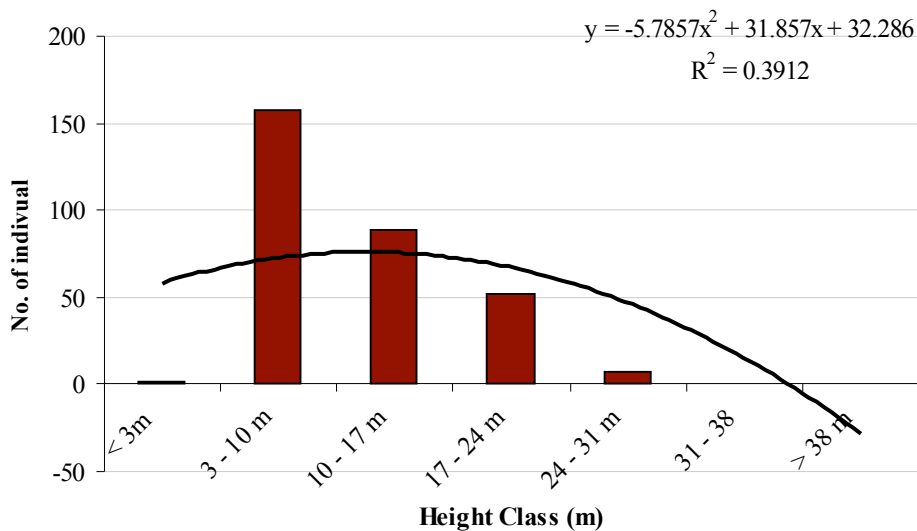


Figure (10) Population distribution by DBH classes

### 6.3. Discussion and Conclusion

A total of 77 tree species representing 64 genera and 28 families were analyzed in the study area. The main vegetation types discovered in Lasa Dam site can be grouped into four formations, i.e. low land evergreen forest, oak forest, lowland secondary forest, and bamboo forest. In some disturbed sites, degraded forests which generally composed of *Solanum* sp., *Melastoma* sp., *Clerodendron fragrans* and wild banana can be seen as patches.

The important value index indicates the extent of dominance of a species in the structure of a forest stand (Curtis and McIntosh, 1950). It is stated that species with the greatest important value are the leading dominants of the forest. Accordingly, the ten leading dominants in study area were *Castanopsis* sp., *Schima wallichii* (DC.) Korth., *Cinnamomum* sp., *Dipterocarpus obtusifolius* Teysm.ex.Mig., *Ficus* sp., *Lithocarpus* sp.3, *Shorea* sp., *Brassaiopsis* sp., *Dipterocarpus* sp.1, and *Lithocarpus* sp., contributing highest IVI value (25.88, 16.21, 14.88, 10.84, 10.31, 8.68, 8.04, 6.83, 6.83, 6.66)

respectively. Those tree species could be considered as ecological indicator species of the study area.

In mature site, the largest trees can reach up to 25m in height while the main canopy is 17-24m with poor ground cover. The canopy of the forest is more or less close, but in some disturbed sites, the canopy is open and the estimated height was probably not more than 10m with stunted tree species.

The forest structures in the study area show all types of disturbance. The surrounding of Lasa area has an insufficient protection status that allows the exploitation of natural resources; such as logging, hunting, gold mining, and shifting cultivation. The major crops cultivated in shifting cultivation are *Canna* sp., *Brassica* sp., *Zea mays*, *Oryza indicum*. Gold mining is the chief destructive force and one of the influencing factors for ecosystem.

The following species that recorded in the study area assessed in IUCN Red list as follows;

| No. | Botanical Name                            | Family           | Red Lists      | Year      |
|-----|-------------------------------------------|------------------|----------------|-----------|
| 1.  | <i>Aquilaria malaccensis</i> Lam.         | Thymeliaceae     | VU Alcd        | IUCN-2000 |
| 2.  | <i>Dipterocarpus turbinatus</i> Gaertn.f. | Dipterocarpaceae | CR Alcd+2cd    | IUCN-2000 |
| 3.  | <i>Shorea assamica</i> Dyer               | Dipterocarpaceae | CR Alcd, B1+2c | IUCN-2000 |

#### 6.4. Recommendation

1. The socioeconomic development and community awareness on environment should be planned and implemented under the project. It may support the conservation and maintenance of remaining forest.
2. Reforestation project should be implemented to substitute the inundated forest cover and to balance the forest ecosystem services lost by dam construction.
3. Resettlement area for inundated villages should be selected in environmentally least impact area.
4. Infrastructure development as well as new access road from Myitkyina to Putao should be carried out with great care and it should have minimal impacts on environment, social and cultural aspects of the indigenous people.

One or more compensatory protected area should be established and managed under the project. The remaining forest cover should be systematically managed and conserved since the action not only maintain the watershed area but also support the biodiversity rich ecosystem.

### Appendix (1) Ranking of Important Value Index (IVI) in the Lasa Area

| No. | Species Name                                    | R.D. % | R.D.m % | R.F % | IVI % |
|-----|-------------------------------------------------|--------|---------|-------|-------|
| 1   | <i>Castanopsis</i> sp.                          | 5.52   | 15.81   | 4.55  | 25.88 |
| 2   | <i>Schima wallichii</i> (DC.) Korth.            | 2.27   | 11.66   | 2.27  | 16.21 |
| 3   | <i>Cinnamomum</i> sp.                           | 5.52   | 4.81    | 4.55  | 14.88 |
| 4   | <i>Dipterocarpus obtusifolius</i> Teysm.ex.Mig. | 1.30   | 8.03    | 1.52  | 10.84 |
| 5   | <i>Ficus</i> sp.                                | 4.55   | 1.98    | 3.79  | 10.31 |
| 6   | <i>Lithocarpus</i> sp.3                         | 2.27   | 4.13    | 2.27  | 8.68  |
| 7   | <i>Shorea</i> sp.                               | 2.60   | 4.68    | 0.76  | 8.04  |
| 8   | <i>Brassaiopsis</i> sp.                         | 3.57   | 0.23    | 3.03  | 6.83  |
| 9   | <i>Dipterocarpus</i> sp.1                       | 0.65   | 5.43    | 0.76  | 6.83  |
| 10  | <i>Lithocarpus</i> sp.                          | 1.62   | 2.76    | 2.27  | 6.66  |
| 11  | <i>Spondias</i> sp.                             | 2.60   | 1.72    | 2.27  | 6.59  |
| 12  | <i>Erythrina</i> sp.                            | 2.27   | 1.69    | 2.27  | 6.24  |
| 13  | <i>Mallotus</i> sp.                             | 2.92   | 1.47    | 1.52  | 5.90  |
| 14  | <i>Vernonia arborea</i> Buch-Ham.               | 1.95   | 2.34    | 1.52  | 5.80  |
| 15  | <i>Macaranga kurzii</i> (O.k.) Pax & Hoffm.     | 2.27   | 1.14    | 2.27  | 5.69  |
| 16  | <i>Osbeckia</i> sp.                             | 2.92   | 0.06    | 2.27  | 5.25  |
| 17  | UN-12                                           | 2.92   | 0.26    | 1.52  | 4.70  |
| 18  | UN-2                                            | 1.95   | 1.23    | 1.52  | 4.70  |
| 19  | <i>Mallotus paniculatus</i> Muell. Arg.         | 2.27   | 0.89    | 1.52  | 4.68  |
| 20  | <i>Bischofia</i> sp.                            | 1.62   | 1.47    | 1.52  | 4.61  |
| 21  | <i>Dipterocarpus</i> sp.2                       | 0.97   | 2.36    | 0.76  | 4.10  |
| 22  | UN-10                                           | 2.27   | 0.22    | 1.52  | 4.01  |
| 23  | <i>Lithocarpus</i> sp.1                         | 0.65   | 2.47    | 0.76  | 3.88  |
| 24  | UN-1                                            | 1.62   | 0.67    | 1.52  | 3.80  |
| 25  | <i>Actinodaphne</i> sp.                         | 1.95   | 0.34    | 1.52  | 3.80  |
| 26  | UN-19                                           | 1.62   | 0.59    | 1.52  | 3.73  |
| 27  | <i>Knema</i> sp.                                | 0.65   | 2.25    | 0.76  | 3.66  |
| 28  | <i>Macaranga denticulata</i> Muell. Arg.        | 0.97   | 0.36    | 2.27  | 3.61  |
| 29  | UN-8                                            | 1.30   | 1.55    | 0.76  | 3.61  |
| 30  | <i>Chisocheton siamensis</i> Craib              | 1.30   | 0.72    | 1.52  | 3.54  |
| 31  | UN-18                                           | 1.62   | 0.32    | 1.52  | 3.46  |
| 32  | <i>Dalbergia</i> sp.                            | 1.30   | 0.43    | 1.52  | 3.25  |
| 33  | <i>Lithocarpus</i> sp.2                         | 0.97   | 1.50    | 0.76  | 3.23  |
| 34  | UN-15                                           | 1.30   | 0.30    | 1.52  | 3.11  |
| 35  | <i>Glochidion</i> sp.                           | 0.97   | 0.47    | 1.52  | 2.96  |
| 36  | UN-13                                           | 1.30   | 0.07    | 1.52  | 2.88  |
| 37  | <i>Cordia myxa</i> L.                           | 0.65   | 1.27    | 0.76  | 2.68  |
| 38  | <i>Phoebe</i> sp.                               | 0.65   | 0.42    | 1.52  | 2.58  |
| 39  | <i>Gordonia</i> sp.                             | 1.62   | 0.20    | 0.76  | 2.58  |
| 40  | <i>Albizia</i> sp.                              | 0.65   | 0.40    | 1.52  | 2.57  |
| No. | Species Name                                    | R.D. % | R.D.m % | R.F % | IVI % |

|    |                                              |        |        |        |        |
|----|----------------------------------------------|--------|--------|--------|--------|
| 41 | <i>Ardisia</i> sp.                           | 0.97   | 0.05   | 1.52   | 2.54   |
| 42 | <i>Syzygium</i> sp.                          | 0.65   | 0.35   | 1.52   | 2.52   |
| 43 | <i>Saurauia</i> sp.                          | 0.65   | 0.33   | 1.52   | 2.49   |
| 44 | UN-9                                         | 1.30   | 0.38   | 0.76   | 2.44   |
| 45 | <i>Itea macrophylla</i> Wall.                | 0.97   | 0.68   | 0.76   | 2.41   |
| 46 | <i>Terminalia</i> sp.                        | 0.65   | 1.00   | 0.76   | 2.41   |
| 47 | <i>Ficus</i> sp.1                            | 0.97   | 0.62   | 0.76   | 2.36   |
| 48 | UN-23                                        | 0.65   | 0.76   | 0.76   | 2.16   |
| 49 | UN-14                                        | 0.65   | 0.68   | 0.76   | 2.09   |
| 50 | UN-11                                        | 0.97   | 0.30   | 0.76   | 2.03   |
| 51 | UN-6                                         | 0.97   | 0.26   | 0.76   | 1.99   |
| 52 | UN-16                                        | 0.97   | 0.19   | 0.76   | 1.92   |
| 53 | UN-7                                         | 0.97   | 0.15   | 0.76   | 1.88   |
| 54 | <i>Phyllanthus</i> sp.                       | 0.65   | 0.46   | 0.76   | 1.87   |
| 55 | <i>Macaranga gigantea</i> (Rchb. F. & Zoll.) | 0.65   | 0.35   | 0.76   | 1.76   |
| 56 | <i>Sterculia macrophylla</i> Vent.           | 0.65   | 0.34   | 0.76   | 1.74   |
| 57 | <i>Sloanea</i> sp.                           | 0.65   | 0.26   | 0.76   | 1.67   |
| 58 | UN-5                                         | 0.65   | 0.19   | 0.76   | 1.60   |
| 59 | <i>Alangium</i> sp.                          | 0.32   | 0.50   | 0.76   | 1.59   |
| 60 | UN-17                                        | 0.65   | 0.16   | 0.76   | 1.57   |
| 61 | <i>Zanthoxylum</i> sp.                       | 0.65   | 0.12   | 0.76   | 1.53   |
| 62 | UN-22                                        | 0.65   | 0.12   | 0.76   | 1.53   |
| 63 | <i>Calusena</i> sp.                          | 0.65   | 0.11   | 0.76   | 1.52   |
| 64 | <i>Saurauia</i> sp.4                         | 0.32   | 0.41   | 0.76   | 1.50   |
| 65 | UN-20                                        | 0.32   | 0.40   | 0.76   | 1.49   |
| 66 | <i>Cedrela sinensis</i> (Juss.) Roem         | 0.32   | 0.36   | 0.76   | 1.44   |
| 67 | UN-4                                         | 0.32   | 0.31   | 0.76   | 1.40   |
| 68 | <i>Limonia</i> sp.                           | 0.32   | 0.26   | 0.76   | 1.34   |
| 69 | <i>Bredelia</i> sp.                          | 0.32   | 0.22   | 0.76   | 1.30   |
| 70 | UN-24                                        | 0.32   | 0.21   | 0.76   | 1.29   |
| 71 | UN-21                                        | 0.32   | 0.16   | 0.76   | 1.25   |
| 72 | UN-26                                        | 0.32   | 0.15   | 0.76   | 1.23   |
| 73 | <i>Ficus roxburghii</i> Wall.                | 0.32   | 0.14   | 0.76   | 1.22   |
| 74 | <i>Ficus hirta</i> Vahl.                     | 0.32   | 0.11   | 0.76   | 1.20   |
| 75 | UN-3                                         | 0.32   | 0.09   | 0.76   | 1.17   |
| 76 | UN-25                                        | 0.32   | 0.06   | 0.76   | 1.14   |
| 77 | <i>Albizia</i> sp.2                          | 0.32   | 0.02   | 0.76   | 1.10   |
|    | Total                                        | 100.00 | 100.00 | 100.00 | 300.00 |

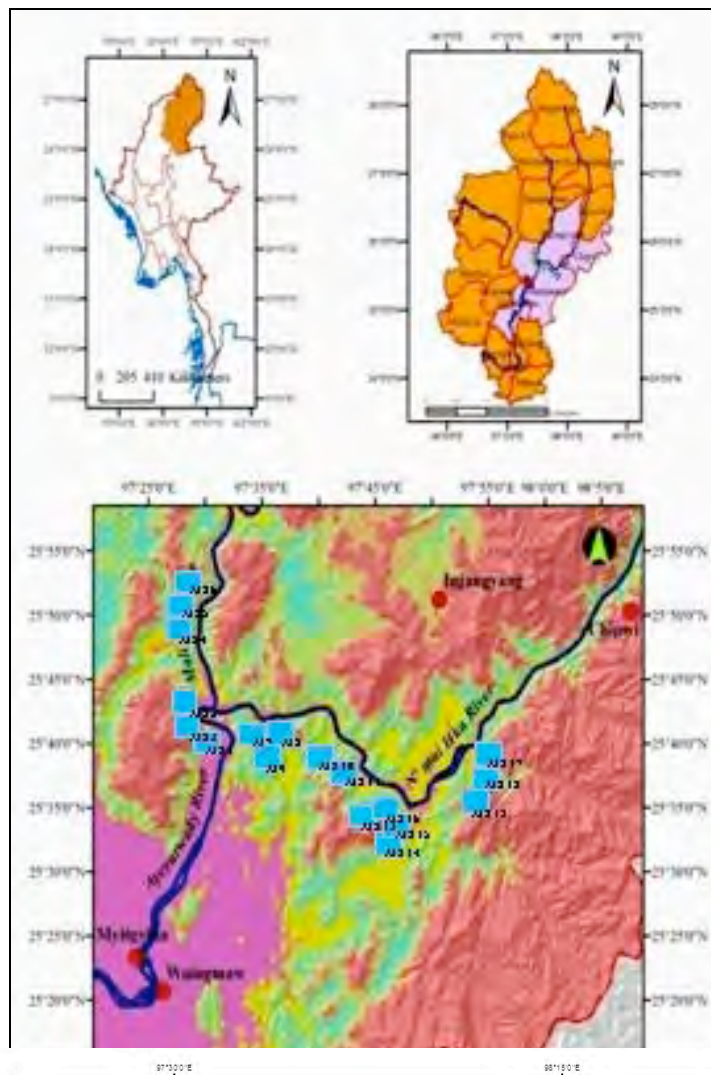
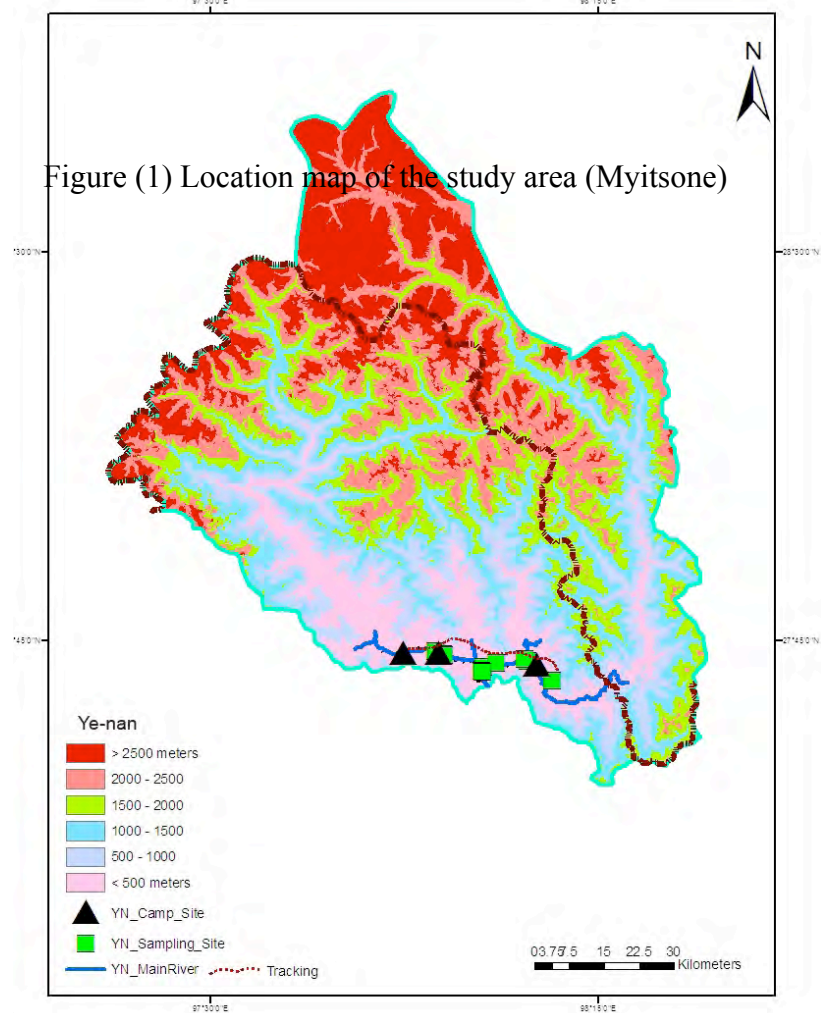


Figure (1) Location map of the study area (Myitsone)



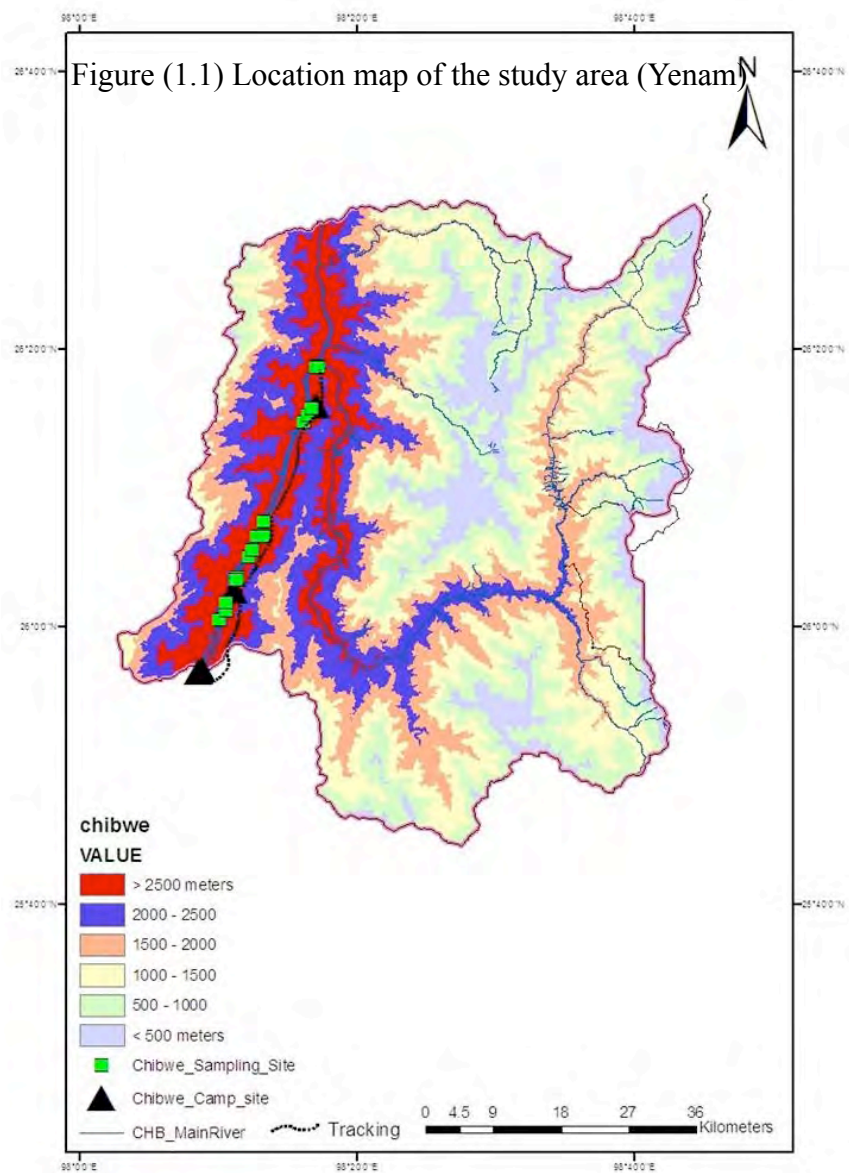


Figure (1.2) Location map of the study area (Chibwe)

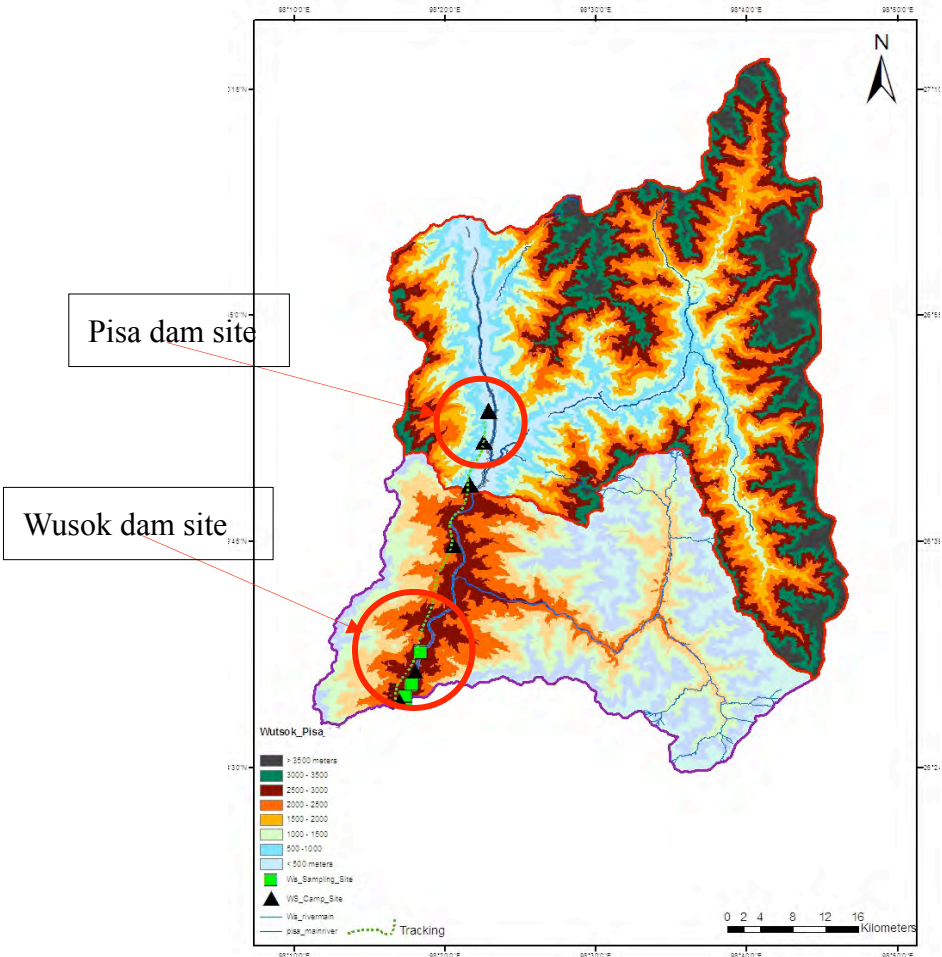


Figure (1.3) Location map of the study area (Pisa & Wusok)

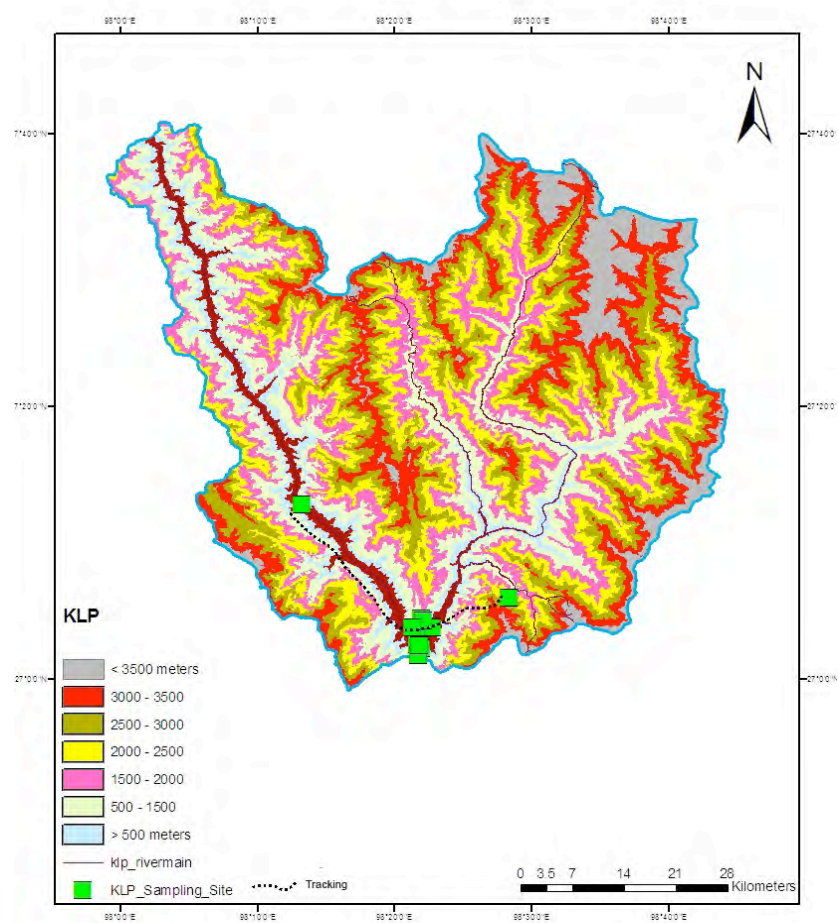


Figure (1.4) Location map of the study area (Khaunglanhpu)

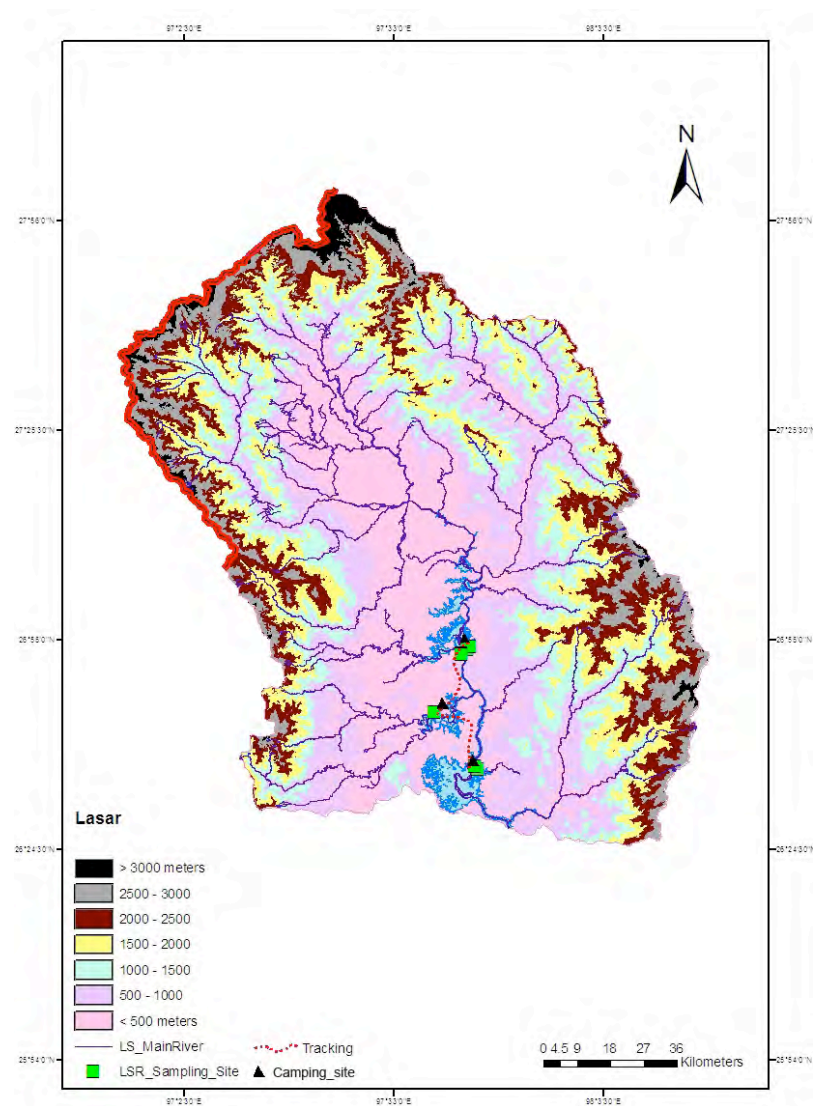


Figure (1.5) Location map of the study area (Lasa)

#### **List of Plates (Myitsone)**



Plate – 1 Primary forest in Myitsone



Plate – 2 Secondary forest in Myitsone



Plate – 3 Degraded secondary forest in Myitsone



Plate – 4 Dipterocarpus forest in Myitsone



Plate – 5 Oak forest in Myitsone



Plate - 6 Bamboo forest in Myitsone



Plate – 7 Banana forest beside Mayhka River



Plate - 9 Logging in Myitsone

Plate – 8 Shifting Cultivation in Myitsone



Plate - 10 Gold mining in Myitsone

### List of Plates (Yenam)



Plate - 1 Primary forest in Yenam



Plate - 2 Secondary forest in Yenam



Plate - 3 Degraded secondary forest in Yenam



Plate - 4 Oak forest in Yenam

Plate - 5 Bamboo forest in Yenam



Plate - 6 Grass land in Yenam



Plate - 7 Shifting cultivation in Yenam

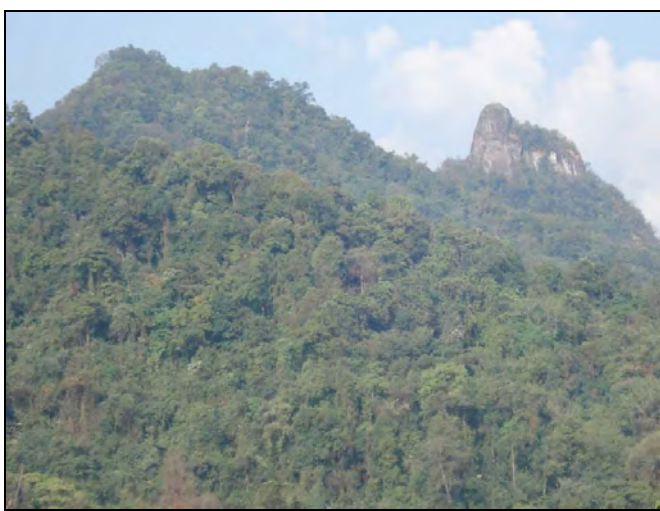


Plate - 1 Primary forest in Chibwe



Plate - 2 Secondary forest in Chibwe



Plate - 3 Degraded secondary forest in Chibwe



Plate – 4 Bamboo forest in Chibwe

Plate – 5 Banana forest in Chibwe

### List of Plates (Wusok)



Plate - 1 Primary forest in Wusok



Plate - 3 Degraded secondary forest in Wusok

Plate - 6 Citrus cultivation in Wusok



Plate - 4 Oak forest in Wusok



Plate - 5 Shifting cultivation in Wusok

### List of Plates (Khaunglanhpu)

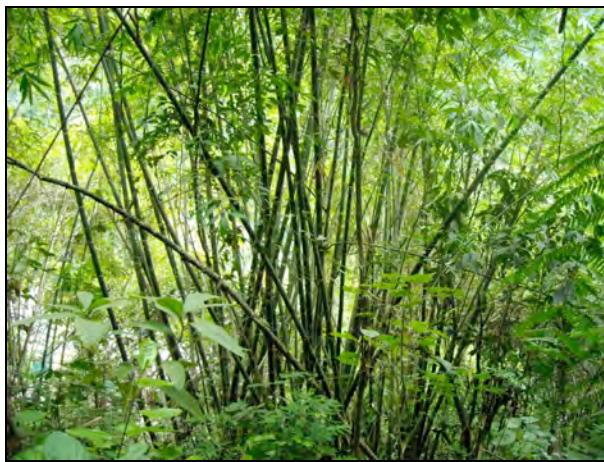


Plate - 1 Primary forest in Khaunglanhpu



Plate - 2 Secondary forest in Khaunglanhpu



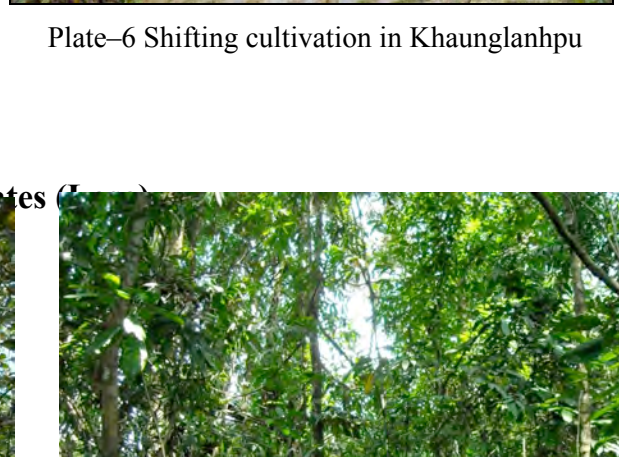
Plate - 3 Degraded secondary Forest in Khaunglanhpu

Plate -4 Alnus forest in Khaunglanhpu



Plate - 5 Bamboo forest in Khaunglanhpu

Plate-6 Shifting cultivation in Khaunglanhpu



#### List of Plates (Table)

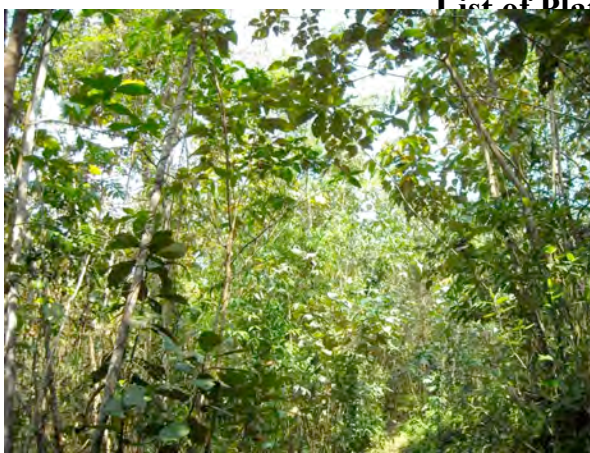


Plate - 1 Lowland evergreen in Lasa



Plate - 2 Oak forest in Lasa



Plate - 3 Degraded Secondary Forest in Lasa



Plate - 4 Bamboo forest in Lasa



Plate - 5 Grass land in Lasa

Plate - 6 Gold mining in Lasa

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## Glossary

|                         |                                                                                 |
|-------------------------|---------------------------------------------------------------------------------|
| DBH                     | Diametre breast Height                                                          |
| Relative density (RD)   | No. of individuals of the species / No. of individuals of all the species x 100 |
| Relative frequency (RF) | No. of occurrences of the species / No. of occurrences of all the species x 100 |

|                             |                                                                                                  |
|-----------------------------|--------------------------------------------------------------------------------------------------|
| Relative dominance (R.Dm)   | $\text{Total basal area of the species} / \text{Total basal area of all the species} \times 100$ |
| Important Value Index (IVI) | Sum of relative density + relative frequency + relative dominance                                |
| Species Diversity           | The number and relative abundance of species in defined area                                     |
| Diversity Indices           | Combine both richness and abundance                                                              |