Investigation on Tree Species Composition and Above-ground Biomass, Tree growth and Productivity after Seven Years of Rehabilitation through Natural Means in the Ngahlaingsan Degraded Forests

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ငလိုင်စမ်းတောကျန်အားနှစ်အတန်ကြာသဘာဝနည်းအတိုင်းပြန်လည်ထိန်းသိမ်းပြီးနောက် တွေ့ရှိရသောငင်းတော၏သစ်ပင်ပေါက်ရောက်မှုနှင့်မြေပေါ်ပိုင်းဇီဝဒြပ်ထု၊အပင်များကြီးထွားမှု နှင့် တောထွက်ကိုလေ့လာခြင်း

ဒေါက်တာချောချောစိန်၊ဦးကျော်ထွန်း
ဦးစီးအရာရှိ၊ ပါမောက္ခ(အငြိမ်းစား)
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

မြန်မာနိုင်ငံအလယ်ပိုင်းဒေသရှိ သစ်တောများသည်အဓိကအားဖြင့် လူတို့၏နေ့စဉ် လိုအပ်ချက်အတွက် သုံးစွဲမှုနှင့်သဘာဝဖြစ်စဉ်များကြောင့် တောအတန်းအစားကျဆင်း နေပါသည်။ အလယ်ပိုင်းဒေသအား ပြုပြင်ထိန်းသိမ်းခြင်းများမရှိပါက လူတို့နေထိုင်ရန် ခက်ခဲလှသည့် သဲကန္တာရအသွင် ပြောင်းလဲသွားနိုင် ပါသည်။ထို့ကြောင့်သစ်တောဦးစီးဌာန၊ အပူပိုင်းဒေသစိမ်းလန်း စိုပြည်ရေးဦးစီးဌာနနှင့် အခြား ပြည်တွင်း ပြည်ပမှအဖွဲ့အစည်းများပူးပေါင်းကာ သစ်တောပြန်လည် ထူထောင်ခြင်းလုပ်ငန်းများအား သဘာဝနည်း၊ သစ်တောစိုက်ခင်း ထူထောင်ခြင်း နည်းများဖြင့် ဆောင်ရွက်နေပါသည်။ ဤစာတမ်းတွင် မင်းတုန်းမြို့နယ် ငလိုင်စမ်းရွာရှိ သဘာဝတောကျန်အား နှစ်အတန်ကြာ သဘာဝနည်းအတိုင်းပြန်လည် ထိန်းသိမ်းခြင်းဖြင့်တွေ့ရှိရသော ငင်းတော၏သစ်ပင် ပေါက်ရောက်မှုနှင့်မြေပေါ်ပိုင်းဇီဝဒြပ်ထု၊ အပင်များကြီးထွားမှုနှင့်တောထွက်များကို လေ့လာထား ပါသည်။

Investigation on Tree Species Composition and Above-ground Biomass, Tree Growth and Productivity after Seven Years of Rehabilitation through Natural Means in the Ngahlaingsan Degraded Forests

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Abstract

The Central Dry Zone of Myanmar has been experiencing the impacts of forest degradation mainly due to human activities and partly due to natural phenomena. The process of desertification if unchecked could turn the Central Dry Zone of Myanmar into totally unproductive region like a desert where human beings could hardly survive. However, it is encouraging to see the positive results of the efforts of rehabilitation activities in some parts of the region carried out by the Forest Department and Dry Zone

Greening Department in collaboration with the active participation of people and concerned institution. The study area was in Ngahlaingsan village, Mintone Township in Magway Division. The necessary data was collected by conducting inventory of the degraded forest and by following the procedure of above ground biomass estimation. The data was analyzed with Statistics. This study reports on the status of tree species composition and above ground biomass, tree growth and productivity of Ngahlaingsan degraded forests after several years of rehabilitation through natural means.
Key Words: Central Dry Zone, Efforts, Statistics, Forest Department, Desertification

Contents

Investigation on Tree Species Composition and Above-ground Biomass, Tree growth and Productivity after Seven Years of Rehabilitation through Natural Means in the Ngahlaingsan Degraded Forests

1. Introduction

The Dry Zone consists of one third of both the population and area of Myanmar where about 75% of population are rural dwellers. It includes 3 divisions, 13 districts and 57 townships. Various environmental degradations have been observed in this region as a consequence of deforestation, population pressure, ever-increased fuel-wood demand, over-cultivation and over-grazing. The degradation of forest ecosystems is a major threat to the ecological functions and human welfare. Thus, rehabilitation of degraded forests in the region is a matter of major concern.

Presently, there is only 19.7% of area under closed forests, which is too low to meet the environmental as well as socioeconomic needs of the Dry Zone. In Myanmar, the most severe environmental degradation can be found in the Central Dry Zone. The assessment of the change of forest conducted in 1990 revealed that the actual forest area had decreased at an annual rate of 220,000 ha or 0.64 percent of the actual forested area during a period of 14 years from 1975 to 1989. Deforestation in the dry zone area is taking place at an alarming rate. It is estimated that annual deforestation rates of Magway, Mandalay, and Sagaing Divisions are 4.07%, 1.48%, and 0.68% respectively (Annon, 2003).

Forest rehabilitation is human intervention to counter forest degradation processes, e.g. promotion of the recovery process in large gaps of the forests. Forest rehabilitation can be defined as promotion measures that maximize forest functions to satisfy human aims (T. mori, 1999). Rehabilitation of degraded lands will contribute to the sustainable use of forest resources and environmental conservation. Forests produce goods and services for domestic consumption as well as export markets. Moreover, if appropriately managed, the forests will fulfill many purposes, including biodiversity conservation, timber production, carbon sinks, soil and water conservation, wildlife conservation and needs of local people.

This study reviews past and present efforts to rehabilitate the degraded natural forests in the Central Dry Zone of Myanmar, reports on the status of tree growth and productivity after rehabilitation through natural means. The study also deals with tree species composition and above ground biomass after several years of rehabilitation through natural means. Recommendations are made for better rehabilitation of degraded forests in the future.

2. Literature Review

2.1 Rehabilitation Efforts in Some Asian Countries

2.1.1 Forest rehabilitation efforts in Malaysia

The rehabilitaion of degraded forest land in Sabah, Malaysia started in 1976 when the Sabah Forestry Development Authority (SAFODA) was created to implement the reafforestation of wastelands in shifting cultivation areas. As wastelands occur in irregular blocks and sizes, the following strategy is adopted: where available land occurs in small scattered patches the plantation objective is rehabilitation: on larger blocks commercial planting for industrial wood is performed; whilst in idle private lands tree farming is promoted. SAFODA expects these plantations will be able to support a woodchip industry and contribute to the socioeconomic development in this poverty-stricken area. Their reafforestation and settlement project in Bangkok aims to establish an area of 50,000 ha of *Acacia mangium* plantations with the involvement of 200 settlers from the local subsistence farming community. The settlers are employed as plantation workers and contractors on a semi-permanent basis. At the end of 1991, the agency had planted a total area of 25,799 ha with trees and rattan in Sabah. This figure does not include the industrial plantations of the other agencies amounting to 49,000 ha. The Japan International Cooperation Agency (JICA) is providing assistance to train personnel in reafforestation at the supervisory and forest worker levels.

The Sabah Forestry Department, in collaboration with the German Agency for Technical Cooperation (GTZ) is developing a sustainable forest management system for the logged-over commercial natural forests. This new approach to sustainable forest management aims to combine the sustainable production of timber and other products following predetermined standards in nutrient cycling, forest structure, biodiversity, functional diversity and socioeconomic factors. The proposed system has 3 components i.e.; 1) Planning at the forest sector , management and operational levels; 2)Implementation of resource-compatible, low impact harvesting methods and diversification of products, and 3) control by yield regulation, EIA, and licensee performance. The commercial forest estate will be divided into forest management unit of approximately 100,000 ha each to facilitate management planning and further subdivided into compartments of about 200-600 ha for detailed planning in harvesting, silviculture and implementation. However, this holistic approach will require reforms within and without the forestry sector. Its success will depend on the commitment of all concerned, and the injection of large amounts of funds and manpower (Udarbe and Chai, 1992).

2.1.2 Rehabilitation of degraded forest lands through agroforestry in Thailand

The development of tree farm through agroforestry systems is a new popular concept which seems to offer a significant potential. Its main advantage is that, apart from providing a major wood source, it can simultaneously offer a continuous system of food, shelter and in some cases, enables to reclaim degraded areas, hence promoting the development of rural areas. In the conceptualization and principle formulation of agroforestry is based are both biological and socioeconomic. The premises on which the concept of agroforestry is based are both biological and socioeconomic. The biological premises include all the advantages of the forest for the soil and the environment, such as closed and efficient nutrient cycling, maintenance of organic matter, prevention of runoff and soil erosion, regulation of microclimate, and above all the adaptability of trees to soils that are incapable of sustaining annual agricultural crops. The socioeconomic factors supporting the potential value of agroforestry are based on the fact that the poor farmers in developing countries, who live in an environment of mounting population pressures and lack of resources are forced to utilize inherently unproductive areas for crop production and to adopt land management systems that have disastrous consequences, such as deforestation, degradation of soils, flood and drought. These farmers should be given the alternative of a system of land management that combines the practice of agriculture and forestry to provide and wood without causing the deteriorating of the ecosystems.

To substantiate the validity of the concept any agroforestry land use system field performance is the major criterion, based on the results of which the concepts can be modified and the system suitably refined. However, the premises on which the concept is based and the evidence for its implementation cannot be taken as strong indications of its validity unless field trials demonstrate its applicability. The field experiments and demonstration plots that indicate the feasibility and desirability of agroforestry systems have been formulated since 1978 in the representative marginal lowland areas characterized by infertile sandy loam soil at the Huey Thar Silvicultural Research Station, Sisaket Province, Northeast Thailand. These involved the major system, i.e. the taungya system, the multi-storey mixed intercropping system, the planted fallow or cyclical system, the hedgerow intercropping system, as well as the modified multi-storey strip planting system. Evidence accumulating from these studies and the advantages attributed to the implementation of agroforestry systems are sufficient to assume that agroforestry might be a sustainable land use system in our fragile tropical environments (Petmak, P.1994).

2.1.3 Rehabilitation of denuded forest lands in the Philippines using bamboos

The Philippines has a total land area of 30 million hectares, 17 million of which are covered with forests and about three-fourths of the alienable land of 11 million hectares are markedly eroded. Most upland areas are subject to severe erosion during the rainy season owing to high rainfall intensity, forest fires, destructive logging and shifting agriculture. The heavily eroded areas include Batangas with about 80-85% of the total areas eroded, Marinduque, 75-80%; Ilocos and La Union , 60-70%; and Capiz, 50-60%. Erosion is also extensive in Panay, Cotabato, Negros, Zamboanga, Davao, Lanao, Bukidnon and Misamis Oriental. The rest of the country suffers less than 50% erosion losses. Reforestation lags behind forest denudation which is proceeded at the rate of 84,000 ha per year. Although wide areas are initially planted to forest trees, a large percentage of the seedlings finally die. The causes include improper choice of species, pests and diseases, poor maintenance, etc. The giant ipil-ipil (*Leucaena leucocephala*) was attacked by psyllids in epidemic proportions. *Acacia mangium* trees are now being attacked in the stem by a kind of disease resulting in stunting in growth and finally drying up. Agoho (*Casuarina equisetifolia*) plantations in Albay, Philippines have been infested with gall disease. Much plantation of reforestation projects in the Philippines was burned. The plantation could have survived after burning if bamboos had been planted instead of the trees. Where trees have failed due to the aforementioned causes bamboos can be grown on denuded lands and watersheds along the eroded riverbeds and hill slopes. Bamboos have not been observed being attacked by pests and diseases. They are easily propagated and maintained and require watering only during the first year while they are still in the nursery. They survive forest fires by giving rise to new shoots from the rhizomes when the rain comes. New culms are produced during the rainy season which provides harvest every year unlike most trees which need replanting to obtain another harvest. Bamboos along the eroded riverbanks slow down the speed of water with their extended roots and rhizomes acting as filter plants by allowing water to flow and retaining gravel and coarse sediments in the culms. The rhizomes and roots grow in all directions and form a complex network within one meter depth under the ground which prevents soil erosion. They provide enough leaf litter to the soil. Attempts to grow bamboos in the Philippines were made by several workers. Chinte (1965) established plantations of *Bambusa vulgaris* and *Dendrocalamus asper* with yields of 5,991 to 6,900 kg/ha, respectively 3-4 years after planting while *Bambusa blumeana* failed to grow. Other plantations were established by Bumarlong(1981), Suzuki(1982)and Ramoran (1989).

2.2 Review of Rehabilitation Efforts in the Central Dry Zone, Myanmar

2.2.1 Past rehabilitation efforts

The Agricultural and Rural Development Corporation (ARDC) with the seconded personnel of the Forest Department was entrusted with afforestation of the central Dry Zone. The implementation of the scheme commenced from the rains of 1953. The scheme was to afforest, in some parts reforest to prevent erosion and stabilize the soil, to raise and maintain the water level and to improve the socioeconomic conditions of the people by increasing the supply of fuel-wood.

One of the previous significant projects in the Dry Zone was the "Popa Hills Project (Popa Catchment Area)". Due to unsound and incorrect landuse practices in the Popa watershed area, the existing forests had been dried up, especially in the dry season and soil erosion had taken place. The aims and objectives were to rehabilitate the area by re-clothing the denuded areas to prevent or arrest further erosion of the soil, to stabilize it, and to control and regulate the water supply. The project came into force in 1954-55. The operations carried out included the protection of the drainage area of 200 sq. miles (518 sq. km), including reserves, under Rule 27 of the rules under the Burma Forest Act. This prohibits the further cutting of trees in the catchment area. The area was also fire protected. An area of 140,000 acres (56,657 ha) had been brought back under forest cover. Nearly 2,500 acres (1,012 ha) of plantations were formed in the Popa reserve. During 1959-60, no new works were carried out; but tending, maintaining, and protection were carried out in the previous years. People today can enjoy the prosperity and luxuriance of the Popa area. The Popa area has been turned into an oasis of the Dry Zone due to the past rehabilitation and afforestation efforts.

The Forest Department took over the responsibility of reforestation activities in the central Dry Zone from October 1963 until July 1997 when the Dry Zone Greening Department was formed. Ten year plans (1963-64 to 1972-73 plan and 1972-73 to 1981-82 plan) were implemented to rehabilitate the Dry Zone area. The Forest Department carried out the special Nine District Greening project in the Dry Zone (from 1994-95 to 1996-97). About 52,680 acres (21,320 ha) were planted during the project period.

2.2.2 Current rehabilitation efforts

The Dry Zone Greening Department was formed on the 22nd July 1997 with the following objectives.

- To green the Central Dry Zone of Myanmar;
- To protect and conserve the environment as a whole, and land and water resources in particular;
- To provide the basic needs for forest products of the rural people;
- To enhance the socioeconomic development of rural people on a sustainable basis;
- To raise local people's awareness of the value and beneficial effects of forest and trees;

- To enhance knowledge and promote participation of public on environmental conservation and sustainable development;
- To improve micro-climate conditions of the environment so as to support sustainable productivity of agriculture; and
- To prevent desertification.

Four main tasks are laid down as follows:

(a) Establishment of forest plantations;
(b) Protection and rehabilitation of remaining natural forests;
(c) Promotion of Fuel wood Substitute Utilization; and
(d) Development of water resources.

2.2.2.1 Establishment of forest plantations

Forest plantations have been established in deforested and degraded areas in Sagaing, Mandalay, and Magway Divisions to restore forest cover and rehabilitate the environment. The total area planted between 1994-1995 and 2005-2006 has reached about 228,142 acres as shown in Table 2.1. There are three types of forest plantations established in the Dry Zone, namely;

(1) Village supply plantation;
(2) Watershed plantation; and
(3) Plantation for greening the hills.

2.2.2.2 Protection and rehabilitation of remaining natural forests

Protection against human, cattle and fire has been found to be effective in rehabilitating the degraded forests. The following benefits can be achieved through protection.

(i) The existing remnant forests could be saved and protected against further degradation.
(ii) Extensive areas could be rehabilitated with less cost and within a short period of time
(iii) The revitalization of degraded natural forest would be much more adaptable to microclimatic and edaphic conditions with more resistance to the harsh environment Protection of natural forest in three divisions from 1994-95 to 2005-2006 is given in Table 2.2.

2.2.2.3 Promotion of fuel wood substitute utilization

In support of forest protection and conservation, the following activities are being carried out.

2.2.2.3.1 Distribution of improved cooking stoves

As the first stage to utilization of fuel-wood substitutes, improved cooking stoves with low fuel-wood consumption distribution have been distributed to the local people. Improved cooking stoves had been distributed from 1997-2006 is shown in Table 2.3.

2.2.2.3.2 Promotion of fuel briquette production and utilization

For mass production of fuel briquettes, fuel briquette producing factories were set up in Sagaing and Pyinmana. The fuel briquettes were distributed as fuelwood substitutes.

Table 2.4 shows promotion of fuel briquette production and utilization from 1997 to 2006.

2.2.2.3.3 Utilization of agricultural residues

For encouragement of fuel wood substitution, upholding utilization of residues of agricultural crops such as stalks of sesame, pigeon pea, cotton and peanut husks. Table 2.5 shows utilization of agricultural residues from 1997 to 2006.

2.2.3 International cooperation in rehabilitation activities

The Dry Zone Greening Department implemented the following projects in cooperation with international organizations in Nyaung U Township.

(a) Myanmar-Yomiuri Afforestation Project

With the assistance of the Yomiuri Shinbum, an NGO from Japan, Myanmar-Yomiuri Afforestation Project was initiated in 1996. The project is mainly to address the fuelwood needs of the rural population and to improve the environment through greening. The project planted 300 acres (121 ha) every year from 1996 to 1999 in Pyinma protected public forest making altogether 12,000 acres (486 ha). Species planted were Eucalyptus and other indigenous species such as Mezali (*Cassia siamea*), Dahat (*Tectona hamiltoniana Wall*), Tanaung (*Acacia leucocephala* Willd), Tamar (*Azadirachta indica*) and Sha (*Acacia catechu*). Yomiuri contributed about 12 million Japanese Yens.

(b) Afforestation Projects with JIFPRO

The Dry Zone Greening Department conducted three projects with the financial assistance from Japan International Forestry Promotion and Cooperation Center (JIFPRO) in Nyaung-U with the aim to improve the environment by planting trees and subsequently to supply fuelwood to local people. Species planted were Eucalyptus, Sha (*Acacia catechu*), Kokko (*Albizzia lebbek*), Tamar (*Azadirachta indica*), Mezali (*Cassia siamea*), and Magyi (*Tamarindus indica*).

The projects were:

(i) A Forest for the Green Earth (JIFPRO I)
(ii) Myanmar –Japan Friendship Afforestation Project (JIFPRO II);
(iii) A Forest for the Green Earth Phase II (JIFRO III)

(i) A Forest for the Green Earth (JIFPRO I)

The project was implemented in Dahasi protected public forest in Nyaung-U. Altogether 857 acres (346.97 ha) of forest plantations were established.

Year	Planted area (ha)
1997-1998	40.49
1998-1999	259.11
1999-2000	47.37

About 9 million Japanese Yen was provided by JIFRO for this purpose.

(ii) Myanmar- Japan Friendship Afforestation Project (JIFPRO II)

The Project was conducted in Kyupinkway protected public forest. During the three year period (from 1998-99 to 2000-01) about 1,110 acres (449 ha) of plantation were established as mentioned below.

Year	Planted area (ha)
1998-1999	149.67
1999-2000	149.67
2000-2001	149.67

JIFPRO provided about 18.4 million Japanese Yens for the above-mentioned project.

(iii) A Forest for the Green Earth Project- Phase II (JIFPRO III)
The project site was located in Kyauku Protected Forest. Beginning from 2000-2001, about 250 acres (100 ha) of fuel-wood plantation was established annually for three consecutive years.

Year	Planted area (ha)
2000-2001	100
2001-2002	100
2002-2003	100

JIFPRO allotted 1.5 million Japanese Yens in this regard.
(c) In the fiscal year 2004-05, the following two more projects were conducted in Naung-U Township with the assistance of KOICA (Korea International Cooperation Agency) from Republic of Korea and JICA.
The projects implemented were
(i) Greening of the central Myanmar - Phase II,
(ii) Project for afforestation in the Dry Zone - Phase II.

(i) Greening of the central Myanmar – Phase II
KOICA provided US $ 300,000 to implement the second phase project. The project site is in Ngalinpok protected public forest in Nyaung-U. The duration of the project was two years from 2004 to end 2005.
Four main activities of the project were:
❖ Provision of equipment to Myanmar from Korea
❖ Dispatch of Korea experts to Myanmar
❖ Invitation of Myanmar trainees to Korea
❖ Establishment of 815 acres (330 ha) of forest plantation

(ii) Project for afforestation in the Dry Zone - Phase II.
The Japanese Government extended a grant up to 344 million Japanese Yens to the Government of the Union of Myanmar. This was the second phase of the five-year project for Afforestation in the Dry Zone and conducted in Myethindwin Protected Forest in Nyaung-U. It began in 2004-05 and terminated in 2005-2006.
Main components of the project are:
(a) Establishment of Forest Plantation
Plantation for Protection 6777.00 acres (274 ha)

Plantation for fuelwood	412.66	acres	(167 ha)
Community Forests	79.00	acres	(32 ha)
Total	1168.66	acres	(473 ha)

(b) Repair and maintenance of forest roads
(c) Formulation and Implementation of action

3. RATIONALE OF THE STUDY

The Dry Zone has an estimated population of about 18 million constituting 34 percent of the country's total population, supporting half of the national cattle population. It constitutes an important agricultural region in the country, producing cash crops such as peas, beans and major oil crops. When the population is beyond the carrying capacity of a given area, the overpopulation always makes certain impacts on the socioeconomic and ecological conditions of the area. Forest lands have been progressively encroached to satisfy the needs for fuel, fodder, other forest products and agricultural purposes. As a consequence, availability of fuel-wood and other forest products is increasingly difficult and even old tree stumps and roots are being dug up and used as fuel. People depend on reserves and protected public forests beyond their carrying capacity there by resulting in desert-like formation in the driest parts of the dry zone. Thus, rehabilitation of the degraded forests and denuded lands in the region has become a matter of great concern. Initiated since 1953, rehabilitation of degraded and denuded natural forests was institutionalized in 1997.Rehabilitation by means of conserving and protecting degraded natural forest is advocated from ecological, biological and socioeconomic support.

4. Objectives

The Central Dry Zone of Myanmar has been experiencing the impacts of forest degradation mainly due to human activities and partly due to natural phenomena. The process of desertification if unchecked could turn the Central Dry Zone of Myanmar into totally unproductive region like a desert where human beings could hardly survive. However, it is encouraging to see the positive results of the efforts of rehabilitation activities in some parts of the region carried out by the Forest Department and Dry Zone Greening Department in collaboration with the active participation of people and concerned institutes. The present study has the following objectives:

(1) To review past and present rehabilitation efforts of degraded forests in the Central Dry Zone;
(2) To study tree composition and above-ground biomass after a certain period of rehabilitation;
(3) To report on the status of tree growth and productivity after rehabilitation through natural means.

5. Materials and Methods

5.1 Study Area

Ngahlaingsan village was established over 100 years ago. The village and its environment have been once a rich forest of Dry Upper Mixed Deciduous (DUMD) forest type with valuable commercial species like Teak, pyinkado and padauk. The area was subjected to slash and burn cultivation for over a hundred years. The number of households increased from the original 20 to 152 at present. With the increase of population, the rate of degradation of the forests had been faster. To protect the remaining forests from further deterioration, the local authorities of Magway Division have issued an order to stop slash and burn practice. After constructing Pathein-Monywa Car Road in 1984 passing near the village, the FD of Magway Division issued an order to stop slash and burn practice in order to protect the remaining forests. In 1998, Japan Overseas Forest Conservation Association (JOFCA) and Forest Resource Environment Development Association (FREDA) initiated a project on community collaboration in reforestation and forest conservation with the primary objective of developing viable approaches to community based management of reforestation and to improve the livelihood of the local rural community.

As a protective measure, the villagers are no longer allowed to expand their cultivation into the remaining forest areas. The possible solution for their sustainable development is to introduce agro-forestry in the place of permanent slope cultivation for livelihood security and to cultivate suitable successive crops in flat areas instead of only a single crop of paddy in a year. The village was so isolated from high technology and the markets that even the famous pigeon peas was introduced only in the last decade. The most area is on the slope. The farmers plant hill rice, pigeon peas and sesame. To be more productive, it was planned to grow Banana, Mango, Jack fruit and citrus on the bottom line of the slope which is adjacent to the paddy land and the moisture condition is favourable. FREDA has introduced a bio-terracing method using which trees like Custard apple, Tamarind, Kyaungsha, Zizyphus and drum–stick are planted in the pits and Jatropha, Leucaena and Sasbania are planted in the hedge rows on a total area of 562 acres. FREDA planned to manage the remnant forest and the secondary growth on the old fallow land of 482 acres as community forest and to assist natural regeneration through timber stand improvement operations. It was divided into 10 blocks and managed according to natural conditions.

5.1.1 Location and extent

The village is situated on the west bank of the Ayeyarwady River, about 75 miles from Sin Te indusrial site, opposite Pyay. Pathein-Monywa highway passes through between old and new villages. In the East Maung Zin Range and Saing Do Reserved Forest, in the north Oo yin pu village and in the south Shan village are situated. The total rehabilitation area by natural means is 482 acres.

5.1.2 Topography and drainage

It is about 200 feet above sea level. About 25% of the village land (about 400 acres) is flat and the rest 75% is hilly with the highest peak of the Maung Zin Range at 1,450 feet high. About 10% of these hills are steep and rocky. Tardo stream starts flowing from these hill ranges running through the middle of the village boundary. There is no other stream, river nor canals apart from the streamlets of Tardo. There is a small pond for the cattles.

5.1.3 Climate and Soil

The monthly temperature of the village varies from a maximum of 40° C in April to a minimum of 19° C. The average rainfall is around 48.5 inches mostly during April to November. Relative humidity varies from 47% in March to 79% in August. Physical damage due to cyclones is negligible. The soil is rather unstable, loose and fragile. It is mixed with gravels on the upper slopes.

5.1.4 Forest type and species

Most of the forests near the village area are of Dry Upper Mixed Deciduous type with some major tree species like Cutch (*Acacia catechu*), Teak (*Tectona grandis*), Pyinkado (*Xylia dolabriformis*), In (*Dipterocarpus tuberculatus*), Pyinma (*lagerstormia Flos-reginae*) and several Terminalia spp. The rests are Dipterocarpus forests, bamboo forests and degraded forest patches on the steep eastern range.

5.1.5 Transportation and Land Use

Ngahlaingsan is only three miles by car tract and nine miles by motor road to Mindon town. It is 45 miles to Thayet, 90 miles to Pyay and 78 miles to Minbu. The present land use pattern of the Ngahlaingsan village is given in Table 5.1. The fall and degraded forests is the largest land use contributing to almost half of the total land use.

5.1.6 Demographic Information

The population of the Ngahlaingsan Village is 550 in 155 households comprising 109 males and 117 females in the new village and 172 males and 152 females in the old village. It was listed that there are 88 males and 67 females of age under 18 years and 193 males and 202 females over 18 years. Both male and female work equally hard in this area. The youngest household head is 23 years and the oldest 80 years of age. Almost all the people in the village are Barmars.

5.2 Tree Species Composition and Above-ground Biomass, Tree Growth and Productivity

The effects of rehabilitation of degraded dry zone forest ecosystems by natural and artificial means in terms of environmental conservation and socioeconomic benefits to local communities were investigated. Regarding environmental conservation, the status of tree species composition and above-ground biomass, tree growth and productivity of the rehabilitated natural forests through natural means were studied in the Ngahlaingsan Village, Mindon Township, Magway Division. A 1-ha plot was set up in the Ngahlaingsan and further divided into subplots of 20m x 20m.The diameters at breast height (dbh) - 1.3 m above ground and heights of all the standing trees were measured using diameter tape and clinometer respectively. Before measurements, the trees were classified into dominant and suppressed trees based on their crown positions.

5.3 Biomass Estimation

5.3.1 Estimation of biomass in the Ngahlaingsan rehabilitated natural forest

Biomass is defined as the total amount of living organic matter in trees and expressed in tones per hectare. Above ground biomass may be defined as a combination of all tree components above ground level and is important in estimating the productivity of a forest.

5.3.1.1 Methodology

Six sample trees (all are different dominant species) were felled to develop an allometric equation in order to estimate the above-ground biomass of the Ngahlaingsan rehabilitated natural forest. Layout of sample plot for measuring tree species composition and above ground biomass and tree growth and productivity in the Ngahlaingsan rehabilitated natural forest is shown in Figure 5.2.

(a) Measurement of felled trees

Sample trees were felled at 0.3 m above the ground. All the boughs, twigs and leaves were cleared off the felled trunk. The height of the felled tree was measured before the trunk was being cut into logs for the convenience of weighing. Each log was weighed and noted in the field note. Boughs, twigs and leaves including saw dust were weighed and noted.

(b) Collection of samples for dry weight estimate

The samples of the trunk, bark, boughs, twigs and leaves were collected in separate paper bags for drying and weighing. Leaf sample of 10 kg, branch sample of 50 kg, 2 cm disks to represent trunks were collected.

(c) Drying samples

After felling, the trunk, branches and leaves of each sample tree were separated and weighed. Small samples were then extracted from each separated organ, weighed, dried for 96 hours (leaves, 48 hours) at 80°C, and re-weighed in order to determine their fresh to dry weight ratios. The biomass of each organ was calculated from the fresh weight and fresh to dry weight ratio thus obtained.

(d) Estimation of total dry weight of each sample tree

Total dry weight (TDW) of each organ of each sample tree was calculated from its total fresh weight (TFW), the fresh weight of its organ sample (SFW) and its dry weight (SDW) (JIFPRO &JOPP, 2004)

$$TDW=SFW/ SDW \times TFW$$

6. Results and Discussions

6.1 Tree Species Composition

A total of 30 species belonging to 16 families were recorded in 1 ha plot in the study forest area. Family Combretaceae is represented by the largest number of trees (320 trees) followed by Verbenaceae (264 trees) and Lythraceae(198 trees). *Anogeissus acuminate* (Yon), *Tectona grandis* (Kyun), *Lagerstroemia villosa* (Zaungpalwe) and *Acacia catechu* (sha) are frequently found in the study area. Table 6.1 shows taxonomic composition of trees 1cm dbh and above in 1ha plot. Tree density (number of trees 10cm in DBH and above per 1 ha) in the ten largest families ranged from 19 to 320 with Combertaceae the most common. Table 6.2 shows species composition and density in 1 ha plot. Combretaceae has the highest tree density of the ten largest family found in the study area and the least family Boraginaceae with 19 in the 10 cm and above DBH class. The presence of many original species, such as *Anogeissus acuminata* from the family Combretaceae and *Tectona grandis* from the Verbenaceae shows that this forest was disturbed in the past and is still at an early stage in succession. The large number of small diameter trees in this stand is also an indication of the early stage of succession.

Individual tree by diameter class is given in Figure 6.2. About 55% of trees are in DBH class under 5cm, 22% are 5.0-9.9 cm, 9% are 10-14.9cm, 7% are 15-19.9cm, 3% are 20-24.9 cm , 2% are 25-29.9 cm and 20-24.9 and 2% exceeds 30 cm. Horizontal distribution of the forest, based on all trees with a DBH≥1 cm are shown in Figure 6.2. Most of which showed the individual trees accumulated in the lower diameter classes. The number of trees decreases from lower diameter classes to higher diameter classes sharply. Vertical distribution of the forest follows the same trend as the Horizontal distribution (Figure 6.3). Vertical distribution of the forest also concentrated in the lower classes. The number of trees decreases with increasing height classes.

6.2. Estimatiom of above ground biomass in the Ngahlaingsan rehabilitated natural forest

Biomass is defined as the total amount of living organic matter in trees and expressed in tones per hectare. Above ground biomass may be defined as a combination of all tree components above ground level and is important in estimating the productivity of a forest (Brown, 1997).

Estimation of biomass using allometric relation

Biomass was estimated from the allometric relation between DBH and the total dry weight (TDW) of each organ obtained from sample trees. Table 6.3 shows measurements of six species in biomass estimation. Allometric relation is expressed as follow. The allometric relation between dbh and total dry weight of stem is shown in Figure 6.4.

$$TWD = a.\ DBH^{b}$$

where, TDW =Total Dry Weight
DBH = Diameter at Breast Height, a and b are coefficients

A summary of the above ground biomass (trees of 1cm dbh and above) by family is shown in Table 6.5. Estimated total above ground biomass is 66.15t ha^{-1}. Verbenaceae had the highest biomass 12.06 t ha^{-1}. Table 6.5 shows biomass by dbh class. Dbh class under 5 cm constituted about 50.17% (33.19 t ha^{-1}) of the total above ground biomass, which is the largest among the dbh classes.

Biomass information can be used to quantify nutrients in the ecosystems, provide estimates of carbon content in a forest, quantify forest growth increments, yield or productivity and assess changes in the forest structure. Since biomass is the organic matter fixed by trees, it is thus the source of all other productivity of the forest (Roland and Lim 1999).

6.3 Tree Growth and Productivity

Growing stock is one of the important indices of land productivity. Rehabilitation is important in degraded forest land of the tropical region (Sakuri,1982). This study will report on the condition of growing stock and productivity of Ngahlaingsan rehabilitated natural forest conserved in 1998 with the aid of Japan Overseas Forest Conservation Association (FREDA) to community based management of reforestation and to improve the livelihood of the local rural community. A site specific volume equation was developed using the felled trees data.

$$Y = - 0.078982 + 0.014402 \times DBH$$

where; Y = volume in cubic meter

DBH = diameter at breast height

R square=.93487 and Sig T=.0016

The stem volume of the Ngahlaingsan rehabilitated natural forest using the above equation is given in Table 6.6. Figure 6.5 is a scatter plot of residuals versus predicted values. There are no extremely large residuals (and hence no apparent outliers) and there is no trend in the residuals to indicate that the linear model is in appropriate. Figure 6.6 is a scatter plot of residuals versus the dependent x variable (diameter). A pattern of residuals as shown in the figure indicate homogenous error variance across values of x. The figure does not indicate the error variance increase with increasing values of x.

The largest average DBH of dominant and suppressed trees are 21.2 cm and 9.3 cm respectively. The highest average heights of dominant and suppressed trees were 13.5 m and 9.1 m respectively. Number of trees above dbh of 5 cm is 555 per hectare and correspondent basal area per ha is 24.04 m^2. *Sha* has the largest total volume of 15.75 m^3 ha^{-1} followed by *Kyun* (15.70 m^3 ha-^{1}) and *Yon* (6.80 m^3 ha^{-1}). Figure 6.7 shows productivity per hectare of the Ngahlaingsan rehabilitated natural forest. Total volume per hector amounts to 65.90 m^3.

The two most dominant species i.e. *Sha* and *Teak* constitute about half of the total productivity of the rehabilitated natural forest under study. Growing stocks of *teak* and *sha* are 15.70 m^3 and 15.75 m^3 respectively. Teak is a premier timber and *sha* is used to make farm implements and is a good fuel-wood species commonly used in the study area. The current productivity of the site (65.90 m^3) can be improved through a systematic conservation and protection. The current productivity of about 66 m^3 per ha is approaching 90 m^3 of closed broad-leaved forest in a typical natural environment. Others are all other species combined. Once degraded site has been enriched with valuable timber species and a forest cover is restored after a certain period. Today, the forest starts providing its functions.

7. Conclusions and recommendations

7.1 Conclusions

The central region of Myanmar is characterized by a dry and hot climate with low precipitation due to its location and topography. Because of increased population, practice of shifting cultivation, fuel-wood extraction, overgrazing and other anthropogenic activities, the environmental situation became worse. Very little of the original natural vegetation remains and a degraded form of trees is found in many part of the central Dry Zone. As the government of Myanmar heeded to the critical situation, consistent and strenuous efforts have been made to rehabilitate the deteriorating environmental situation of the region with might and main since 1953 through several rehabilitation programmes and projects with or without external assistance. The rehabilitation activities came to a peak when the Dry Zone Greening Department was formed in 1997 to concentrate on greening activities in the Central Dry Zone. The degraded forests in the Dry Zone of Myanmar are currently rehabilitated by two different means: conservation and protection of existing remnant natural forests and plantation establishment in deforested areas.

Effects of rehabilitation of degraded forests and denuded forest lands after a number of years have been studied. The results provide evidence that tree species composition and above-ground biomass have been relatively improved. Likewise, the tree growth and productivity in once degraded or denuded areas have been improved after a years of rehabilitation through natural means in the Ngahlaingsan.

Because of the concerted efforts of the government, non-governmental organizations and local communities, the environmental situation in some parts of the dry zone has been improved gradually. It will take time to completely turn the whole Central Dry Zone to a lush environment. As endeavors to rehabilitate the Dry Zone are gaining momentum, more enthusiastic efforts are needed to achieve the ultimate goal of greening the region whereby the community can again enjoy ecological and socioeconomic functions of the forests.

7.2 Recommendations

- The causes of rehabilitation should be analyzed to be able to take appropriate measures. To achieve this objective, it would be desirable to carry out research on multi-disciplinary basis involving the participation of experts in various fields.
- Research programs should be planned to fulfill the needs of the communities.
- The objectives of management for rehabilitation should be well defined. It is important to determine what the communities wish to derive from reclaimed lands: biomass production, biodiversity, recreation, sustainability issues, etc.
- The future use of the land reclaimed must be determined.
- Information on the species used for rehabilitation of the land should be obtained, including the search for improved germplasm, different accessions or different species and varieties.
- Indigenous species may be preferable to exotic ones while sometimes, the introduction of exotic species far from the center of origin may be beneficial.
- The monitoring and prediction of changes are limited by the techniques available. It may be necessary to identify new parameters and indices of productivity in the changes including soil and productivity changes.
- An integrated package of measure is needed to reduce the present magnitude of degraded forests at the national level.

- Technical solutions alone are not enough to rehabilitate degraded and denuded forest lands. Human and social activities and their consequences should be taken into consideration.
- Rehabilitation of degraded and denuded forest lands should be mainstreamed into the national development programmes and special funds should be earmarked for the implementation.
- It is generally recognized that socioeconomic and policy constraints outweigh physical constraints such as soil fertility, pests, etc. As such, people participation and political commitment will play a crucial role in rehabilitation of degraded forests.

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REFERENCES

Annon. 2003 . Forestry in Myanmar, Forest Department .Yangon, Myanmar.

Brown, S. 1997.Estimating biomass and biomass change of tropical forests. FAO Forestry Paper 134. Food and Agriculture Organization, Rome, Italy.

Bumarlong, A. 1981. Survival and growth of some erect bamboos as affected by methods of propagation, fertilization and site preparation. Proceeding of the Congress

Group 5.3A, Production and Utilization of bamboos and related species, XVII IUFRO World Congress, Kyoto, Japan; Sept. 6-17, 1981.

Japan International Forestry Promotion and Cooperation Center (JIFPRO) and Japan Overseas Plantation Center for Pulpwood (JOPP). 2004. Manual of biomass measurements in plantation and in regenerated vegetation.

Mori, T. 2000. Effects of droughts and forest fires on dipterocarp forests in East Kalimantan. In: Guhrdja, E. Fatawi, M., Sutisna, M., Mori,T. and Ohta, S.(eds.) Rainforest Ecosystems of East Kalimantan: El Nino, drought, fire and human impacts,29-48. Springer, Tokyo.

Petmak, P. 1994. Rehabilitation of Degraded Forest Lands through Agroforestry in Thailand. The FAO's Response. In: Rehabilitation of Degraded Forest Lands in the Tropics. JIRCAS International Symposium Series No.1. March 1994. Japan International Research center for Agricultural Sciences. Ministry of Agriculture, Forestry and Fisheries. Japan.

Ramoran, E.1989. Bamboo project: a deal between government and communities-splitting responsibilities. Canopy International, 15(5). Philippines.

Roland, K.J.H. and Lim, M.T. 1999. An estimate of forest biomass in Air hitam Forest Reserve, Selangor. Paper presented at Seminar Pengurusan dan Ekologi Hutan Simpan Ayer Hitam, Selangor. UPM,Serdang, 12-13 October 1999.

Suzuki,T. 1982. Propagation of some bamboo species in the Phillippines by various methods of planting cuttings.

Udarbe,M.P. and Chai, N.P. 1992. The Deramakot Model-An Approach to a Sustainable Forest Management System: Paper persen ted at the 11th Malaysian Forestry Conference held on 27 July-2 August , Kota Kinabalu.

Table (2.1) Plantation establishment in the Dry Zone (1994-95 to 2004-05) (ha)

No.	Year	Sagaing	Mandalay	Magway	Total
1.	1994-95	931.17	2388.66	3097.17	6417.00
2.	1995-96	1477.73	2489.88	3360.32	7327.94
3.	1996-97	1295.55	2550.61	3736.84	7582.99
4.	1997-98	1439.27	1748.99	4718.62	7906.88
5.	1998-99	3087.05	4883.40	6315.79	14286.23
6.	1999-00	2967.21	5146.56	6072.87	14186.64
7.	2000-01	2965.58	5131.58	6336.03	14433.2
8.	2001-02	2024.29	2914.98	5914.98	10854.25
9.	2002-03	1862.35	3319.84	4858.3	10040.49
10.	2003-04	1417.00	2805.26	4400.81	8623.08
11.	2004-05	1214.58	1827.94	4655.87	7698.38
12.	2005-06	1133.60	1712.55	4453.44	7299.60
	Total	21815.39	36920.25	57921.06	116656.8

***Source:* DZGD-Four Main Tasks (1994-95 to 2005-2006)**

Table (2.2) Protection and rehabilitation of remaining natural forests (ha)

No.	Year	Sagaing	Mandalay	Magway	Total
1.	1997-1998	5668.02	8502.02	24291.5	38461.54
2.	1998-1999	7692.31	9716.60	25883	43291.9
3.	1999-2000	7692.31	12550.61	20242.91	40485.83
4.	2000-2001	7692.31	12550.61	20242.91	40485.83
5.	2001-2002	24291.5	24291.5	32388.66	80971.66
6.	2002-2003	24291.5	24291.5	32388.66	80971.66
7.	2003-2004	20242.91	8097.17	32388.66	60728.74
8.	2004-2005	20242.91	8097.17	32388.66	60728.74
9.	2005-2006	16194.33	809.7	23481.78	40485.83
	Total	5668.02	8502.03	24291.5	38461.54

Source: **DZGD-Four Main Tasks (1994-95 to 2005-2006)**

Table (2.3) Distribution of improved cooking stoves (number)

No	Year	Sagaing	Mandalay	Magway	Total
1.	1997-1998	625	2,695	12,841	16,161
2.	1998-1999	18,720	16,564	60,044	95,328
3.	1999-2000	12,835	13,778	22,048	48,661
4.	2000-2001	17,167	19,112	32,164	68,443
5.	2001-2002	9,905	9,637	25,826	45,368
6.	2002-2003	9,000	10,062	13,591	32,653
7.	2003-2004	9,000	9,053	11,694	29,747
8.	2004-2005	9,000	9,259	12,055	30,314
9.	2005-2006	9,000	9,000	13,400	31,400
	Total	95,252	99,160	203,663	398,075

Source: **DZGD-Four Main Tasks (1994-95 to 2005-2006)**

Table (2.4) Promotion of fuel briquette production and utilization (number)

No	Year	Sagaing	Mandalay	Magway	Total
1.	1997-1998	-	1,044,796	653,036	1,697,832
2.	1998-1999	691,000	1,623,000	5,963,893	8,277,893
3.	1999-2000	1,410,000	3,500,000	4,117,891	9,027,891
4.	2000-2001	1,953,960	4,263,483	5,840,549	12,057,992
5.	2001-2002	1,158,850	3,832,939	5,716,597	10,708,386
6.	2002-2003	1,000,000	2,699,196	4,750,615	8,449,811
7.	2003-2004	1,000,000	2,027,189	4,524,750	7,551,939
8.	2004-2005	1,000,000	1,603,705	2,377,848	4,981,553
9.	2005-2006	1,000,000	1,500,000	2,000,000	4,500,000
	Total	9,213,810	22,094,308	44800000	67253297

Source: **DZGD-Four Main Tasks (1994-95 to 2005-2006)**

Table (2.5) Utilization of agricultural residues (tons)

No	Year	Sagaing	Mandalay	Magway	Total
1.	1997-1998	-	400	50	450
2.	1998-1999	2,153	2,525	28,743	33,421.00
3.	1999-2000	2,315	2,697	20,944	25,956.00
4.	2000-2001	2,489	4,271	13,630	20,390.00
5.	2001-2002	3,056	5,249	15,617.39	23,922.39
6.	2002-2003	2,780	3,575	15,810.84	22,165.84
7.	2003-2004	2,977	3,004	13,432.84	19,413.84
8.	2004-2005	2,850	3,016	12,410.00	18,276.00
9.	2005-2006	2,500	2,500	10,000.00	15,000.00
	Total	21,120	27,237	130,638.07	178,995.07

Source: **DZGD-Four Main Tasks (1994-95 to 2005-2006)**

Table (5.1) Current land use of the Ngahlaingsan Village

No.	Types	Acres	%
1.	Paddy field	185	11.56
2.	Permanent cultivation	70	4.38
3.	Shifting cultivation	110	6.87
4.	Grazing Land	215	13.44
5.	Fallow and degraded forests	720	45.00
6.	Remaining patches of forests	300	18.75
	Total	1600	100

Source: FREDA report in 2000

Table (6.1) Taxonomic composition of trees 1cm dbh and above in 1ha plot

Family	No. Genera	No. Species
Anacardiaceae	1	1
Apocynaceae	1	1
Bignoniaceae	3	3
Bombaceae	1	1
Boraginaceae	1	1
Caesalpiniaceae	2	2
Combretaceae	2	4
Euphorbiaceae	3	3
Fabaceae	1	2
Fabenaceae	1	1
Lythraceae	1	1
Meliaceae	1	1
Mimosaceae	3	5
Rhamnaceae	1	1
Rubiaceae	1	1
Verbenaceae	2	2
Total	**25**	**30**

Table (6.2) Species Composition and Density in 1 ha plot

Species Composition	No .Stems
Mitragyna diversifolia Havil	19
Bombax insigne	5
Diospyros montana Roxb	2
Cordia grandis Roxb	32
Albizzia lebbek (L) Benth	2
Oroxylum indicum Vent.	5
Vitex pubescens Vahl	41
Tectona grandis L.f	223
Terminalia pyrifolia	29
Vatica lanceaefolia (Korth) Blume	60
Lannea coromandelica Houtt.Merr.	34
Cassia renigera	7
Bauhinia acuminata L	94
Terminalia chebula Retz.	6
Xylia dolabriformis Benth	2
Bridelia ovata Spreng	79
Acacia catechu Willd	105
Phyllanthus albizzioides(Kurz) Hook.f	2

Albizzia procera Benth	17
Terminalia tomentosa Wight& Arm	56
Sterospermum fimbriatum	4
Millettia pendula Benth	2
Heterophragma sulfureum Kurz	2
Albizzia odoratissima (L.f) Benth	2
Millettia brandisiana Kurz	5
Aporusa villosa	6
Chukrasia tabularis A. Juss	10
Anogeissus acuminata Wall.	229
Lagerstroemia villosa Wall. ex Kurz	198
Zizyphus jujube	7
Total	1285

Table (6.3) Measurements of six species in biomass estimation

Species	DBH (cm)	TFW (kg)	TDW (kg)
Sha	9.3	46.73	22.72
Kyun	11	86.21	32.14
Zaungbale	13.0	97.98	31.34
Yon	8.5	29.09	13.25
Palan	8.6	35.58	14.6
Lein	15.2	132.3	59.92

Table (6.4) Above-ground biomass of trees of 1cm dbh and above by family

Family	Biomass ton ha^{-1}	Family	Biomass ton ha^{-1}
Anacardiaceae	1.39	Fabaceae	0.10
Apocynaceae	3.67	Fabenaceae	0.80
Bignoniaceae	0.16	Lythraceae	8.90
Bombacaceae	0.31	Meliaceae	2.10
Boraginaceae	0.42	Mimosaceae	12.69
Caesalpiniaceae	8.59	Rhamnaceae	0.14
Combretaceae	12.06	Rubiaceae	1.4
Euphorbiaceae	0.65	Verbenaceae	12.77
Total			66.15

Table (6.5) Above -ground biomass by diameter class

Diameter class (cm)	Above ground biomass (t ha^{-1})	% of total
0-4.9	33.19	50.17
5-9.9	3.39	5.12
10-14.9	3.47	5.25
15-19.9	7.45	11.26
20-24.9	5.34	8.07
25-29.9	5.01	7.57
≥30	8.30	12.56
Total	**66.15**	**100.00**

Table (6.6) General description of the Ngahlaingsan rehabilitated natural forest

Upper rows indicate dominant trees and lower rows the suppressed ones.
Others include Nabe, Kyaung Sha, Kyet yo, Hmaik, Zi, Thakut po, Binga, Panga,Thit pagan, Didu, Ngu sat, Sit, Yinma and Thit Linda.

Species	Average		Per hectare			Total volume (m^3)
	dbh(cm)	Height(m)	No	B.A(m^2)	Volume(m^3)	
Seikchi	12.7	13.2	9	0.06	0.93	1.24
(sp4)	6.8	7.0	17	0.1	0.31	
Zaungbale	12.5	11.4	5	0.01	0.51	0.75
(sp2)	6.2	7.9	22	0.07	0.24	
Sha	18.2	12.8	83	2.42	15.20	15.75
(sp8)	9.3	9.1	10	0.07	0.60	
Kyun	18.9	12.3	75	10.90	14.50	15.70
(sp7)	7.3	7.9	46	0.80	1.20	
Palan	13.7	12.2	21	0.36	2.49	2.90
(sp5)	6.8	7.6	21	0.08	0.40	
Lein	11.0	11.0	4	0.04	0.30	0.60
(sp1)	7.2	7.7	13	0.06	0.30	
Yon	13.3	11.4	60	0.90	6.70	6.80
(sp6)	7.0	8.0	26	0.20	0.10	
Taukkyant	12.4	11.3	9	0.11	0.90	1.10
(sp3)	6.3	7.5	14	0.04	0.20	
Others	21.2	13.5	85	7.80	19.30	21.10
	7.8	8.3	35	0.20	1.80	
Total						65.90

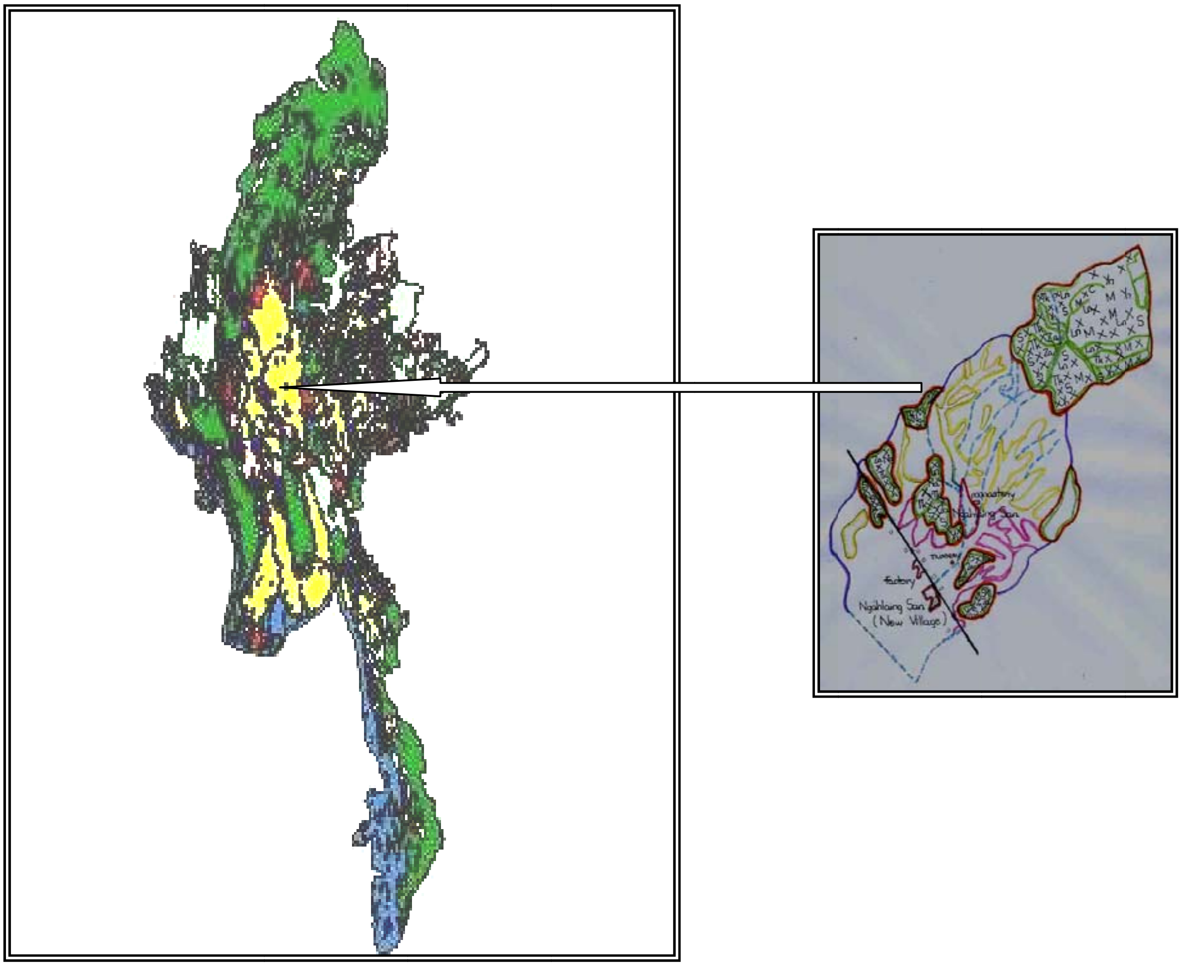

Figure (5.1) Study Area of Ngahlaingsan Natural Forest

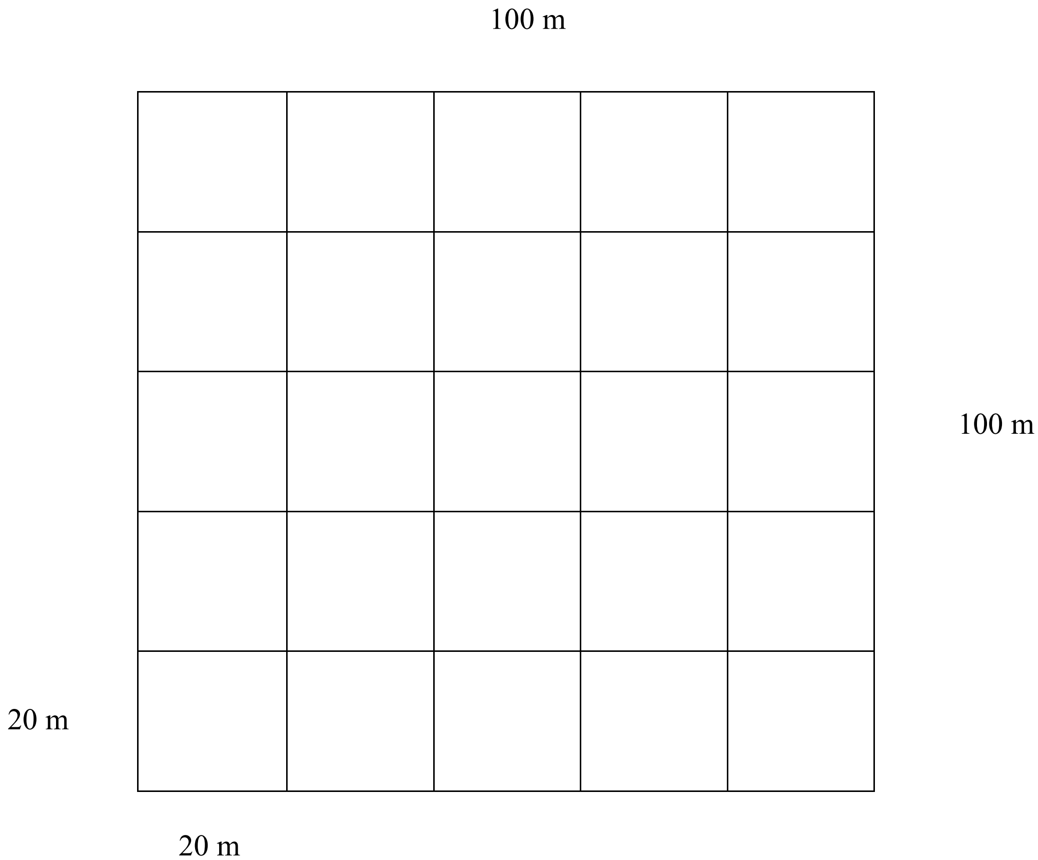

Figure (5.2) Layout of sample plot

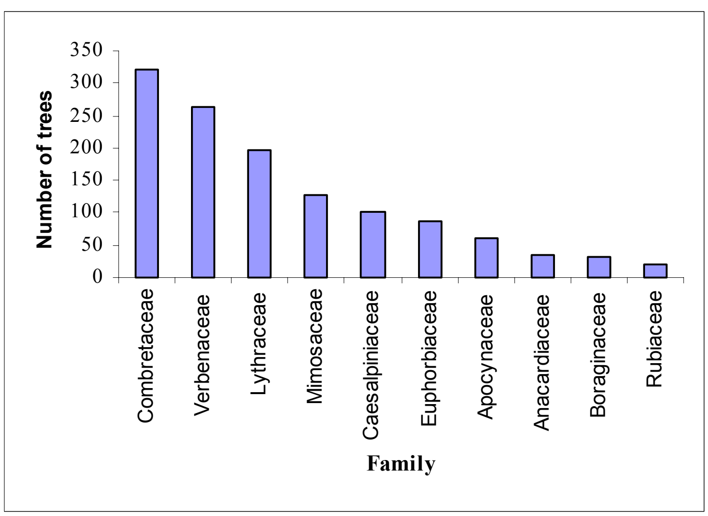

Figure (6.1) Number of trees of 10 largest families

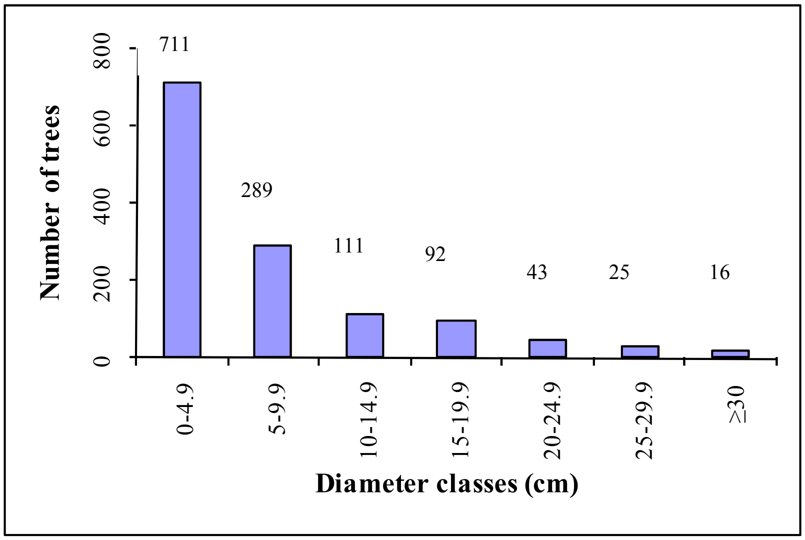

Figure (6.2) Horizontal distribution of trees in the study area by DBH class (Total sample area=1ha).

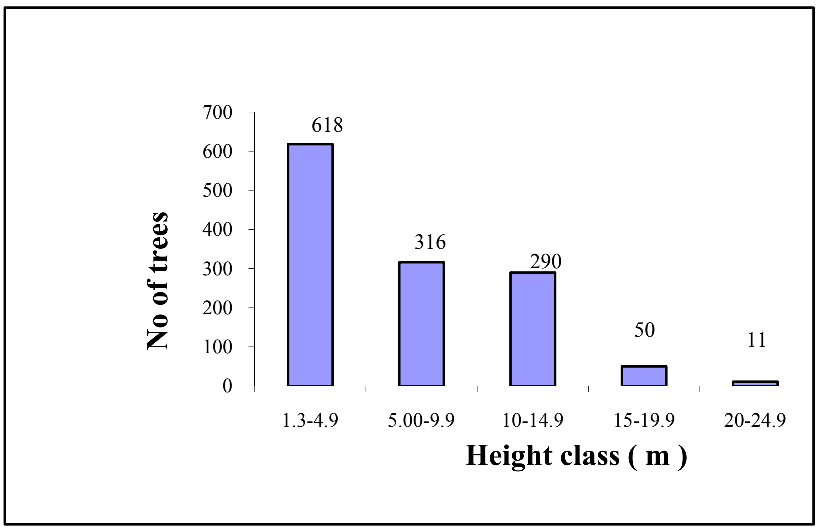

Figure (6.3) Vertical distribution of trees in the study area by Height class (Total sample area =1 ha)

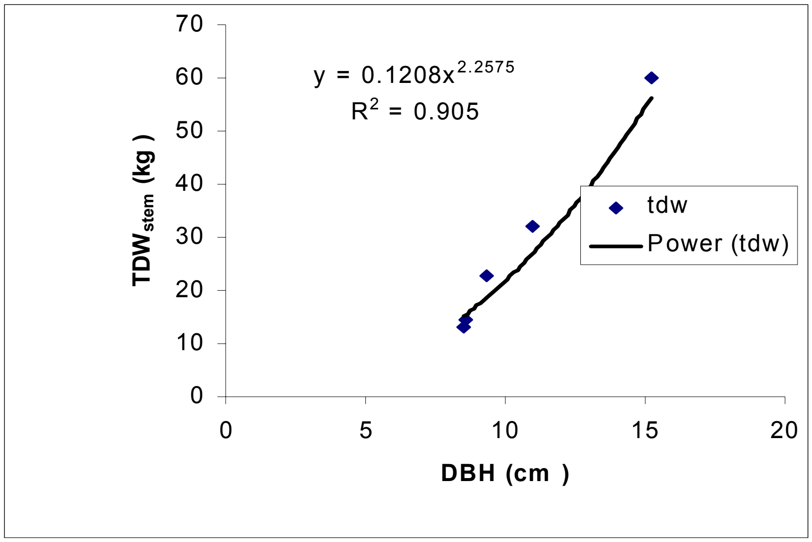

Figure (6.4) The allometric relation between DBH and total dry weight of stem

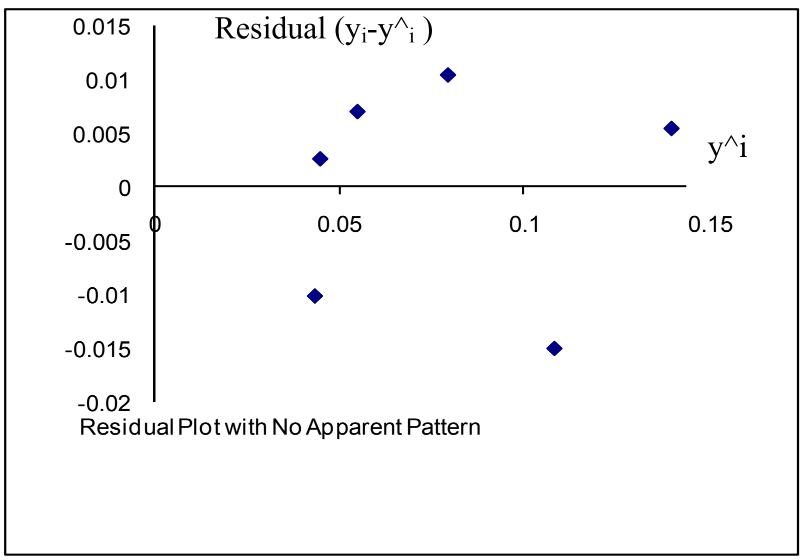

Figure (6.5) A scatter plot of residuals versus predicted value

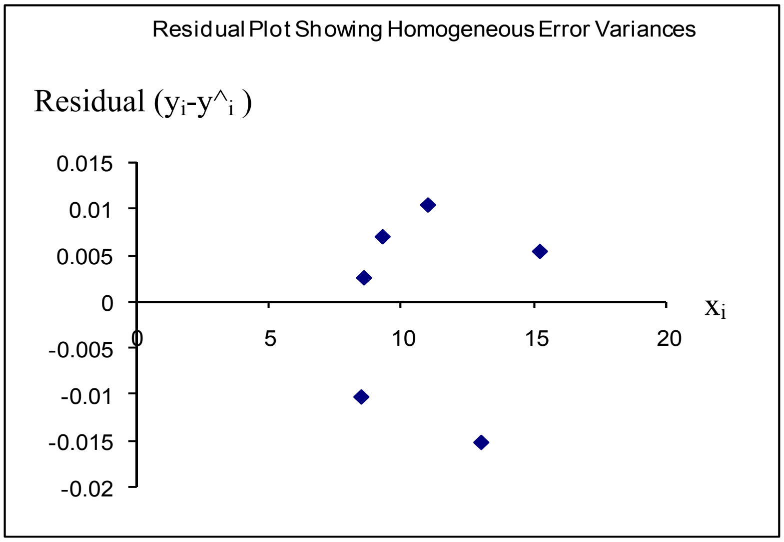

Figure (6.6) A scatter plot of residual versus the dependent variable

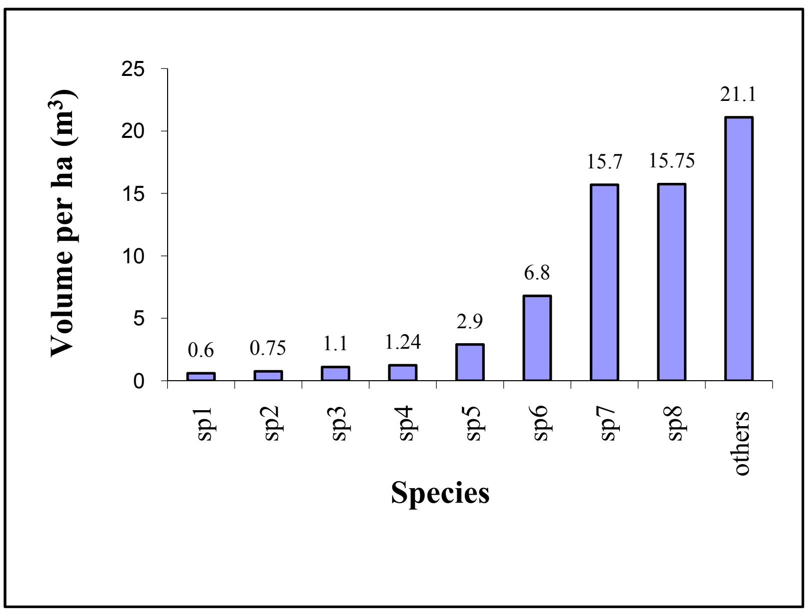

Figure (6.7) Volume per hectare by species