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Study on Effects of Community Forest on Microclimate and Socioeconomic Conditions with Special Reference to Central Dry Zone of Myanmar

Wai Mon Kyaw, Range Officer
Forest Research Institute

Kyaw Htun, Deputy Director-General
Planning and Statistics Department
Forest Department

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မြန်မာနိုင်ငံ အလယ်ပိုင်း အပူပိုင်းဒေသရှိ ဒေသခံပြည်သူအစုအဖွဲ့ပိုင် သစ်တောများ၏ သဘာဝပတ်ဝန်းကျင်နှင့် လူမှုစီးပွားရေးအပေါ် အကျိုးသက်ရောက်မှုကိုလေ့လာခြင်း။

ကျော်ထွန်း၊ ဒုတိယညွှန်ကြားရေးမှူးချုပ်
စီမံကိန်းနှင့်စာရင်းအင်းဦးစီးဌာန
သစ်တောဦးစီးဌာန

ဝေမွန်ကျော်၊ တောအုပ်ကြီး
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

ဒေသခံပြည်သူ အစုအဖွဲ့ပိုင်သစ်တောလုပ်ငန်း (Community Forestry) ဆိုသည်မှာ ဒေသခံပြည်သူလူထု၏ လိုအပ်ချက်ဖြစ်သော ထင်းနှင့် အခြားသစ်တောထွက်ပစ္စည်းများ ရရှိရေးအတွက် ဒေသခံပြည်သူများ ကိုယ်တိုင်ကိုယ်ကျ ပါဝင်ပတ်သက်သည့် သစ်တောများထူထောင်ခြင်း လုပ်ငန်းတစ်ခု ဖြစ်ပါသည်။ ဤသုတေသနသည် မြန်မာနိုင်ငံအလယ်ပိုင်း အပူပိုင်းဒေသတွင် အစုအဖွဲ့ပိုင်သစ်တောများ ထူထောင်ခြင်းဖြင့် ဒေသခံပြည်သူတို့၏ လူမှုရေး၊ စီးပွားရေးနှင့် သဘာဝပတ်ဝန်းကျင်အပေါ်အကျိုးသက်ရောက်မှုများ ကိုလေ့လာထားခြင်း ဖြစ်ပါသည်။ သဘာဝပတ်ဝန်းကျင်အပေါ် အကျိုးသက်ရောက်မှုနှင့် ပတ်သက်၍ အစုအဖွဲ့ပိုင်သစ်တောများ၏ အပင်ကြီးထွားနှုန်းနှင့် ထွက်ရှိမှုကို မန္တလေးတိုင်း၊ ကျောက်ပန်းတောင်းမြို့နယ်ရှိ အစုအဖွဲ့ပိုင်သစ်တော(ဖ)နေရာတွင် တိုင်းတာလေ့လာခဲ့ပါသည်။ မြေပေါ်ရှိဇီဝဒြပ်ထု (Aboveground Biomass) ကို မကွေးတိုင်း၊ မကွေးမြို့နယ်ရှိ ကန်သာလေး အစုအဖွဲ့ပိုင်သစ်တောတွင်လေ့လာခဲ့ပါသည်။ အစုအဖွဲ့ပိုင်သစ်တောနှင့် အစုအဖွဲ့ပိုင် သစ်တောအနီးအနား တဝိုက်ကို အပူချိန်၊ စိုထိုင်းဆ၊ မြေဆီလွှာ အခြေအနေများ နှိုင်းယှဉ်လေ့လာခဲ့ပါသည်။ အစုအဖွဲ့ပိုင်သစ်တောထူထောင်ခြင်းဖြင့် ဒေသခံပြည်သူတို့၏ စီးပွားရေးအပေါ် မည်သည့်အတိုင်းအတာအထိ အကျိုးသက်ရောက်မှုရှိကြောင်းအတိုးနှုန်း အမျိုးမျိုးပေါ် အခြေခံ၍ တွက်ချက်လေ့လာခဲ့ပါသည်။ ဒေသခံပြည်သူတို့၏ လူမှုရေးအနေဖြင့်လည်း ကန်သာလေးရွာ၏ လူဦးရေ ၁၀ရာခိုင်နှုန်းကို မေးခွန်းများ မေး၍ဆန်းစစ်ခဲ့ပါသည်။ အုပ်စုလိုက်ဆွေးနွေးပွဲများကျင်းပ၍လည်း ဒေသခံပြည်သူတို့၏ သဘောထားကို မေးမြန်းခဲ့ပါသည်။ အထက်ပါ လေ့လာတွေ့ရှိမှု ရလာဒ်များကို ဤစာတမ်းတွင်တင်ပြထားပါသည်။

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Abstract

Community Forestry refers to tree planting activities undertaken by a community on a communal land and it is based on the local people's direct participation in the process, either by growing trees by themselves or by processing the tree products locally.

The present study investigated the effects of community forests in three aspects: environmental, social and economic aspects. The study concentrated on the issues of the Central Dry Zone of Myanmar.

With respect to environmental aspect, tree growth and productivity were studied in six different community forest plantations in Kyaukpadaung Township. Tree growth is one of the important indices of land productivity. Productivity in terms of aboveground biomass was studied in Magway Township. Effects on microclimate were conducted on four different sites in Kyaukpadaung Township.

Regarding economic aspect, land valuation and financial analysis of community forest were conducted at different interest rates for Kanthalay Community Forest Plantation in Magway Township. The results reflect the value of the community forest plantation.

With regard to social aspect, the Focus Group Discussion was held and a household survey conducted at a sampling intensity of 10% to investigate the socioeconomic profile of Kanthalay village in Magway Township.

Key Words: Community Forest, Environmental Aspect, tree growth, Biomass,
Land productivity, Land Valuation

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1. Introduction

Community forestry refers to tree planting activities undertaken by a community on communal lands; it is based on the local people's direct participation in the process, either by growing trees by themselves, or by processing the tree products locally. The 1995 Community Forestry Instructions (CFIs) were issued with the objectives of attaining environmental stability and meeting the basic needs of rural communities. According to the CFIs, local people's active participation is intended to play a key role in the afforestation and rehabilitation of denuded and degraded lands. Correct understanding and trust between the forest Department and the users is necessary and once achieved, a community forestry programme will be successful.

Community forests can perform environmental functions such as erosion control, soil conservation, watershed protection, regulation of soil fertility, temperature and humidity, carbon sequestration, heat mitigation and biodiversity conservation; socioeconomic functions such as supply of fuelwood, timber and non-wood forest products, income and employment opportunities, provision of food and fodder and rural amenities. This study assessed the contributions of community forests in terms of social, economic and environmental benefits in the Central Dry Zone.

2. Objectives

The objectives are as follows:

- to study the effects of community forests on socioeconomic conditions of the rural community;
- to study the effects of community forests on microclimate conditions;
- to study tree growth and land productivity under community forests;
- to study the economic aspect of community forestry; and
- to provide recommendations for future development of community forestry in Myanmar.

3. Materials and Methods

3.1 Data Sources

The studies were conducted in two Townships, namely Kyaukpadaung Township of Mandalay Division and Magway Township of Magway Division located in the Central Dry Zone. The data were collected in the two townships.

3.2 Methods of Data Collection and Analysis

3.2.1 Tree growth and growing stock in community forest

To study tree growth and growing stock, 1 ha (100 m x 100 m) plot was established and further divided into 5 contiguous subplots of 100 m x 20m in six separate community forest plantations. All trees of dbh of 1 cm and above were measured on the plots and recorded in the predesigned formats. The trees measured were classified into suppressed and dominant trees. The dominant and suppressed trees were differentiated based on their crown positions. To estimate stand volume, six sample trees were selected and then felled at 0.3 m from the ground. The whole stem was cut into two-meter sections in order to determine the sectional volumes.

Representative soil samples were collected at a depth of 0-10 cm from each selected site. The samples were analyzed for the moisture content, total organic matter (OM), pH, contents of total N, available P and exchangeable K in the soil laboratory. Characterization of soil bulk density was also performed. The moisture content of each sample at the net dry weight conditions was calculated using the following equation.

$$MC\ (\%) = \frac{I.\ wt - O.\ D\ wt}{O.D\ wt} \times 100$$

MC = moisture content of the soil sample
I. wt = initial weight of sample
O.D wt = Oven-dry weight of the sample

3.2.2 Productivity in terms of aboveground biomass (AGB)

A plot of 1 ha (100 m x 100 m) size was established and further divided into 4 contiguous subplots of 50 m x 50 m. Total dry weight (TDW) of each organ of a sample tree was calculated from its total fresh weight (TFW), the fresh weight of its organ sample (SFW) and its dry weight (SDW).

TDW = SDW/SFW x TFW

where,

TDW = Total dry weigh

SDW = Sample dry weight

SFW = Sample fresh weight

TFW = Total fresh weight

The aboveground biomass (AGB) of each sample tree was the summation of biomass of trunk, branches, twigs and leaves. The AGB of no-destructive trees in the plot was estimated from allometric equation relating the AGB to D of the sampled trees:

$AGB = a (D)^{b}$

where,

AGB = aboveground biomass

a and b are coefficients of the regression function.

D = the trunk diameter at 1.3 m high above ground of all trees.

The AGB of the community forest plantation was estimated based on the allometric equation developed using the SPSS software.

3.2.3 Effect on microclimate conditions

Simultaneous hourly observations of the air and soil temperatures, and relative humidity were conducted on the selected sites on selected days. The objective of this study was to investigate the variability of ecological factors under different localities.

3.2.4 Socioeconomic survey

A socioeconomic survey was conducted through holding the Focus Group Meeting (FGM) with the members of the management committee of the community forest plantation.

Households were randomly selected at a sampling intensity of 10% (i.e. 22 out of 228 households) using the random number table. The socioeconomic survey formats were attached as annexes. Data were recorded in pre-designed formats. The data was analyzed using the SPSS and the findings were reported.

4. Results and Discussion

4.1 Environmental Aspect of Community Forestry

4.1.1 Tree growth and growing stock in community forest

Tree growth is one of the important indices of land productivity (Sakurai *et. al*. 1998). Site quality essentially determines tree growth and consequently productivity. This study reports on the status of tree growth and growing stock of six community forest plantations established in Kyaukpadung Township, Mandalay Division. All are 9-year old *Eucalyptus camaldulensis* plantations. Growth and growing stock in respective communities are given in Table 4.1

Table 4.1. Growth and growing stock in six community forests

Name of Community Forest	Average		Per hectare				MAI	
	DBH (cm)	Height (m)	No. of trees	Basal Area (m^2)	Volume (m^3)	Total Volume (m^3)	Height (m)	DBH (cm)
Kanbyu	8 4.5	7.5 3.6	203 133	1.2 0.3	10.2 2.5	12.7	0.8 0.4	0.8 0.5
Layar	13 6	10.8 4.5	187 44	2.9 0.2	25.4 1.4	26.8	1.2 0.5	1.4 0.6
Saigaung	9.4 4.6	8.3 3.8	126 36	1 0.1	8.3 0.5	8.8	0.9 0.4	1.0 0.5
Htauksha	8 4.1	7.2 4	118 56	0.7 0.1	5.8 0.9	6.7	0.8 0.4	0.8 0.5
Letpanbin	6.4 3.9	6.3 3.3	124 176	0.4 0.3	3.6 2	5.6	0.7 0.4	0.7 0.4
Myinthartaung	7.3 4.5	7.2 4	169 62	0.8 0.1	6.9 1	7.9	0.8 0.4	0.8 0.5

Note: Upper rows are dominated trees and lower rows the suppressed trees

Growing stock in this study refers to the total number and volume of all the trees growing on one-hectare plot in each community forest.

Eucalyptus species was planted at a spacing of 12 ft x 12 ft (4 mx4 m) in the six community forest (CF) plantations in 1996. Same planting and silvicultural methods were applied to the CF plantations. Eucalyptus species characteristically grows fast and its productivity is high. One-hectare sample plots were set up in each stand and the diameter at breast height (dbh at 1.3 m above ground) and height of all dominant and suppressed trees were measured. The dominant and suppressed trees were differentiated based on their crown positions. Six sample trees (4 trees in Letpanbin and 2 in Kanbyu CFs) were felled to develop a volume equation in order to estimate the stem volume. Figure 4.1 shows the volume equation used in estimating the stem volume. Thinning was not performed in all stands. The diversity in growth and productivity was observed. The best growth among the six stands was observed in Layar CF plantation. The largest average diameters at breast height of both dominant and suppressed trees were 13 cm and 6 cm respectively and the highest average heights of both dominant and suppressed trees were 10.8 m and 4.5 m respectively. The poorest growth among the six stands was observed in Letpanbin CF plantation. The smallest average diameters at breast height of both dominant and suppressed trees were 6.4 cm and 3.9 cm respectively and the lowest average heights of both dominant and suppressed trees were 6.3 m and 3.3 m respectively. Layar CF Plantation had the largest total volume per hectare amounting to 26.8 m^3 per hectare while the smallest total volume amounting to 5.6 m^3 was in Letpanbin CF plantation. It is obvious that the same species cannot grow well on all sites. Layar CF plantation has favorable site conditions for tree growth (Table 4.4). Total N%, which is essential for plant growth process, is higher in Layar than in Letpanbin. Consequently, available P% and extractable K% are lower in Layar. Soil moisture content is the most important determinant for successful tree planting especially in arid regions such as the Central Dry Zone of Myanmar. Soil moisture content in Layar is significantly higher than that in Letpanbin although organic matter, which is the main source of soil organisms, is not significantly different in the two villages.

The initial planting stock was 303 trees per acre (748 trees per ha). Number of trees per hectare varies differently in the CF plantations. Kanbyu has the highest number trees per hectare (i.e. 203 trees) indicating the highest survival rate of 45% while Saigaung has the lowest, i.e. 162 trees, indicating the lowest survival rate of 22%. The latter survival percentage is deemed particularly unsatisfactory. It seems that most trees died during the dry season in the initial period after planting due to a long stress of moisture and/or intense fire. Anthropogenic activities such as fire and cutting for fuelwood may also affect the growing stock of the stands at the later stages. The Central Dry Zone of Myanmar is characterized by low rainfall and intense heat. There are often rainless periods lasting for three to four weeks in the study area. Such severe dry spells also prevent the development of the vegetations in the Central Dry Zone. Low moisture content is the major challenge for tree planting in the region. Sufficient water supply may improve the survival rate of the stands in initial years. Equally important is protection of animal destruction. Systematic management and regular tending usually provide satisfactory tree growth and growing stock in man-made forests.

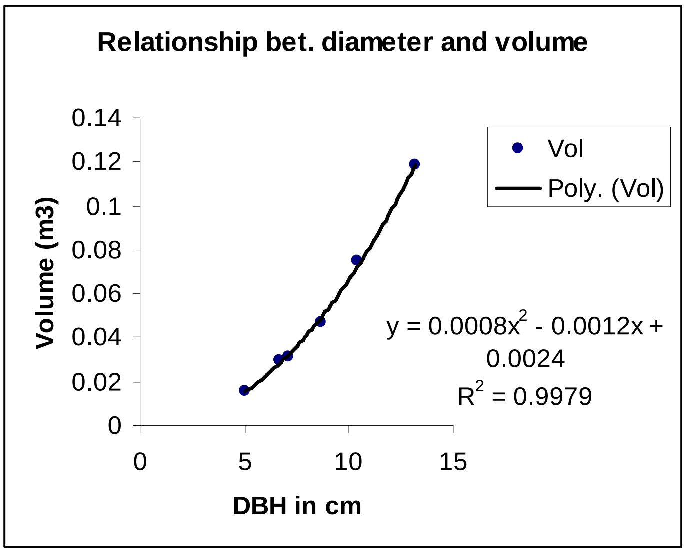

Figure 4.1. Relationship between diameter and volume of *Eucaluptus camaldulensis*

Development of a Volume Function

A polynomial regression model was developed based on the data obtained from the six felled trees for the study area using SPSS version 11.5. The validity of the model was tested in accordance with the prescribed statistical procedures. The felled trees data are given in Table 4.2.

Table 4.2 Measurements of felled trees

Sr. No.	Species	DBD (cm)	Volume (m^3)
1.	*Eucalyptus camaldulensis*	5.0	0.01569
2.	"	6.7	0.02944
3.	"	7.1	0.03129
4.	"	8.7	0.04708
5.	"	10.4	0.07471
6.	"	13.2	0.11820

Table 4.3. Comparison between equations with differing numbers of independent variables

Regressison	R^2	Adjusted R^2	Constant	Variable	B	SE (B)	Sig T
Linear	0.9758	0.9698	-0.055708	DBH	0.012733	0.001002	0.0002
Quadratic	0.9979	0.9965	0.002397	DBH	-0.001192	0.002489	0.6647
				DBH**2	0.000759	0.000134	0.0110
Cubic	0.9984	0.9960	0.036007	DBH	-0.013787	0.016167	0.4836
				DBH**2	0.002238	0.001878	0.3557
				DBH**3	-5.456E-05	6.90E-05	0.5124

It was observed that the quadratic regression was that of optimum fit to the data.

Testing the validity of a regression model

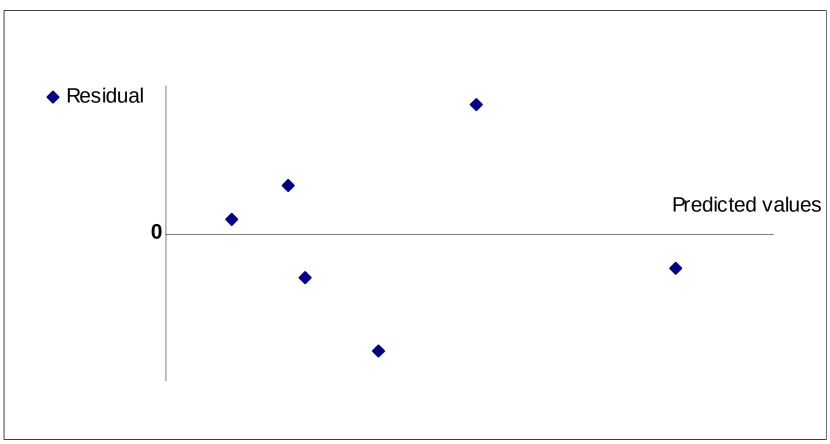

Figure 4.2 A scatterplot of residuals versus predicted values

It can be concluded from Figure 4.2 that there are no extremely large residuals (and hence no apparent outliers) and that there is no trend in the residuals to indicate that the present polynomial is inappropriate.

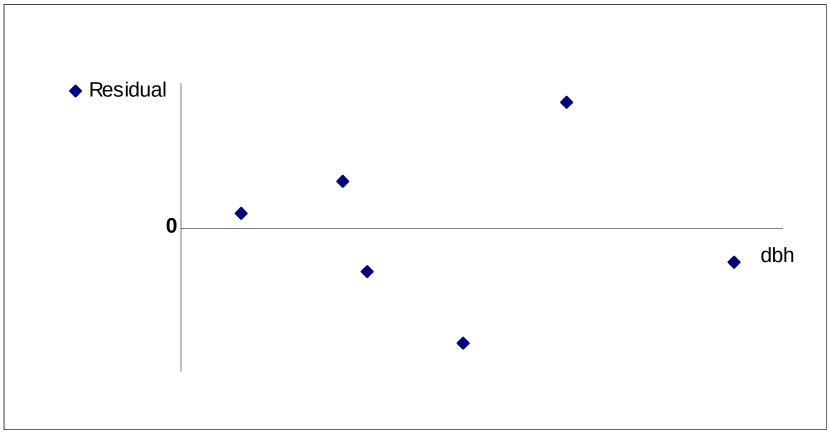

Figure 4.3. A scatterplot of residuals versus dbh

A check of the constant variance assumption was addressed with a plot of the residuals versus dbh. A pattern of residuals in Figure 4.3 more or less indicates homogeneous error variances across values of dbh.

Table 4.4. Soil properties in two CF plantations

Sr. No.	Community Forest	pH	Total N%	Ava. P%	Ext. K%	M.C%	OM%
1	Layar	7.77	0.0719	0.000040	0.0045	3.67	2.40
2	Letpanbin	7.44	0.0592	0.000428	0.0106	0.27	2.55

4.1.2 Productivity in terms of aboveground biomass (AGB)

The productivity of Kantharlay Community Forest plantation was evaluated in terms of aboveground biomass.

4.1.2.1 All tree censuses

Four sample plots, each having a size of 50 m x 50 m, were set up in Kantharlay CF plantation for data collection. Species name, diameter at breast height (dbh) and total height of all species, i.e. planted species (*Eucalyptus camaldulensis*) and naturally grown native species (*Acacia catechu, A. leucophloea, Azadirachta indica* etc.) were recorded. Density (no. of trees per ha.), average height and diameter, and the total basal area per hectare of the species observed are given in Table 4.5.

Table 4.5 Density, average height and diameter, basal area per ha by species

Species name	Density (no. of trees per ha)	Average height (m)	Average diameter (cm)	Basal area per ha (m^2)
Eucalyptus camaldulensis	600	15.3	15.3	11.03
Acacia catechu	22	7.8	11.4	0.25
Acacia leucophloea	18	6.1	8.4	0.11
Azadirachta indica	12	8.8	11.7	0.15
Total	652	-	-	11.54

Initial spacing of the CF plantation was 12' x 12' (4 m x 4 m) and stocking was 303 trees per acre (750 per ha). Thinning was performed in congested areas. After 11 years, the growing stocking per ha remain 600 trees, i.e. 80% of the original stocking of 750 per ha. Naturally regenerated trees constitute about 8% of the total trees per ha. Prohibition of grazing and collection of fuelwood in the CF plantation has contributed to the natural regeneration of some native species. Tree density and basal area of the CF is in good shape due to intensive management. The relationship between diameter and height of the planted *Eucalyptus camaldulensis* was studied (See Figure 4.4). The high R^2 value of 0.7 indicates a strong relationship.

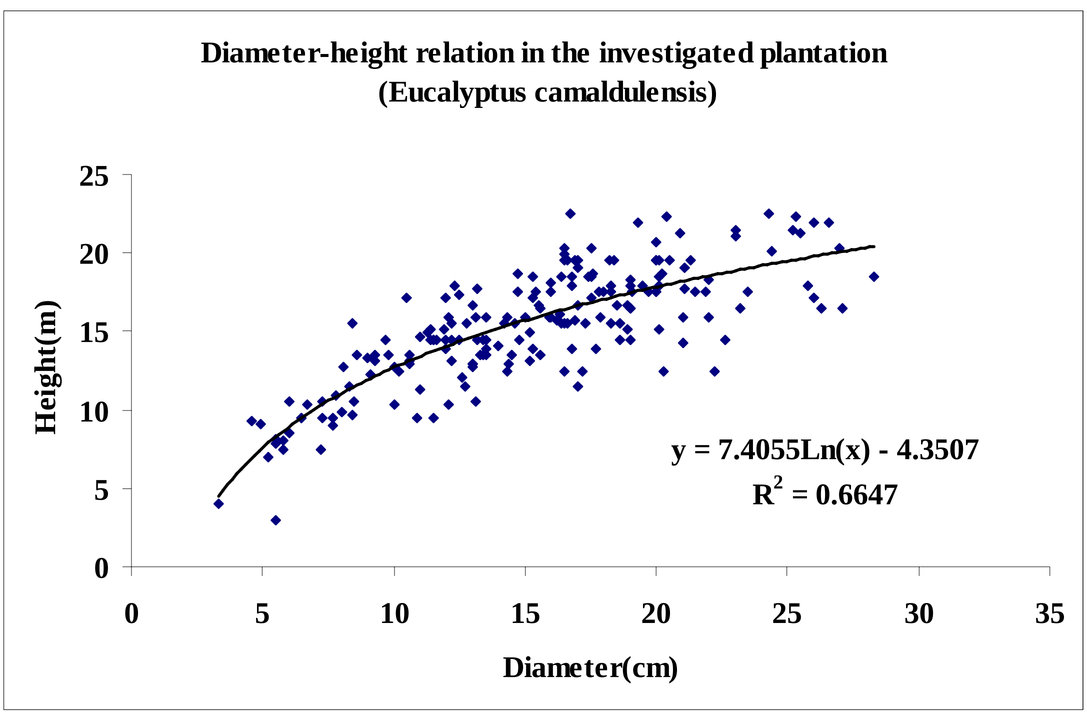

Figure 4.4. Diameter – Height relation of the *Eucalyptus camaldulensis*

4.1.2.2 Estimation of aboveground biomass using allometric equation

This study uses diameter as a single parameter for the development of allometric equation. The allometry based on diameter is sufficient for predicting biomass. The diameter is the most commonly used tree measurement for any site, and the most easily measurable variable for compiling data on the size of the trees in a specific forest.

Destructive sampling was conducted to estimate the aboveground biomass of the whole plantation. Four (*E. camaldulensis*) sample trees, which represented the most abundant diameter classes of the plantation, were selected and cut to collect the samples from various organs (leaves, twigs, branches, boughs and trunk).

The dry weights of the samples were acquired by drying samples in the laboratory according to the procedures described in the JOPP (Japan Overseas Plantation Center for Pulpwood). Using the ratio of the sample dry weight to sample fresh weight, the total dry weight (biomass) for each organ of a sample tree was calculated from the recorded total fresh weight of the respective organ. The total dry weight (aboveground biomass) of each sample tree was the sum of the total dry weights of all the organs.

For the woody parts of the sample trees, moisture content was calculated from the dry weight and fresh weight of the samples. Moisture content values were used to calculate the total dry weight (aboveground biomass) of the felled trees. However, the biomass values obtained were more or less the same.

Table 4.6. Average values for various organs of sample trees (n = 4)

Sample	Sample fresh weight (g)	Sample dry weight (g)	Total fresh weight (g)	Moisture Content (%)	Total Dry weight (biomass) (g)	Percent to total (%)
Leaves	280	151.1	14,800	-	8,157.9	4.9
Small branches	373	210.7	27,300	-	15,357.7	9.3
Twigs	198	112.8	7,175	-	4,050.7	2.4
Boughs	550	283.7	47,125	-	24,494.0	14.8
Stem	5,434	3,304.7	186,925	65	113,459.9	68.5
Total	6,834	4,063.0	283,325	-	165,520.1	100.0

Note: Average height is 16.7 m; Average diameter is 18.4 cm

A general allometric equation was developed using the Statistical Package for Social Science (SPSS) version 11.5 and shown in Figure 4.5.

Sample	Diameter (cm)	Biomass (kg)
1	19.7	196.99
2	18.3	176.92
3	16.7	113.56
4	18.9	174.62

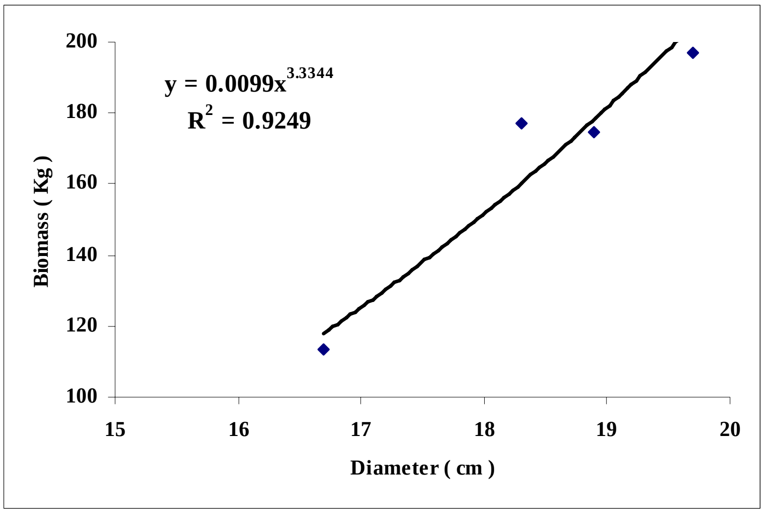

Figure 4.5. The allometric equation between dbh and aboveground biomass obtained from the sampled trees

The aboveground biomass of individual trees on one-ha sample plot of the CF tree in the site was estimated using the allometric equation. To estimate the land productivity of the Kantharlay CF plantation, aboveground biomass was calculated using the formula: Biomass (Kg) = 0.0099 (dbh) $^{3.3344}$. The aboveground biomass of the three native species was also calculated.

Table 4.7. AGB and MAI by species

Sr. No.	Species	AGB (Kg / ha)	MAI (ton/ha/yr)
1.	*Eucalyptus camaldulensis*	74,094	6.736
2.	*Acacia catechu*	1,035	0.094
3.	*Acacia leucophloea*	239	0.022
4.	*Azadirachta indica*	825	0.075
Total		76,193	6.927

Note: MAI stands for mean annual increment.

Table 4.8. AGB at different localities.

Site (Age)	Species	Density		AGB Mg/ha	spacing
		Initial (n/ha)	Actual (n/ha)		
Madang, PNG (7 years)	*Acacia mangium*	816	844	113.2	3.5 m x 3.5 m
Kantharlay, Myanmar (11 years)	*Eucalyptus camaldumelsis*	750	652	76.2	4 m x 4 m
Bogor, Indonesia (8 years)	*Acacia mangium*	1,111	231	51.0	3 m x 3 m

AGB of Kantharlay CF plantation is estimated at 76,193 Kg ha^{-1} (76.2 Mg ha^{-1}), which seems to be lower than that of well-stocked natural forests. However, the amount of AGB from a CF plantation is significant. The current productivity can be enhanced through reduction of mortality rate and disturbance of human beings. Land productivity is an indicator of a good environment. The original site was once unproductive under an environment with a poor tree cover; however, the site has become productive again after a certain period of time under a good forest cover.

4.1.3 Effect on microclimate conditions

Simultaneous hourly observations of the air and soil temperatures, and relative humidity were conducted on the selected sites on selected days. The objective of this study was to investigate the variability of ecological factors in different localities. Thermometer was used to measure of air and soil temperatures and a thermo-hygrometer was used to measure relative humidity. Measurements were recorded 8 times a day from 14-3-05 to 23-3-05 daily in the community forest (*Eucalyptus camaldulensis* old plantation), in nearby 3-years old *Eucalyptus camaldulensis* young plantation, palmyra palm grove and open space.

a) Air temperature

Figure 4.6 shows the hourly air temperature in the four sites during a representative day. Open area consistently showed the highest air temperature followed by the palmyra palm grove. The third highest air temperature occurred in young plantation. Lowest air temperatures were recorded in the community forest. The most remarkable difference in the air temperature occurred at 2:00 pm. In the early morning and late afternoon, the differences in the air temperature among the sites tended to be less pronounced.

b) Soil temperature

Hourly variations in the soil temperature among the four sites were most pronounced only on the soil surface (10 cm depth). The soil temperature was consistently highest in the open space and palmyra palm grove. Lowest soil temperatures were recorded in the community forest (Figure 4.7). A peak in the surface soil temperature occurred at 2:00 pm.

c) Relative humidity (RH)

Figure 4.8 shows the variations in the values of RH in the difference sites. Relative humidity values were generally higher in the community forest, while lowest values occurred in the open space.

The results of air temperature, soil temperature and relative humidity variations in the study areas were analyzed by using Complete Randomized Design (CRD) and means were compared using Duncan's Multiple Range Test (DMRT).

Table 4.9. Hourly air temperature in the four sites

Time	CF (C^o)	YP (C^o)	PPG(C^o)	Open space (C^o)
09:00	29.4	30	30.6	31.9
10:00	30.2	32.6	33.7	36.5
11:00	31.6	35.2	38.3	40.9
12:00	32.9	36.9	41.1	44.2
01:00	33.8	38.2	43.9	46.6
02:00	34.7	38.8	45.3	47.3
03:00	35.4	39.5	46.1	47.6
04:00	34.5	38.2	45.3	46.7

CF = Community Forest; YP = Young Plantation; PPG = Palmyra Palm Grove

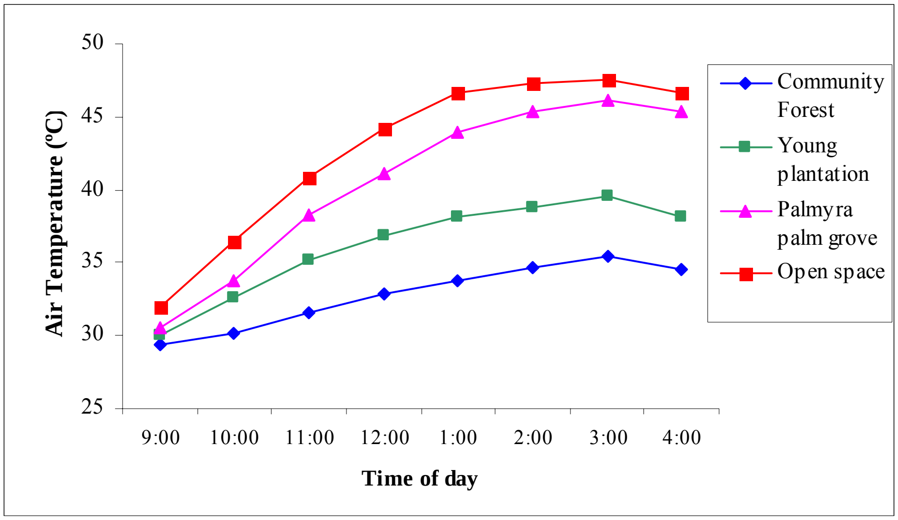

Figure 4.6. Comparison of air temperature in different sites

Table 4.10. Mean comparison of air temperature for different sites

Site	Ranks	Means
Community Forest	1	32.81 b
Young Plantation	2	36.18 b
Palmyra palm grove	3	40.64 a
Open Space	4	42.71 a

Note: Means followed by a common letter are not significantly different at 5% level by DMRT.

The air temperature inside the community forest is lower than that in young plantation, although there is no statistically significant difference between them. The air temperature of community forest is significantly lower than those of in palmyra palm grove and open space.

Table 4.11. Hourly soil temperature in four sites

Time	Community Forest (C°)	Young plantation(C°)	Palmyra palm grove(C°)	Open space(C°)
9:00	28.4	28.9	30.1	30.4
10:00	28.7	30	30.9	31.8
11:00	29.7	30.9	31.9	32.8
12:00	31	31.8	33	33.9
1:00	31.3	32.5	33.8	34.6
2:00	31.9	33.2	34.2	35.3
3:00	32.8	34.2	34.7	35.7
4:00	32.1	33.5	34.4	35.3

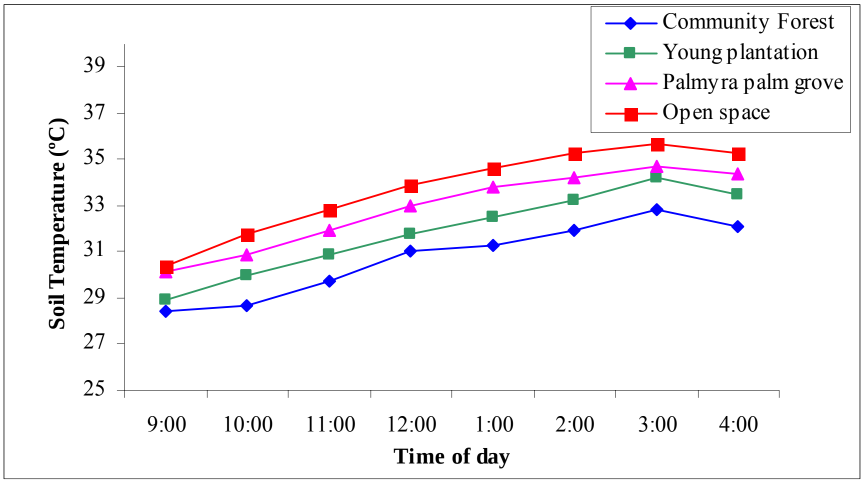

Figure 4.7. Comparison of soil temperature in different sites

Table 4.12. Mean comparison of soil temperature for different sites

Treatment	Ranks	Means
Community Forest	1	30.74 b
Young Plantation	2	31.88 ab
Palmyra palm grove	3	32.88 a
Open Space	4	33.73 a

Note: Means followed by a common letter are not significantly different at 5% level by DMRT.

Community forest has the lowest soil temperature in all study sites and there is a statistically significant difference between them. But, there is no significant difference palmyra palm grove and open space.

Table 4.13. Hourly relative humidity in the four sites

Time	Community Forest(%)	Young plantation (%)	Palmyra palm grove (%)	Open space (%)
9:00	45	43.4	42.1	41.3
10:00	42.4	40.5	38.7	37.2
11:00	39.9	37.4	36.1	34.5
12:00	37.6	36.4	34.5	31.8
1:00	35	33.8	32.2	28.5
2:00	32.5	31.3	30.2	25.7
3:00	29.4	28.1	26.8	22.9
4:00	26.7	25.4	24.3	20.5

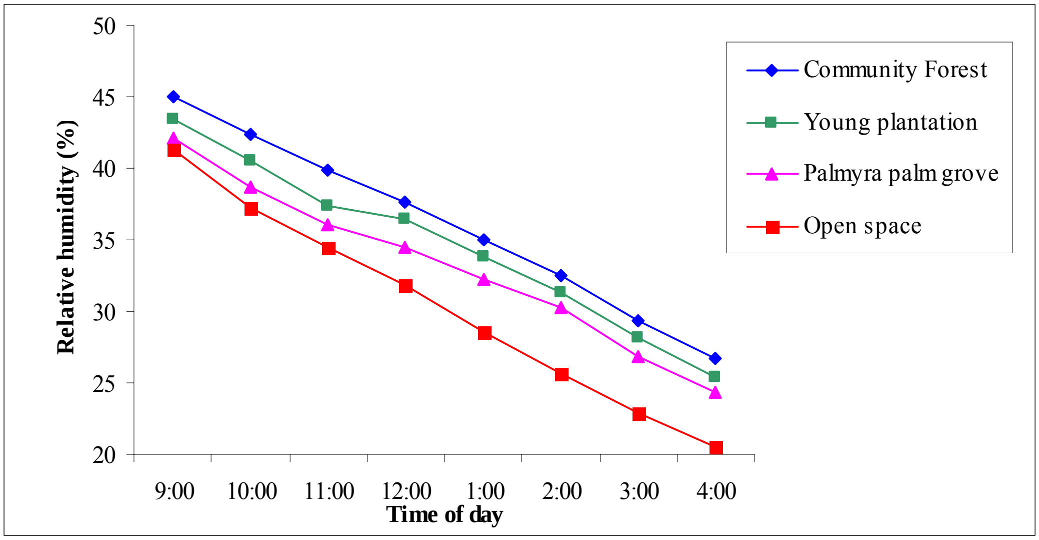

Figure 4.8. Comparison of relative humidity different sites

Table 4.14. Mean comparison of relative humidity for different sites

Treatment	Ranks	Means
Open space	1	30.3 a
Palmyra palm grove	2	33.11 a
Young plantation	3	34.54 a
Community forest	4	36.06 a

Note: All means are not significantly different at 5% level by DMRT.

There is no statistically significant difference among the community forest, young plantation, palmyra palm grove and open space. The difference in terms of relative humidity in the four different sites is not significant due to inherently low humidity in the Central Dry Zone of Myanmar.

4.1.4 Biodiversity conservation

Very little of the original natural vegetation remains and a degraded form of trees was found in many places of the Central Dry Zone of Myanmar. Introduction of community forestry in the region is one of the best ways to protect biodiversity and the environment, and to fulfill basic forest produce requirements of the rural people.

Kantharlay community forest plantation not only provides fuelwood and, food and fodder but also generate income and environmental services. The people living in the locality have started enjoying favorable microclimate conditions due to better forest conditions. The results of the present study indicate that the establishment of community forest is a legitimate with the management in accordance with the Community Forestry Instructions for social, economic and ecological benefits especially in the context of the Central Dry Zone of Myanmar. A lush community forest will become a refuge for wild animals and plants in the future.

4.2 Economic Aspect of Community Forest

4.2.1 Land valuation of community forest

The value of a forest land depends on the crop it produces. Estimation of this value necessarily requires measurement of these crops over a considerable span of time. Time span involved in timber production and interest charges during the period must also be taken into consideration.

The following formula gives an indication of this capital value of the land, which is also known as the land expectation value (*L_e*).

$$L_e = \frac{\sum_{t=0}^{r} R_t (1+i)^{r-t} - \sum_{t=0}^{r} C_t (1+i)^{r-t}}{(1+i)^{r} - 1}$$

where R_t = revenue received at time t

C_t = cost incurred at time t

r = length of rotation, years

i = interest rate expressed as a decimal.

The total receipts per acre at the end of 11 years rotation in Kantharlay community plantation are Ks. 724893.61 at a discount rate of 5 percent. The total expenditures per acre are Ks. 43442.83 at the end of rotation (Table 4.15). Therefore, the net income at the rotation is Ks. 681450.78 per acre. The ceiling capital value of Kantharlay community plantation (land expectation value - *L_e*) is Ks. 959384.46 per acre.

The total receipts per acre at the end of 11 years rotation in Kantharlay community plantation are Ks. 725,756.60 at a discount rate of 10 percent (Table 4.16). The total expenditures per acre are Ks. 70,890.27 at the end of rotation. Therefore, the net income at the rotation is Ks. 654,866.33 per acre. The ceiling capital value of Kantharlay community plantation (land expectation value - L_e) is Ks. 353,389.63 per acre.

Therefore, one-acre land value (capital value) of Kantharlay community forest plantation amounts to Ks. 959,384.46 at the interest rate of 5% and Ks. 353,389.63 at the interest rate of 10% for the rotation age of 11 years. It is obvious that land expectation value (L_e) is related to the rate of interest employed. L_e value of Kantharlay community forest plantation is higher at the lower rate.

Table 4.15. Land expectation value per acre of a community forest (*Eucalyptus* plantation) at age 11 (Interest at 5 per cent)

Receipt \ Expenditure Rate at time "t"	Value per acre (K)	Compound Formula	Value of Interest Factor	Receipt/Expenditure at "r"
Receipts: Final harvest at age 11, 240 trees per acre at Ks 1500/- per tree	360,000			360,000.00
Thinning in				
1998	534	$(1.05)^7$	1.4071	751.39
1999	360	$(1.05)^6$	1.3401	482.43
2001	1,470	$(1.05)^4$	1.2155	1,786.79
2004	1,060	$(1.05)^1$	1.05	1113.00
2005	760	$(1.05)^0$	1	760.00
Total receipts				**724,893.61**
Expenditures: Site preparation, planting, weeding, patching, fire protection, etc.	19,325	$(1.05)^{11}$	1.7103	33,051.55
Weeding & fire protection	2,475	$(1.05)^{10}$	1.6289	4,031.53
Weeding & fire protection	1,975	$(1.05)^9$	1.5513	3,063.82
fire protection	1,750	$(1.05)^8$	1.4775	2,585.63
Annual costs for protection & admin, etc.	50	$\frac{(1.05)^{11}-1}{0.05}$	14.206	710.30
Total expenditures				**43,442.83**
Net income at Rotation				681,450.78
Land expectation value				959,384.46

Table 4.16. Land expectation value per acre of a community forest (Eucalyptus plantation) at age 11 (Interest at 10 per cent)

Receipt \ Expenditure Rate at time "t"	Value per acre (Ks.)	Compound Formula	Value of Interest factor	Receipt/ Expenditure at "r"
Receipts: Final harvest at age 10, 240 trees per acre at Ks 1500/- per tree	360,000			360,000.00
Thinning for various uses in				
1998	534	$(1.1)^7$	1.9487	1040.61
1999	360	$(1.1)^6$	1.7716	637.76
2001	1,470	$(1.1)^4$	1.4641	2,152.23
2004	1,060	$(1.1)^1$	1.1	1,166.00
2005	760	$(1.1)^0$	1	760.00
Total receipts				**725,756.60**
Expenditures: Site preparation, planting, weeding, patching, fire protection, etc.	19,325	$(1.1)^{11}$	2.8531	55,136.16
Weeding & fire protection	2,475	$(1.1)^{10}$	2.5937	6,419.41
Weeding & fire protection	1,975	$(1.1)^9$	2.3579	4,656.85
fire protection	1,750	$(1.1)^8$	2.1436	3,751.30
Annual costs for protection & admin, etc.	50	$\frac{(1.1)^{11} - 1}{0.1}$	18.531	926.55
Total expenditures				**70,890.27**
Net income at Rotation				654,866.33
Land expectation value				353,389.63

4.2.2 Financial analysis of community forest

The following formulae were used in calculating the NPV and BCR**.**

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

where:

NPV = Net present value (Ks.)

B_t = Benefits (Ks.)

C_t = Cost (Ks.)

n = Rotation age (years)

i = Discount rate

When the NPV of a project is exactly zero (NPV =0), the IRR is the discount rate used to calculate the NPV. Mathematically, i.e. IRR = I such that

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$$

The NPV and B/C ratio were calculated for discount rates and profitability analysis was done.

$$\text{B/C Ratio} = \frac{\text{Total discounted benefits}}{\text{Total discounted costs}}$$

The calculation was done with the aid of Microsoft Excel 2002.

Table 4.17. Discount Rates, NPV, and BCR of Kantharlay Community Plantation

Discount rate	NPV (Ks.)	BCR	Remarks
5%	188,081.34	8.44	DE = 25264.4 DR = 213345.7
10%	103,473.02	5.18	DE = 24722.44 DE = 128194.46

In this study, the NPV is Ks. 188,081 at 5% discount rate while it is Ks. 103,473 at 10% discount rate. It is obvious that the NPV is higher at the higher discount rate. The BCR also ranged from 5.18 at 10% discount rate to 8.44 at 5% discount rate (Table 4.17). The higher the ratio of benefits to costs, the better the project. A profit of Ks. 7.44 will be obtained for every one kyat invested at a discount rate of 5% in Kantharlay community plantation. A profit will be reduced to Ks. 4.18 for every one kyat invested when the discount rate is 10%.

4.3 Social Aspect of Community Forestry

4.3.1 Background information

Kantharlay village is situated on Magway - Yenanchaung road, 10 miles north of Magway Town. Comprising 228 households, the village was established 65 years ago. The majority of the population is Bamars and Buddhists.

Dependency Ratio (DR) is the number of dependent population per 100 working-age population. In Kantharlay village, young-age DR (0-14) and old-age DR (60+) are 57.67% and 20.71% respectively. Therefore, total DR of Kantharlay village is 78.38%, which is greater than national dependency ratio of 68.7% (Department of Labour, 2004).

A socioeconomic survey was conducted in May 2005 to investigate the status of socioeconomic situation of Kantharlay Village. A total of 22 sample households representing 10% of the total households of the village were randomly selected and sample households were individually interviewed. A period of settlement among the villagers ranges from 20 to 65 years.

The size of the labour force is basically dependent upon the size of the population and its age distribution, which in turn depends on the demographic factors of the population. The size of the labour force therefore depends not only on population growth but also on the prevailing socio-economic conditions of the population (Department of Labour, 2004). In 22 sample households, the potential labour force is 67%. The total actual workers in the sample 22 households were 64 (i.e. 96% of potential labour force) indicating that almost all people in working-age class are actually working.

(a) Farming system

The main agricultural products comprise groundnut, sesame and variety of peas and beans and the nearest market for these agricultural products is nearby Magway Town.

Almost all households practice the dry farming system. Out of 22 sample households, 14 households possess lands and the rest are landless. The maximum land holding is 50 acres and the minimum is 1.5 acres. Almost all households grow groundnut, maize, sesame, sunflower and pulses. The main product is sesame (63% of all agricultural products). Sunflower, green gram, pigeon pea and maize are grown in intercropping and double cropping. Sunflower and pigeon pea are mostly grown in intercropping and green gram in double cropping. The soil is usually ploughed and harrowed and manure is put to the lands before cultivation. As soil fertility conservation practices, farm debris and cow-dung are dumped in cultivated lands. Fertilization and water harvesting practices are observed.

(b) Land ownership pattern

About half of the total households (123 households) are the land owners, of which 52 households (42%) hold 1 to 5 acres of lands and 17 households (13%) more than 10 acres. The rest own less than one acre of land. Two types of land ownership patterns were observed in the village. About 64% of the sample households received their lands from their parents and the rest bought the land.

(c) Risks and difficulties in Farming

Drought is a major problem in cultivation. Insects and some diseases, wind and water erosion sometimes affect the crop production. As a result, fluctuation in productivity is a potential risk annually.

Transportation is relatively available. The difficulties encountered in farming practices include technology, capital investment, insufficient animals for cultivation, availability of quality seeds and fertilizer, insufficient labours.

(d) Non- farming system

A few households have alternative sources of income from non-farming activities. Agriculture sector plays a major role contributing 50% of the employment in the village under investigation. Non-farming activities include trade, carpentry and mason. The workers on daily wages make up about 38% of the total workers. About 18% of sample households were hairdresser, carpenters, small-scale traders and shoppers.

(e) Educational status

As regards education, there are one primary and one post-primary schools in the village. There are nine teachers educating a total of 180 students. Since the village is situated near Magway Town, the students have an opportunity to study higher education. A total of 35 villagers had graduated from the University. Currently 30 students are studying in high school, 50 in middle school and 150 in primary school. There is one library. The Village Education Committee undertakes the matters relating to the education of the village.

Literacy rate is satisfactory (nearly 1% of sample households is illiterate). Out of 22 sample households, primary and middle school level (20.7% and 33.3% of sample households), which is satisfactory. There are the university students in the village.

(f) Status of living

Thatch is the roofing material commonly used in the village. Only a few households can use corrugated iron sheets. The walls and the floor are mostly made of bamboo. Only rich households can use wall and floor made of planking. The average monthly income is about Ks 10,000. In the village, a few households can earn up to about Ks 100,000 monthly. The households can make both ends meet.

About 40.9% of sample households have cassette. Only 22.7% have TV and 13.6% have video. Only 4.5% can use the generator for electricity. The majority from Kantharlay village still cannot enjoy using luxury goods. The villagers mainly raises chicken for consumption and cows to be used in farming. Farming is a major livelihood in the village.

(h) Energy sources

Fuelwood and agricultural residues are the main sources of energy for cooking. About 96% of the total energy is fuelwood and 68% is agricultural residues in sample households. Out of 22 sample households, only two households extracted timber from the nearby forests only for their own use.

About 36% of sample households still use coverless stoves while 64% of sample households are using efficient stoves. The Forest Department of Myanmar and UNDP have introduced energy efficient stoves in the village.

The village still depends on the supply of fuelwood from nearby villages but the amount of fuelwood has significantly reduced thanks to the availability of fuelwood from the community forest plantation. The UNDP established a fuelwood plantation in the village in 1994. The plantation has been well managed according to the Community Forestry Instructions issued by the Forest Department.

Kantharlay community forest is located beside Magway-Yenanchaung road (Mile post No.339/6) about one mile South-east of the village. Community Forest covers a total area of 50 acres and Eucalyptus species was planted at a spacing of 12' x 12'. The plantation site is a flat plain and the soil is loamy sand. Mean annual temperature is 30.5ºC and mean annual rainfall is 27.5 inches. Rain is a single source of water for the community forest.

The primary objective of the community forest is to support the fuelwood to the village. The UNDP and the Forest Department selected the planted species (*Eucalyptus* species) in consultation with the local people because of its fast growth rate and adaptability to the soil and climate of the region. The UNDP also provided the technical support. The villagers voluntarily participated in plantation works such as digging, filling the soil, planting, weeding, fire protection, etc.

At the outset in 1995, only 180 households were involved, but today all 228 households became the users of the community forest plantation. The villagers selected a committee of five members to supervise the village community forest. All the users need to attend the meetings held at every 2 months to discuss the management of the plantation. The plenary meetings are held at every 6 months. The decisions are made in consensus. A forest guard is appointed to protect the possible damages such as fire, animals, etc. The committee members monitor the plantation.

To promote the efficiency of the administration committee, the Forest Department and the UNDP have conducted relevant training courses and the Forest Department has trained a number of villagers to manage the community forest at the Central Forestry Development Training Center, Hmawbi in Yangon.

The products of the community forest were extracted with the approval of all user members. The poles were obtained from thinning in the congested stands after 4 years of plantation establishment. The thinning poles were used in the village development activities (e.g. Library, posts for power lines, school) and the surplus was sold to the users at an affordable price. The revenue from the community forest plantation is maintained by the committee for future tending operations and development activities of the village.

As the grazing and fuelwood collection were prohibited in the community forest since it was established, the natural vegetation has a significant growth within 10 years. *Zi (Ziziphus jujuba*) and *Sha* (*Acacia catechu*) forms a major part of the natural vegetation. Nowadays, the users can earn additional income from the collecting of plums. Substantial amount of fuelwood is obtained by pollarding and pruning *Zi* and *Sha* trees, which partly contribute to the need for fuelwood.

Kantharlay Community Forest is successful from the socioeconomic aspect. It can provide both fuelwood and income to the village. The users are willing to extend the area of Community Forest to obtain more social and economic benefits. However, they cannot fulfill their desire due to land limitation. Therefore, the users decided to use genetically superior *Zi* species in the available space.

4.3.2 Supply of fuelwood

The information on fuelwood budget of Kantharlay village was collected through the Focus Group Discussion (FGD). The main source of energy is fuelwood (50%) and agricultural residues (50%) especially from sesame plants. A family with up to 3 members consumes about half of a cart-load fuelwood per month (about 0.13 stacked ton of fuelwood); a family with 4-5 members about a cart-load (0.25 stacked ton); and a big family with more than 5 members need more than a cart-load fuelwood (about 0.35 stacked ton).

Agricultural residues are available from their own farm land for land owners, however the others and even land owners have to collect their fuelwood by cutting branches or sometimes digging the roots of naturally growing vegetation in the reserved and protected public forests. As the population of the village gradually increased, the nearby natural vegetation cover was seriously affected; come guently the shortage of fuelwood acute.

The users of Kantharlay Community Forest have the right to exploit fuelwood during the first 10 years of establishment. Fuelwood extraction is limited to the by products of the tending operations of the plantation such as pruning, removal of sprout coppices, and removal of unhealthy and/or congested stand. Therefore, the users can use the poles for village development activities and small branches, boughs and sprouts for fuelwood. Under the supervision of the community forestry administrative committee, the fuelwood collected from the plantation is sold to the users in ration at a low price. About 16 stacked tons of fuelwood was annually distributed for local consumption during the initial 5 years of the plantation establishment.

The site on which community forest plantation is established was a fallow land on which natural vegetation did exist in patches. The dominant species included *Zi* (*Ziziphus jujuba*), *Sha* (*Acacia catechu*), *Tamar* (*Azadirachta indica*) and *Tanaung* (*Acacia leucophloea*). However, the vegetation experienced repeated die-back phenomena because of a heavy collection of fuelwood. The fuelwood collection and grazing practices were prohibited when the plantation was established and in consequence, the coppices of the naturally growing species grew well so that they could provide some income and fuelwood to local community during a period of 11 years of community forest.

The villagers have realized the importance of natural vegetation in the plantation and now plan to use them sustainably. There are totally 4 acres of plum and substantial amount of other tree species. These well protected natural vegetation not only provide fuelwood and income for local people but also serve the aesthetic value, recreation and rich biodiversity of the area. It is estimated that the fuelwood availability from plum trees reaches 15 cart-loads (3.75 stacked ton) and 30 cart-loads (7.5 stacked ton) from *Sha* trees. Therefore, preserving and extracting fuelwood by pruning and pollarding the trees can give about 11 stacked ton of fuelwood every year without damaging the productivity of fruits and non-wood products. Amount of fuelwood bought from nearby villages was reduced and money saved. More importantly, depletion of forests due to fuelwood collection is mitigated and as a result, biodiversity is conserved.

4.3.3 Provision of food and fodder

The site of the community forest was a fallow land before the establishment of plantation. *Zi* trees naturally grow. After the establishment of the community forest, more *Zi* trees were planted in 1998-99. Fruits are plucked yearly. The villagers are permitted to collect the fruits for consumption but not for the commercial purpose. Since the fruits from the naturally grown *Zi* trees are sour, better quality *Zi* trees are planted. There is a total of 4 acres of *Zi* trees in the 50 acres of community forest. The community sold the fruits and consumed as a traditional food. The users are now willing to extend the area of *Zi* trees by growing genetically superior *Zi* species in the future as they realize the economic potential of *Zi* trees. *Zi* trees are easy to plant and maintain. They provide both income and fuelwood. After gathering the fruits, it is necessary to cut the branches of *Zi* trees, to protect insect attack as well as to sprout new fresh branches and the cutting branches can be used as fuelwood.

As fodder, only grass is obtained from the community forest. Domestic animals such as cows, goats are raised by fencing or by grazing beside the naturally occurring pond located vicinity of the community forest. The expense of fodder for a cow ranges from Ks 400 to Ks 800 per day.

4.3.4 Availability of small timbers and other NWFPs

Poles, posts, and tops and logs were obtained when thinning was carried out in the congested stands after 4 years of plantation establishment. They were used for village development activities and some parts were sold as fuelwood to nearby villages. The poles, posts and tops and logs which were obtained from the community forest are shown in table.

4.3.5 Income and employment opportunity

Poles yielded from the cultural operations are mainly used in the village development activities such as building of school and livestock feed shop etc. Moreover, substantial income was earned from the selling of the poles to the communities. The branches, boughs and coppices are also distributed to the users at an affordable price. Another source of income is the collection of plum fruits in the community forest. The fuelwood obtained through pruning and pollarding of the natural vegetation generates additional revenue.

The community forestry administrative committee holds the revenue obtained from the community forest and uses the money to expedite the implementation of village development activities and for the maintenance of the plantation. The revenues obtained from the community forest are shown in table 4.24 and 4.25.

Until now, Kantharlay community forest cannot provide the employment for the community. The users voluntarily undertake tree planting, maintenance of the plantation, fire protection, thinning operations, pruning and pollarding activities. One plantation guard has been employed to tend the community forest up till now. The community forestry committee has a plan to extend planting of *Zi* trees. Therefore, more income and employment can be expected in the near future.

4.3.6 Availability of water, aesthetic and recreational values

There has been a natural pond near the community forest since its establishment. In the past, the pond retains the water only for a few months. Today the pond can retain the water throughout the year after the establishment of the community forest. This may attributable to absorption of more water and maintenance of undergrowth and roots under the community forest. The village uses the water from the pond for drinking, bathing, also for the animals.

Kantharlay community forest together with a pond is located together with a pond in the center of the farmlands, serving as an oasis. The people stop for a rest under the shade of trees during their travels. The villagers often come to the pond for recreation. Now they realize the importance of community forest and are determined to manage the community forest sustainably. Kantharlay community forest not only provides fuelwood and income but also generate both aesthetic beauty and recreational services.

Fruit and shady trees are planted in household compounds. Forest trees and shady trees are planted in farmlands. Generally, fruit trees are not planted in farmlands because of security reason. The villagers actively participated in road-side planting, planting of trees in school compound, and monastery. They are interested in tree planting activities because they understand that tree planting is meritorious.

5. Conclusions and Recommendations

5.1 Conclusions

Kantharlay Community Forest Plantation demonstrates good practices such as good governance, presence of a proper mechanism for sharing benefits from the community forest among the users, adherence to the Community Forestry Instructions, and trust built and enthusiasm adopted in community forestry, and fullest cooperation of the Forest Department and the local authority.

Kantharlay Community Forest Plantation shows the enormous potential of community forest. However, one may conclude that Kantharlay CF is successful because it is a small plantation (50 acres), which is under managerial scale. After having realized both social and economic benefits, the users today wish to extend the current community forest plantation. Unfortunately, additional land is not available around Kantharlay village. The best practices of successful community forests should be documented and replicated to other parts of the country.

The National Forest Master Plan stipulates that community forests will fulfill 25% of the demand for fuelwood at the end of the plan period i.e. 2030-2031.The Ministry of Forestry should be well geared up to realize this target. It is believed that the community forestry is a good option to meet the basic needs of local people as well as to reduce the pressure on the foresters to conserve the forests. Political will and support would be the driving force for further development and implementation of community forestry in Myanmar.

5.2 Recommendations

- The effects of Community Forestry should be demonstrated to attract the potential users;
- Community Forestry Instructions should be reviewed, and revised accordingly;
- To mainstream the community forestry program into National Development Programs;

- The positive effects of community forestry should be communicated to the people through different media;
- A specific mechanism for sharing the benefits should be developed to avoid possible conflicts among users;
- Some limitations should be relaxed. The current duration of land lease (i.e. 30 years) should be extended, for example, 50 years in the case of establishing commercial forest plantations;
- A mechanism should be developed to expedite the issuance of community forestry certificate. It takes months or years to get a certificate for the establishment of community forestry, especially in public forest due to a lengthy process;
- A networking should be established with national and international aid technical institutes such as RECORF in Thailand and aid agencies;
- A think tank concerning community forestry institutes should be formed within the Ministry of Forestry to provide expert advice in relation to the implementation of community forestry programs; and
- Finally and may be more importantly, political will and political commitment should be sought to ensure success in community forestry initiatives.

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