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# Study on potentialities of community forestry with special emphasis on rural development and plant species conservation: a case study in Ywa-ngan Township, Shan State

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# အစုအဖွဲ့ ပိုင် သစ်တောလုပ်ငန်းများ၏ ကျေးလက်ပြည်သူများ ဖွံ့ ဖြိုးတိုးတက်မှုနှင့် အပင်မျိုးစိတ်များ ထိန်းသိမ်းခြင်းအပေါ် အကျိုးသက်ရောက်နိုင်မှု အလားအလာများအား လေ့ လာခြင်း။


## စာတမ်းအကျဉ်း

ဤသုတေသနလုပ်ငန်းအား ရွာငံမြို့နယ်၊ လက်ပံပင်နှင့် မြိုင်ကျေးရွာ အစုအဖွဲ့ပိုင် သစ်တောများတွင် ဆောင်ရွက်ခဲ့ပါသည်။ ရေဝေရေလဲဧရိယာများရှိ အစုအဖွဲ့ပိုင် သစ်တောနှင့် ဥယျာဉ်ခြံမြေ လုပ်ငန်းများ၏ ကျေးလက်ဒေသ ဖွံ့ဖြိုးတိုးတက်မှုနှင့် အပင် မျိုးစိတ်များ ထိမ်းသိန်းကာကွယ်ခြင်းတွင် အကျိုးသက်ရောက်နိုင်မှုများကို လေ့လာတင်ပြရန် ရည်ရွယ်ပါသည်။ လူတွေ့မေးမြန်း စုံစမ်းခြင်းနှင့် သစ်တောသယံဇာတ စာရင်းကောက်ယူခြင်းများကို အဓိကနည်းလမ်းများအဖြစ် အသုံးပြု၍ ဤသုတေသနလုပ်ငန်းကိုဆောင်ရွက်ခဲ့ပါသည်။ လက်ပံပင်ကျေးရွာနှင့် မြိုင်ကျေးရွာရှိ အိမ်ထောင်စုများသည် ၎င်းတို့၏ ဥယျာဉ်ခြံမြေမှ ဝင်ငွေသည် လယ်ယာလုပ်ငန်းမှ ရရှိသည့် ဝင်ငွေ စုစုပေါင်း၏ ၂၂.၁% နှင့် ၂၁.၅% အသီးသီးစီ ရှိပါသည်။ ထို့အပြင် ဥယျာဉ်ခြံမြေမှ ထင်း၊ တိုင်၊ တန်းနှင့် ရာသီအလိုက် သစ်သီး၊ ဟင်းသီးဟင်းရွက် များလည်း မိမိသုံးအတွက် ရရှိပါသည်။ ထိုရရှိသည့် ပမာဏမှာ လက်ပံပင်ကျေးရွာတွင် လယ်ယာလုပ်ငန်းမှ ရရှိသော ဝင်ငွေ၏ ၁၃.၉၅ ရာခိုင်နှုန်းနှင့်ညီမျှပြီး မြိုင်ကျေးရွာတွင် ၁၁.၃၉ ရာခိုင်နှုန်းနှင့် ညီမျှပါသည်။ လက်ပံပင်အစုအဖွဲ့ပိုင် သစ်တော၏ အပင်မျိုးစိတ်ကြွယ်ဝမှု (Species richness) မှာ ၇၅.၇၂ ± ၅.၈၈ ဖြစ်ပြီး မြိုင်အစုအဖွဲ့ပိုင်တော၏ အပင်မျိုးစိတ်ကြွယ်ဝမှုမှာ ၁၀၁.၂၀ ± ၁၃.၂၉ ဖြစ်ပါသည်။ Shannon အညွှန်းကိန်း (Shannon Index) အရ ၃ . ၉၃ နှင့် ၃. ၉၉ အသီးသီး ဖြစ်ပါသည်။


**Study on Potentialities of Community Forestry with Special Emphasis on Rural Development and Plant Species Conservation: A Case Study in Ywa Ngan**

**Township, Shan State**

**Thaung Naing Oo[1*], Lwin Ko Oo[2] and Yin Yin Kyi[3]**

**Abstract**

This study was carried out in Let-pan-bin and Myaing community forests, Ywa-ngan Township. The objectives were to examine the contributions of homegarden and community forestry to the rural development, and to investigate the plant species diversity of community forests established in the watershed areas. Rapid rural appraisal (RRA) and forest inventory were used as the main methodologies of the study. Home-garden contributed 176,666 Kyats (±13.91% CV) and 213,333 Kyats (±14.26 % CV) to the household of Let-pan-bin and Myaing villages, respectively. These annual contribution amounted to 22.1 percent and 21.5 percent of household's major income from farming activities, respectively. In addition, every household also obtained fuelwood, small timber and seasonal fruits/vegetables for the subsistence consumption. These amounts had 13.95 percent of income from farming activities in Let-pan-bin village and 11.39 percent in Myaing village. The species richness of Let-pan-bin and Myaing community forests (CF) were 75.72±5.88 and 101.20±13.29 whereas the Shannon's species diversity indices were 3.93 and 3.99, respectively. Shannon's evenness of Let-pan-bin and Myaing CFs were 93 percent and 91 percent, respectively. There were 3336 (±850.83) and 3661 (±734.15) seedlings per ha while 2588 (±682.54) and 3208.13 (±777.91) saplings per ha in Let-pan-bin and Myaing CFs, respectively. In Let-pan-bin CF, Pyinma (*Lagerstroemia macrocapa*) occupied the highest important value index (IVI) (15.90 percent) while Monn (scientific name not available) (16.89 percent) in Myaing CF. The coefficients of similarity (Ks) showed 50.33 percent between two forests in terms of floristic composition. Thirty-eight species were found as common species in both CFs. The participatory approach and community-based forest management activities were the major factors in achieving watershed conservation in the study area and it should be mimicked to the other rural areas for the environmental conservation and rural development.

**Keywords:** community forests, homegarden, stand structure, tree species diversity, rural development, watershed areas

**Contents**

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## 1. Introduction

There had been a significantly deforestation problem in the study area i.e., Ywa-ngan Township and around looked gully and sheet-eroded and barren. Annual deforestation rate during 1975 to 1989 was 218,800 $ha^{-1}$ because of natural and man-made causes including illicit logging, short fallow cycle of shifting cultivation, excessive cutting of firewood, improper land uses and inappropriate farming system (Forest Department, 1998).

The Government of Myanmar started to focus natural resources management simultaneously with welfare of local people by early 1990 and a project entitled "The Watershed Management of Three Critical Areas (MYA/93/005)" was launched as a component of a holistic program called the Human Development Initiatives (HDI) with a joint sponsorship by UNDP/FAO and Myanmar Government (Win and Sint, 1997). Many rural development activities and watershed conservation activities were initiated in the Shan State (South), the Dry Zone and the Delta area. It has taken the forefront of any local development programs.

Ywa-ngan Township in Southern Shan State was one of the project sites and various agroforestry practices including homegarden were introduced systematically aiming at not only to improve the socioeconomic conditions of the local people but also to conserve watershed areas. In fact, the local people have been adopting most agroforestry practices according to their traditional knowledge and thus the project helped to modify agroforestry practices in order to improve production (income) per unit land area. Intensive activities were launched to apply agroforestry widely throughout the watershed areas. The main essence was participatory approach on conservation of watershed areas. As a result, the project could introduce the concept of community based environmental conservation successfully in the study area. Nowadays, community forestry programme has widely adopted throughout the country with the strong support of Community Forestry Instructions (CFIs).

This study was designed to explore the species composition and stand structure of the community forests in order to show the achievement and role of community forests in watershed conservation. As an integral part of watershed conservation, this study also studied the contributions of homegardens to the livelihoods of the local people. Thus, the objectives of this study were:

(1) To examine the socioeconomic contributions of homegarden as an integral part of rural community development; and

(2) To study the tree species diversity and stand structure of the well-conserved community forests in watershed area.

## 2. Materials and Methods

### 2.1. Description of the study area

This study was conducted in two community forests/villages, namely, Letpanbin and Myaing in Ywa-ngan Township, Taunggyi district, Southern Shan State. The elevation is about 1,500 m above sea level. Average annual rainfall is 2,100 mm. Mean temperature ranges from 15°C in winter and 26°C in summer. The average relative humidity is 72.3 %. The soil is generally sandy loan and clay. There were 138 and 183 householes in Lep-pan-bin and Myaing villages while the average family size was 5.8 and 7.2 persons per household, respectively.

### 2.2. Rapid rural appraisal (RRA) and forest inventory

For semi-structured interviews and structural questionnaire survey, 10% of the total households of each village were selected randomly with the kind assistance and permission of the local administrative bodies. Therefore, this study covered 14 households in Let-pan-bin village and 18 households in Myaing village.

Forest inventory was carried out in Let-pan-bin CF, which covers an area of 184 ha and in Myaing CF which occupies 89 ha. For vegetation analysis, 25 sample plots were established systematically in each forest. Each plot has a size of 400 $m^2$ (20m x 20m) and total sampling area for each forest was 1 ha (10,000 $m^2$). Height and diameter at breast height (with dbh ≥ 5 cm) of all trees were measured in each plot. For analyzing the natural regeneration (sapling: dbh<5 cm and height >130 cm and seedling: 30 cm< height <130 cm), each plot was sub-divided into four equal subplots measuring 25 $m^2$ (5 m x 5m) and was referred to as C1, C2, C3 and C4. The data analysis was done by MS-Excel 2000 and Statistical Program for Social Science 12.0 (SPSS). Equations used for the tree species diversity, richness and evenness are shown in Table 1.

**Table 1. Equations for the stand structure and species composition analysis**

## 3. Results and Discussion

### 3.1. Contributions of home-garden to the livelihoods of the rural peoples

Agriculture was the major source of income earning activities in the study areas. The major crops planted were orange, tea-leaf, paddy, sesame, a variety of beans and peas, groundnut, potato, cauliflower, cabbage, carrot, radish, garlic, maize and sunflower. These crops were grown alternately. Nowadays, cultivation of orange and tea-leaf orchards had been increased due to its higher demands, attractive market price and easy maintenance. Off-farm income earning opportunities were rarely found in the study area. People were engaged in agricultural activities with great effort for increased production. They use chemical fertilizers, organic fertilizers and pesticides as well. Of course, almost all activities are carried out manually. The average annual incomes of households from their farming are shown in Table 2.

**Table 2. Average annual income of a household from farming activities**

The average annual income of households from farming amounted to Kyats 800,000 in Let-pan-bin village and Kyats 990,000 in Myaing. The income of household from Myaing village is higher than that of Let-pan-bin village. Due to reasonable incomes, people in both villages could participate comfortably in social and religious affairs. They could send their children to schools; even to the universities. Due to increased productivity and good prices of crops, the annual incomes of the households are likely to increase year by year. It would contribute to the all round development of their community.

Crab apple trees, Eucalypt (*Eucalyptus grandis*), *Cassia spectabilis*, and *Senna siamea* are planted around the farmlands for boundary demarcation, fuelwood, small timber, wind break and soil conservation. Residues from cabbage and tomato and other agricultural wastes were applied in the field as organic amendment to the soil. Bamboos, *Calliandra calothyrsus* and *Leucaena leucocephala* were also planted above the farmlands as well as on steep slopes to minimize soil erosion and landslides and for fodder for cattle. It was found out that the nearby streams and natural springs were also well protected by planting bamboos and trees. Knowledgeable village elders (respectable persons) supervised that the trees along both sides of streams are preserved. It ensured the persistent outflow of the springs forever. Better growth of trees of different sizes was found along the streams. Traditional customs, spiritual belief and experiences also reinforced those situations. Degraded lands have been converted to good planted forest and secondary forest, which contributed significantly to the watershed conservation as well as soil stabilization in the sloping terrain.

Every household has its own home-garden, in which perennial trees were grown for subsistence consumption and commercial purpose as well. Seasonal and annual crops were spatially as well as temporally mixed with perennial trees in the home gardens. Seasonal flowering plants were also planted. Home-gardens were established and maintained by members of household and their products were intended primarily for household consumption. The perennial trees were commonly grown in the home-gardens, which are Jackfruit, Avocado, Coffee, Citrus, Mango, Dogfruit and Guava. The typical structure of home-garden is shown in Table 3 and Figure 1.

**Table 3. Typical canopy structure and dominant species**

**Figure 1. Typical structure and components of homegardens in Let-pan-bin and Myaing villages**

It was found out that most home-gardens were dominated by perennial fruit trees. Home-gardens were characterized by high species diversity and usually 3-4 vertical canopy strata, which resulted in intimate plant associations. These consisted of an herbaceous layer such as seasonal crops and vegetable, vines, shrubs, climbers near the ground, a tree layer including perennial crops at the upper canopy and the intermediate layers including small trees and some perennial trees in between. The almost continuous productions were observed throughout the year. It was obvious that the combination of crops with different production cycles and rhythms resulted in a relatively uninterrupted supply of food products. The average annual income of a household from homestead garden and percentage of income from farming is shown in Table 4.

**Table 4. The average annual income from homegarden**

Average annual income of each household from home-garden represented at least 21.5 percent of major income from their farming. Actually this estimate was based only on the income from perennial trees (horticultural trees). There were also other benefits of home-gardens such as seasonal vegetables and fruit which provide food, increase household income and saving.

According to the semi-structured interview, the home-garden and farms provided almost all (almost 100 percent) requirement of fuelwood for household consumption in the study areas. Villagers just lopped the branches off when collecting the fuelwood. Small timbers such as pole and post were also obtained for the household and farm uses. Seasonal crops and vegetables were also available for subsistence consumption and the households do not need to depend on market. Vegetables were grown mostly in their backyards. The average annual consumption of fuelwood, small timers and seasonal vegetable in each household is shown in Table 5.

**Table 5. Average annual consumption of products of home-garden in financial values**

Home garden reduced the dependency on markets by providing products such as fuelwood, vegetables and small timbers that would otherwise need to be purchased. It is clear that the households would have spent some portion of their income for these products unless these are available from their homestead gardens. Reducing market dependency protects farmers from price fluctuations and high inflationary rates. Due to availability of fuelwood and small-timer from homestead gardens and farms, the community forest was less likely to be destroyed and it could be maintained only for watershed conservation and environmental purposes, which in turn increase the productivity of agricultural crops (products) in the study areas.

Almost all homestead gardens were found to be well fenced with profound growth of Kyet-su (*Jatropha curcas*), Garden croton (*Codiaeum variegatum*), and Lantana (*Lantana aculeata*) and Bawzagaing (*Leucaena leucocephala*). These tree species are used as a live fencing, which also provide fuelwood, foliage for cattle and soil and water conservation. Some households planted bamboos especially *Dendrocalamus copelandii* in homestead as fencing.

For the rural people as well as resource poor farmers, economic security is dependent upon environmental health and stability. Environmental degradation contributes to a more desperate type of poverty and malnutrition. Land shortages caused by increasing populations and degradations of available arable land are also the primary cause of food shortages and rural poverty. Home-garden can increase the productivity of existing land thus enabling the rural poor to meet their nutritional needs on the limited amount of land. Home gardens as well as agroforestry systems protect cultivated soils from degradation thereby maintaining the quality of the arable land that is available to the rural people. Thus, any activity that conserves or improves soil productivity and the environment without restricting usage improves economic security in general.

## 3.2. Plant Species Diversity and Stand Structure of Community Forests

### 3.2.1. Species area curve estimate

One of the simplest ways of estimating species richness is to extrapolate the species-area curve for the community forests. The species - area curve expresses the number of species in relation to the size of the area. Since the number of individual tends to rise with the area sampled, one can fit a regression line and use it to predict the number of species on a plot of any particular size (Krebs, 1999). It is also the best criterion for determination of the minimum study area. It was drawn to show that a representative sample of the species composition was obtained by the sample plots. Both curves were based on all trees with diameter at breast height equal to and greater than 10 cm (≥ 10 cm DBH). The number of species in relation to area sampled is shown in Figure 2.

**Figure 2. Species area curves of community forests**

The result indicated that the number of species is strongly related to its area because values of $r^2$ (coefficients of determination) for Myaing CF and Let-pan-bin CF are 0.99 and 0.99, respectively. Total number of species has been increasing up to an area of 1 ha (10,000 $m^2$) and it tends to be more or less stable after 1 ha according to the trend of Logarithmic number of species. It can be noted that the sampling area of 1 ha is enough for analysis of vegetation in the study area.

**3.2.2. Tree species diversity, richness and evenness**

Diversity indices are better measure of the species diversity of a forest than the species density and mixture ration and more informative than species counts alone. In Simpson's diversity index, as the value of D increases, diversity decreases. Shannon-Wiener Function does not exceed 5.0 in biological communities (Krebs, 1999). The diversity indices of two community forests are shown in Table 6. When quadrat sampling is used to sample the community, it is possible to use another nonparametric approach, the jackknife, to estimate the species richness (Krebs, 1999). In this study, the number of tree species with equal and above 5 cm diameter at breast height (dbh) was analyzed. The Jackknife estimates of species richness of two community forests are shown in Table 6.

**Table 6. Tree species diversity, richness and evenness of CFs**

Shannon's Diversity Index (H') and Simpson's Diversity Indices (D) of forests were almost the same for the two CFs (Table 6). The number of species per ha as well as Jackknife estimate of species richness of Myaing CF is higher than that of Let-pan-bin CF. In case of unique species, Myaing CF occupied the higher number of unique species (24.39 percent of total species) than that of Let-pan-bin CF (10.14 percent of total species). It is necessary to explore the succession pattern of forests and to carry out silvicultural intervention for conservation of these rare species and to fulfill the needs of the local people on sustainable basis. Species composition of community forest is shown in Figure 3.

**Figure 3. Structure and species composition of community forests**

One characteristic feature of communities is that they contain comparatively few species that are common and comparatively large numbers of species that are rare. Evenness measure attempts to quantify this unequal representation against a hypothetical community in which all species are equally distribution (Krebs, 1999). The evenness measures of two CFs are shown in Figure 4.

**Figure 4. The evenness measures of the community forests**

In this study, the numbers of species represented by few individuals (i.e. a single individual, two individuals, three individuals and so on) are larger than other species represented by many individuals. Except single individual, the numbers of rare species represented by two individuals to five individuals in both CF are more or less the same. In Let-pan-bin CF 1.3% and in Myaing CF 4.1% of total individuals belong to single individuals.

The most abundant species in Myaing CF were Monn, Gyo (*Schleichera oleosa*), Yingu-akyi (*Quercus helferiana*), Thabye (*Syzygium cumini*) whereas Thebye (*Syzygium cumini*), Pyinma (*Lagerstroemia macrocapa*), Yebadon (*Bischofia javanica*), and Thadi (*Protium serrata*) were found abundantly in Let-pan-bin CF. It was observed that the species composition and succession of both stands have been leading towards semi-evergreen forest type.

### 3.2.3. Coefficients of similarity

The coefficient of similarity is generally used as a means of comparing stands from floristic point of view. Sörensen index is based on the presence or absence of species. If both stands (portions) are floristically identical, Ks value is 100 and if they are completely different, Ks is zero. The coefficient of similarity is modified by Weidelt (2000), which is based on the calculation of dominance (basal area) of species. The similarities of two community forests are shown in Table 7.

**Table 7. The similarity of two community forests**

According to the results, the coefficients of similarity Ks showed 50.33 percent between two forests in terms of floristic composition. It means only about 50 percent of the total species were common in the two forest stands. There were 69 species per ha in Let-pan-bin CF and 82 species per ha in Myaing CF. Thirty-eight species were found as common species in two stands. On the other hand, the coefficients of similarity, which is based on the dominance of the species ($K_G$), also showed 61.84 percent between two forests. Stand basal area per ha of two forests were also different. It means that one community forest possesses greater basal area per ha (standing volume) than the other. Let-pan-bin CF occupied 48.96 $m^2$/ha and Myaing CF has 54.65 $m^2$/ha.

Although two forests have been protected and conserved in the same agro-ecological zone in the same year, their species composition, structure and growth performance in terms of similarity index are different. In fact the geographical situations, altitude, and climatic conditions of these two forests are more or less the same. The main factors might be the difference in the degree of canopy exposure and light intensity (availability of light) and moisture condition of the forest soil. Other possibility is that two community forests are reaching different successional stages.

### 3.2.4. Importance value index (IVI)

Silvicultural Importance Value Index (IVI) is the most well known indicator to generalize the analytical results of individual forest surveys in order to gain a quick overview and to make immediate comparison between different surveys. Table 8 shows the top ten tree species, which occupied the highest IVI in the stand of Let-pan-bin and Myaing CFs.

**Table 8. Ten highest IVI tree species in Let-pan-bin and Myaing CFs**

It was found out that Pyinma occupied the highest IVI followed by Thabye, Yebadon, Thabye-pauk pauk, Pet-sut etc. in Let-pan-bin community forest. These species have higher frequency, more abundant and larger basal area per hectare than these of others. So these species play an important role (key role) to stabilize plant community in this area. Among these species, Pyinma, Thabye, Yebadon, Pet-sut, Thin-wun bo, Thadi and Monn are locally important species and used for various purposes. Thabye, Yebadon, Thabye-pauk pauk, Pet-sut and Monn are also indicator species in hill semi-evergreen forest.

In Myaing CF, Monn occupied the highest IVI value followed by Gyo, Sukhauk, Mak-mawn-awn, Yingu-akyi, Nalin-kyaw etc. In this forest, dry hill forest species such as Gyo, Sukhauk, Than-de, than-that are mixing with semi-evergreen species such as Monn, Yepadon, Nalin-kyaw. It can be noted that the forest is under successional stage between dry hill forests to moist as well as semi-evergreen forest.

### 3.2.5. Natural regeneration

The profound natural regeneration occurred in both stands. It is very important for sustainable development of forests. Mean number per ha of seedlings and saplings between forests were statistically tested. The difference in number of sapling was highly significantly ($p<0.001$) between the forests while that of seedling was not statistically different ($F = 4.45$, $p = 0.0164$). Mean numbers per ha of seedlings and saplings are shown in Table 9.

**Table 9. Natural regeneration of two community forests**

The future successional pattern of the stands could be stimulated with the help of IVI and natural regeneration condition of the stand. In Let-pan-bin CF, Thebye, Monn, Yepadon, Thinwun-bo, Thadi and Pet-sut are dominant in terms of IVI and natural regeneration so that these species will continue to dominate the stand. In Myaing CF, Monn, Thabye, Yingu-akyi, Gyo, Yebadon and Su-khauk dominate the stand and all these species have abundant natural regeneration so that these species will continue to dominate the stand in future. Some species such as On-don, Yepadi, Shitsha, Yin-phyar and Thit-cha also have profound natural regeneration, which would also be co-dominant species in the stand.

### 3.2.6. Stand structure

Stand structure is the physical and temporal distribution of trees and other plants in the stand (Oliver, 1996). In this study, the stands were analyzed horizontally and vertically. Both stands had a wide range of diameter classes (DBH). Diameter classes 35-40 cm to 45 to 50 cm occupied the largest basal area in both stands. Figure 5 shows the relationship between diameter classes and relative basal area (RBA) and relative abundance (RA).

**Figure 5. Relationship between DBH and relative basal area and relative abundance**

Diameter classes 35-40 cm to 45-50 cm are the reasonable sizes for household consumption and local uses. However, these diameter classes contributed larger basal area. It means that trees are protected and conserved successfully only for watershed conservation and environmental purposes in the study area.

In both stands, distribution of diameter classes tends to follow the inversed J-shape curve. It means that the smaller diameter classes are more abundant than that of medium diameter classes, which are also greater than higher diameter classes. One exception was obviously found in the Myaing CF that the diameter class 35-39.9 cm was the most abundant in the stand. In general, it is typical diameter distribution pattern of a natural forest and it could be expected that the stands would continue to grow sustainably unless severe natural and human disturbances occur. The diameter classes represented by species are shown in Table 10.

**Table 10. Diameter classes represented by tree species**

It was observed that the diameter class 20-40 cm represented the highest percentage of total species followed by 5-20 cm, 40-60 cm, 60-80 cm and over 80 cm. The largest diameter class occupies only few species in both stands. Mean DBH of Let-pan-bin CF is 29.76 cm (±16.67) while that of Myaing CF is 33.50 cm (±17.86).

The relationship between diameter and height was strong enough to stimulate the future growth performance of the stands ($R^2$=0.717 and 0.7103 for Let-pan-bin CF and Myaing CF respectively). Mean heights of Let-pan-bin CF and Myaing CF were found as 18.39 m (±7.518) and 19.31 meter (±8.15) respectively (Figure 6).

**Figure 6. Diameter-height relationship**

Species occurring in different vertical layers were also analyzed in the investigated stands in order to realize species distribution pattern in each tree storey and successional patterns of the stands (Figure 7). Based on the height of the trees observed, 3 different storeys were distinguished as upper (U), Middle (M) and lower (L).

**Figure 7. Tree storey and percentage of species**

In Let-pan-bin and Myaing CFs, 25 and 22 percent respectively of total species were found in all storeys. In both stands, the highest percentage of total species occurred only in the Middle storey (M) (78 and 77 percent), followed by lower storey (L) (74 and 74 percent). It is evident, therefore, that most species will continue to grow in a sustainable manner due to the presence of many small trees.

**3.2.7. Estimating above ground biomass**

Forests plays very important role in global climate and climate change because it is related to the global and regional carbon cycle. Carbon storage in forest ecosystems involves numerous components including biomass carbon and soil carbon. In this study, above ground biomass of community forests was estimated using the appropriate regression equations for tropical species developed by Brown (1997) and the results are presented in Table 11.

**Table 11. Above ground biomass and estimated carbon accumulation of CFs**

In order to avoid over estimation and to have closer result, the results of exponential functions should be taken into account. Therefore, above ground biomass of Let-pan-bin and Myaing CF amounted to 564 tons per ha and 666 tons per ha respectively. Thus, total biomass accumulation in each forest accounted for 103,776 tons and 59,274 tons respectively. On the other hand, total carbon accumulation was estimated at 46,184 tons in Let-pan-bin CF and 26,344 tons in Myaing CF.

Establishing forest plantations and conserving natural forest provide an energyconscious world with a clean, efficient means of absorbing some of excess in atmospheric $CO_2$. The ecological role of both CFs is very important in the study areas. Although CF has been established to fulfill the needs of local people and watershed conservation, it provides not only primary objectives, but also other intangible ecological functions, which in turn contribute to the local and regional environmental stability as well as the fight against climate change.

## 4. Conclusion

The use of agroforestry to increase food supplies and protect environmental resources could be one of the long-term solutions for poverty alleviation and rural development. Home-garden is one of the best strategies for rural community development since it produces food (fruits & vegetables) continuously throughout the year with the lowest investment (i.e., land, labor, time, money). It can help lower perceived risks and real risks. System is flexible. It can be designed to meet the needs of the local people and tailored to suit local conditions. The role of community forest in watershed conservation, which in turn contributes to agricultural crops productivity in the study area, is well recognized and appreciated. The participatory approach and community-based forest management activities have been the major factors contributing effectively to the conservation of the watershed area under study. That sort of approach should be mimicked to the other rural areas for environmental conservation and rural development programmes.

There have been good evidences (examples) of contributions of homegarden so that the rural communities and even urban households should plant trees not only for products but also for services. Species composition of homegarden should be considered not only for subsistence consumption but also for marketing so that the surplus products can be sold with good price. In this case, specific market oriented production system is economically more attractive for each particular area (villages or township) unless the edaphic and climatic conditions are limiting factors. Since community-based resources management is the best strategy for watershed conservation (environmental conservation), community forestry should be implemented sustainably and efficiently for win-win solution. Extension activities need to be launched with momentum and the rural people should be encouraged and supported at least technically by the relevant Departments, NGOs and other international organizations.

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**Table 1. Equations for the stand structure and species composition analysis**

| Sr. no. | Equations | Remarks |
|---|---|---|
| 1. | $\hat{S} = s \left(\frac{n-1}{n}\right)^k$ | Where Ŝ is the Jackknife estimate of species richness, s is the observed total number of species in "n" sample plots, *n* is the total number of plots sampled, and k is the number of unique species. |
| 2. | $D=\sum_{i=1}^{s} \left(\frac{(n_i(n_i-1))}{(N(N-1))}\right)$ | Where *D* is the Simpson's index of diversity, $n_i$ is the number of individuals of species "i" in the sample, *s* is the number of species in the sample $\sum n_i$, *N* is the total number of individuals in the sample. |
| 3. | $H' = \sum_{i=1}^{s} (Pi)(\ln Pi)$ | Where *H'* is the Shannon-Wiener function, *S* is the number of species, *Pi* is the proportion of total sample belonging to "$i^{th}$" species, and *ln* is the theoretical maximum value of diversity ($\log_2$). |
| 4. | $E(\%) = 100\,(H'/\ln H_{max})$ | Where *E* is the Shannon's Evenness, *H'* is the Shannon-Wiener function, $H_{max}$ is the *ln (S)*- the theoretical maximum value of diversity by a given number of total species (S) found in the sample. |
| 5. | $Ks = \frac{2c}{a+b} \times 100$ | Where *Ks* is the coefficient of similarity, *a* is the number of species in one stand, *b* is the number of species in another stand, and *c* is the number of species common to both stands. |
| 6. | $K_G = \frac{2G_c}{G_a+G_b} \times 100$ | Where $K_G$ is the coefficient of similarity, $G_a$ is the total basal area of the species in one stand, $G_b$ is total basal area of the species in another stand, and $G_c$ is the sum of smaller values of basal area of each common species in both stands. |
| 7. | IVI = R.A + R.F+ R.B.A | Where *RA* is the relative abundance, *RF* is the relative frequency, and *RD* is the relative dominance. |
| 8. | $Y=42.69-12.800(D)+1.242(D*D)$ ($r^2=0.84$) | Where *Y* is aboveground biomass and *D* is the diameter at breast height. (Brown, 1997) |
| 9. | $Y=\exp\{-2.134+2.530*\ln(D)\}$ ($r^2=0.97$) | Where *Y* is aboveground biomass and *D* is the diameter at breast height. (Brown, 1997) |

**Table 2. Average annual income of a household from farming activities**

| Villages | Average farm area per household (ha) | Average annual income from farming activities per household (Kyats) | CV % |
|---|---|---|---|
| Let-pan-bin | 2.50 | 800,000 | 12.31 |
| Myaing | 3.00 | 990,000 | 14.16 |

**Table 3. Typical canopy structure and dominant species**

| Canopy layers | Percentage of total canopy coverage in home-garden | Dominant plant species in each layer of home-garden |
|---|---|---|
| First layer (< 1 m) | 20 | Vegetables and seasonal flowering plants |
| Second layer (1 – 2 m) | 8 | Citrus, Papaya, Guava, banana, |
| Third layer (2 - 5 m) | 30 | Avocado, Coffee, Mango |
| Fouth layer (>5m) | 42 | Jackfruit, Avocado, dogfruit |

**Table 4. The average annual income from home-garden**

| Villages | Area of home-garden per household (ha) | Average annual income of household from home-garden (Kyats) | CV (%) | Percentage of income from farming activities |
|---|---|---|---|---|
| Let-pan-bin | 0.50 | 176,666 | 13.91 | 22.1 |
| Myaing | 0.50 | 213,333 | 14.26 | 21.5 |

**Table 5. Average annual consumption of products of home-garden in financial values**

| Category | Let-pan-bin village | | | Myaing village | | |
|---|---|---|---|---|---|---|
| | Average annual consumption per household* (Kyats) | CV (%) | Percentage of total consumption | Average annual consumption per household* (Kyats) | CV (%) | Percentage of total consumption |
| Fuelwood | 78,640 | 11.76 | 44.5 | 97,800 | 12.61 | 45.8 |
| Seasonal vegetables | 50,400 | 22.95 | 28.5 | 62,560 | 26.32 | 29.3 |
| Small timber | 47,620 | 13.09 | 27 | 52,973 | 14.24 | 24.8 |
| **Total** | **176,660** | | | **213,333** | | |

*Subsistence consumption only

**Table 6. Tree species diversity, richness and evenness of CFs**

| Parameters of Jackknife estimate of species richness | Species richness (Let-pan-bin CF) | Species richness (Myaing CF) |
|---|---|---|
| Jackknife estimate of species richness (S) (95 % confidence limit) | 75.72±5.88 | 101.20±13.29 |
| Shannon’s Diversity Index ( H' ) | 3.93 | 3.99 |
| Simpson's Diversity Index ( D ) | 0.02 | 0.02 |
| Complement to Simpson's Diversity Index ( 1 - D ) | 0.98 | 0.98 |
| Shannon’s Evenness (E%) | 93% | 91% |

**Table 7. The similarity of two community forests**

| Category | Quantitative estimate of coefficient of similarity (%) |
|---|---|
| Coefficient of similarity (Sörensen index), based on presence or absence of species (Ks) | **50.33** |
| Coefficient of similarity (Weidelt), based on dominance (basal area of species) ($K_G$) | **61.84** |

**Table 8. Ten highest IVI tree species in Let-pan-bin and Myaing CFs**

| Let-pan-bin CF | | | Myaing CF | | |
|---|---|---|---|---|---|
| **Local name** | **Scientific name** | **IVI (%)** | **Local name** | **Scientific name** | **IVI (%)** |
| Pyinma | *Lagerstroemia macrocapa* | 15.90 | Monn | Not available | 16.89 |
| Thabye | *Syzygium cumini* | 14.24 | Gyo | *Schleichera oleosa* | 13.18 |
| Yebadon | *Bischofia javanica* | 13.53 | Su-khauk | *Ziziphus incurva* | 12.38 |
| Thabye-pauk pauk | *Syzygium gratum* | 10.99 | Mak-mawn-awn | *Myrica sapida* | 11.68 |
| Pet-sut | *Eriobotrya bengalensis* | 10.90 | Yin-gu-akyi | *Quercus helferiana* | 11.11 |
| Thinwun-bo | *Millettia pubinervis* | 10.24 | Than-de | *Stereospermum colais* | 10.23 |
| On-don (1) | *Litsaea glutinosa* | 10.12 | Nalin-kyaw | *Cinnamomum obtusifolium* | 9.74 |
| Thadi | *Protium serrata* | 10.06 | Than-that | *Albizzia lucidior* | 9.00 |
| Monn | Not availabe | 9.75 | Yebadon | *Bischofia javanica* | 8.78 |
| Su-khauk | *Ziziphus incurva* | 8.03 | Sega-gyi | *Fraxinus griffithii* | 8.55 |
| Other species | | 186.24 | Other species | | 188.46 |
| | **Total** | **300** | | **Total** | **300** |

**Table 9. Natural regeneration of two community forests**

| Natural regeneration | Let-pan-bin CF | Myaing CF |
|---|---|---|
| Seedlings n/ha (±std.) | 3336 (±850.83)[a] | 3661 (±734.15)[a] |
| Saplings n/ha (±std.) | 2588 (±682.54)[b] | 3208.13 (±777.91)[a] |

*Note: Standard deviations are in the parentheses. Different letters indicate significant differences among the investigated forest stands using Duncan's Multiple Range Test (DMRT) ($p<0.05$)*

**Table 10. Diameter classes represented by tree species**

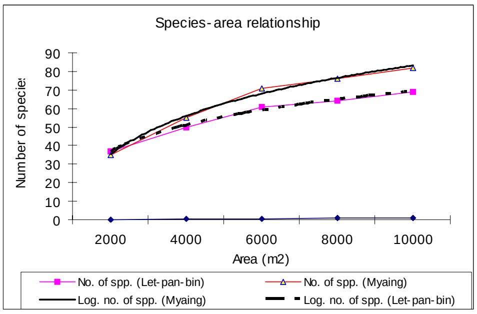
| DBH Classes | Let-pan-bin CF | | Myaing CF | |
|---|---|---|---|---|
| | No. of species | % of total species | No. of species | % of total species |
| 5<dbh≤ 20 cm | 49 | 71 | 54 | 66 |
| 20<dbh≤40 cm | 63 | 91 | 60 | 73 |
| 40<dbh≤60 cm | 35 | 51 | 38 | 46 |
| 60<dbh≤80 cm | 14 | 20 | 14 | 17 |
| dbh>80 cm | 6 | 9 | 7 | 9 |

**Table 11. Above ground biomass and estimated carbon accumulation of CFs**

| Forests | Regression equations[1] | Above ground biomass/ha[2] (ton) | $CO_2$ Content (ton/ha)[3] | Carbon Content/ha (ton/ha)[4] |
|---|---|---|---|---|
| Let-pan-bin (184 ha) | Y=42.69-12.800(D) +1.242(D*D) ($r^2$=0.84) | 593 | 967 | 264 |
| | **Y=exp{-2.134+ 2.530*ln(D)} ($r^2$=0.97)** | **564** | **919** | **251** |
| Myaing (89 ha) | Y=42.69-12.800(D) +1.242(D*D) ($r^2$=0.84) | 678 | 1,105 | 302 |
| | **Y=exp{-2.134+ 2.530*ln(D)} ($r^2$=0.97)** | **666** | **1,086** | **296** |

Note: [1]Brown, 1997, [2] 1g biomass absorb 1.630 g $CO_2$, [3] C/ $CO_2$ = 3/11 (1 ton $CO_2$ = 0.273 ton Carbon)
[4] 1 ton=1metric ton=1,000 kg=2204.62 lb

**Figure 1. Typical structure and components of homegardens in Let-pan-bin and Myaing villages**




Note: Let-pan-bin CF: y=29.722Ln(x)+35.342 $(r^2=0.99)$

Myaing CF: y=20.049Ln(x)+37.003 $(r^2=0.99)$

**Figure 2. Species area curves of community forests**

**Figure 3. Structure and species composition of community forests**

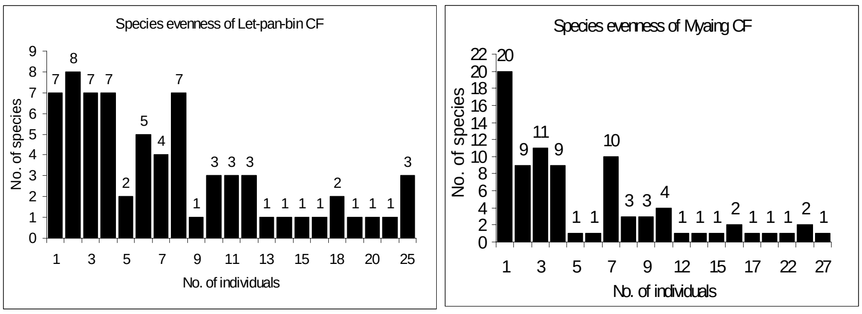



**Figure 4. The evenness measures of the community forests**

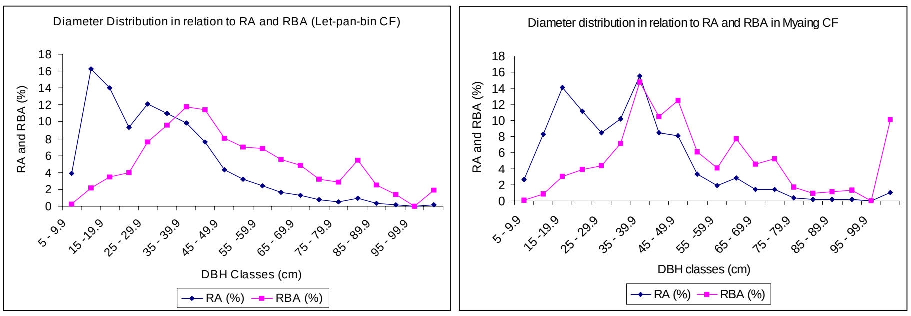



**Figure 5. Relationship between DBH and relative basal area and relative abundance**

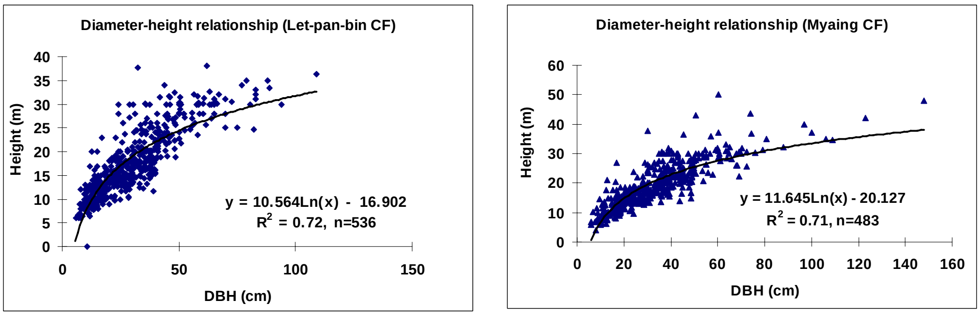



**Figure 6. Diameter-height relationship**

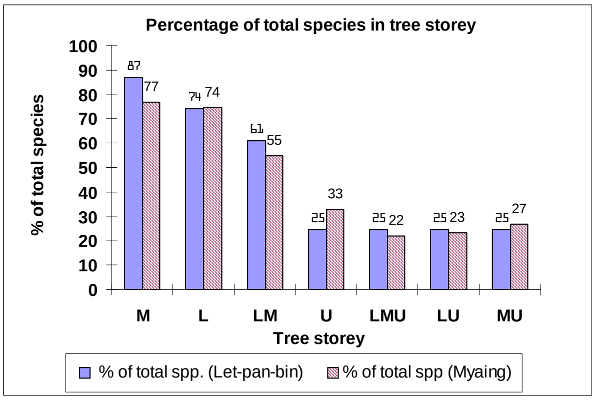



**Figure 7. Tree storey and percentage of species**