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Original article

Status of Bamboo Management in Mixed Deciduous Forest at Yedashe Township, Bago Region, Myanmar

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ABSTRACT

Sustainable management of bamboo is urgently needed in Myanmar as timber yield is decreasing annually due to forest degradation and deforestation. Bamboo is the most important non-timber forest product in Myanmar that can be used in place of timber. This study assessed the status of bamboo management in mixed deciduous forest at Yedashe Township, Bago Region, Myanmar, to provide recommendations for a sustainable bamboo management. The objectives of this study were to analyze (1) the socio-economic characteristics of the local people, (2) the number of bamboo (culms) harvested and the bamboo harvesting method used by the local people residing around the mixed deciduous forest located in Yedashe Township, and (3) tree species composition and the potential of mixed deciduous forest in supplying bamboo. Community meetings and a questionnaire survey, using convenience sampling, were used to perform a social survey and an inventory was constructed to quantify the bamboo production, species composition, and diversity of mixed deciduous forest.

The local people mainly depended on bamboo production for their livelihood. Forest income provided 96.61% of the total annual household income. In total, 53 species belonging to 45 genera and 25 families were identified in the mixed deciduous forest. Within the three-bamboo species found, there were 536 clumps per hectare, equivalent to 7,000 culms per hectare. The local people did not follow the "9 rules" for systematic bamboo harvesting, except for the rule stating that harvesting should preferably be done each year. The average annual rate of bamboo harvesting per household was 24,589.30 (± 17,986.41) culms. The culms harvested were aged one or two years; and the area and season for bamboo harvesting were not specific. The number of bamboo culms harvested (2,742,255 culms) for income generation annually by the local people was higher than the annual sustainable potential of the forest (458,400 culms). The current bamboo management is unsustainable based on the existing bamboo harvesting method. Training the local

people to adopt a systematic bamboo harvesting method should be undertaken so that the bamboo resources can be managed sustainably.

Keywords: Bamboo management status, Mixed deciduous forest, Bamboo harvesting method, Yedashe Township, Myanmar

INTRODUCTION

Sustainable forest management means utilizing the forest for human consumption without destroying the capacity of the forest to reproduce by itself (Montagnini and Jordan, 2005). In Myanmar, although the forests have been managed in accordance with the prevailing forest rules, regulations, and laws with the concept of sustainable forest management, the rate of deforestation and degradation is among the highest in the world, with an annual forest cover reduction rate of 1.2% from 1990 to 2015 (Food and Agricultural Organization, 2015). Consequently, timber yield has been decreasing annually and non-timber forest products (NTFPs) are becoming more important in order to have a sustainable forest management. Therefore, managing NTFPs is an important aspect in sustainable forest management in Myanmar.

Among a wide range of NTFPs in Myanmar, bamboo has been ranked as the most important, which can be used in place of timber (Ministry of Forestry, 2001). On the other hand, most rural people in Myanmar mainly depend on bamboo for their livelihood. Sustainable management of bamboo is of paramount importance as bamboo can be used to replace many traditional timber products. It can also be used to create a sustainable source of income for communities, at the same time reduce deforestation. Reliable and up-to-date information on the state of forest resources is crucial to form decisions related to investment and policy making in forestry and sustainable development (Food and Agricultural Organization, 2015). Since the rural people mainly depend on bamboo and bamboo-related products, their socio-economic conditions need to be studied to formulate a management system for the existing bamboo stocks and to enhance the productivity of natural forests. In Myanmar, the primary source of bamboo is natural forests, which are mainly under the management of Forest Department. The department sets the annual target for bamboo production depending on the productivity of the natural forests and gives license to bamboo traders for its production and collects revenues. However, there are no preset regulations and monitoring of bamboo harvesting. As a result, there is a gap in the knowledge on how the bamboo (culms) is harvested, the number of culms harvested by the local people, and the amount of bamboo sourced from the forests. Such knowledge is essential for a systematic management of bamboo forest to promote its efficient and effective utilization.

The present study assesses the socio-economic characteristics of the local people, the amount of bamboo culms harvested annually by the local people, the bamboo harvesting

method used by the local people residing around a mixed deciduous forest situated in the well-known Bago Yoma natural forest, and the potential of the mixed deciduous forest in supplying bamboo. Information on the tree species composition of the mixed deciduous forest in this area is important because the Bago Yoma region was designated as an area where a logging was banned for 10 years and the necessary restoration activities would be undertaken (Myanmar Timber Enterprise, 2016). Assessing the existing bamboo stock of the mixed deciduous forest is also crucial since the bamboo production would be carried out annually and local people depend on bamboo production for their livelihood.

MATERIALS AND METHODS

Study area

The Saiya Reserved Forest (RF) in Yedashe Township, Bago Region of Myanmar was selected as the study area for this research (Figure 1). Yedashe Township is situated between latitude 19˚18' to 19˚30' N and longitude 95˚50' to 96˚28' E. The forest is legally owned by the State and currently managed by the Forest Department. Two types of survey were conducted: (1) a social survey and (2) a vegetation survey.

Social Survey

To assess the socio-economics characteristics of local people, five villages in the Yedashe Township were selected for social survey, namely 6 Mile, 7 Mile, 8 Mile, 9 Mile, and 10 Mile, situated near the mixed deciduous forest (Figure 1). The five selected villages are used to be the encroached villages inside the Saiya reserved forest before 2013. In 2013, the area of villages was legally excluded from the reserved forest area by the Forest Department. Therefore, the local people legally own their village area. Forest plantations, established by the Forest Department and private companies permitted by the Forest Department, are located in the vicinity of the villages. From each village, 20% of the households were randomly sampled as the population size was less than 1,000. The total numbers of households in the five selected villages (6 Mile, 7 Mile, 8 Mile, 9 Mile, and 10 Mile villages) were 86, 59, 84, 104, and 69, respectively, and the numbers of sampled households were 16, 11, 22, 18, and 16, respectively. Convenience sampling method was used in the interview procedure by contacting the respondents at their available time and place (Etikan *et al.,* 2016). A structured questionnaire consisting of closed-ended questions was used in the interview. In each household, the targeted respondents were the bamboo cutters. Small community meetings were conducted with the bamboo cutters in each village to investigate the bamboo harvesting method. During the meeting, the current bamboo resource conditions were assessed based on the information from the local people. The 9 rules for bamboo harvesting in usage were identified, using the bamboo felling rules recommended for the management of natural mixed bamboo forests by Chaturvedi (1988).

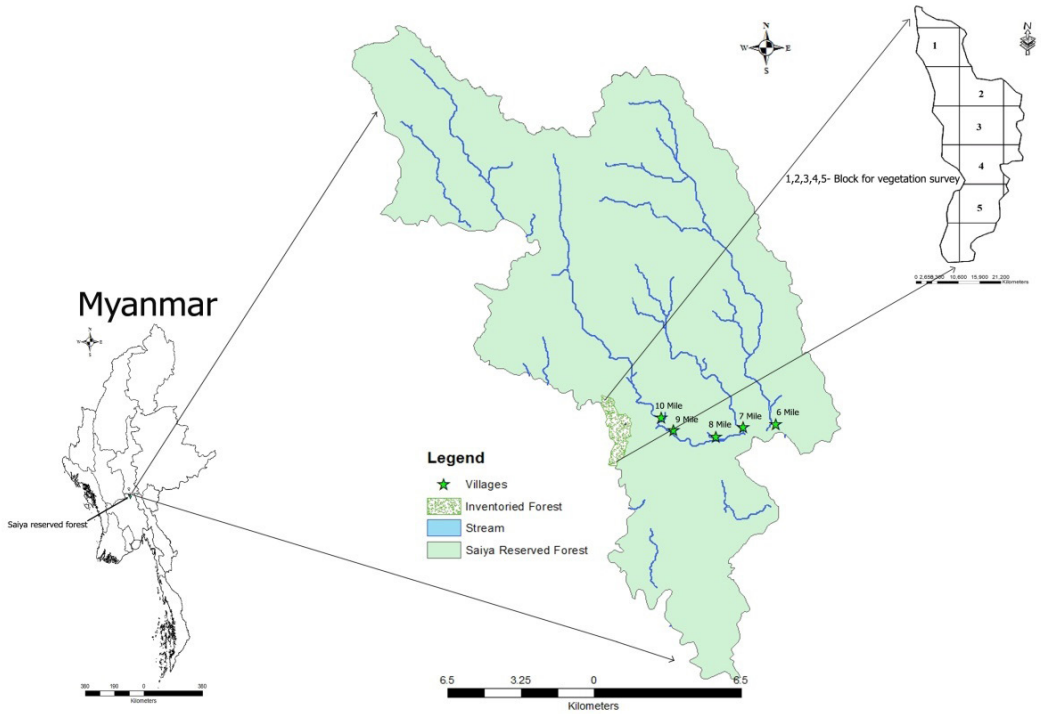

Figure 1 Map of study area showing the location of mixed deciduous forest and villages in the Yedashe Township, Bago Region.

Vegetation survey

The vegetation survey was conducted in 200 ha of the mixed deciduous forest near the villages. The forest area was a part of the Sai Ya Reserved in the Yedashe Township, Bago Region, Myanmar located at 19˚30' N and 96˚15' E. The area was identified using the knowledge of the local villagers. The entire forest area was divided into 500 x 500 m grid blocks using the ArcMap software package and five full grid blocks were obtained as shown in Figure 1. From each full grid block, five random sample plots were taken, with a total of 25 plots sampled from the whole forest. The sampling intensity was 1.25% of the total forest area. Circular plots were used in this study based on the guidebook of the International Tropical Timber Organization (Department of National Parks Wildlife and Plant Conservation, 2013). The size of each sample plot was 1,000 m^2 (17.74 m in radius), where measurements were recorded on all trees with a diameter at breast height (DBH) > 4.5 cm. In the circular subplot B (500 m^2), bamboo data were collected and in subplot C (50 m^2), saplings and shrubs were measured to know regeneration status and the species diversity of the forest. Four circular plots (D_1, D_2, D_3, and D_4), each having a radius of 0.613 m, were constructed to collect seedlings; each plot had an area of 1.25 m^2 and the total area for seedling collection was 5 m^2 (Figure 2).

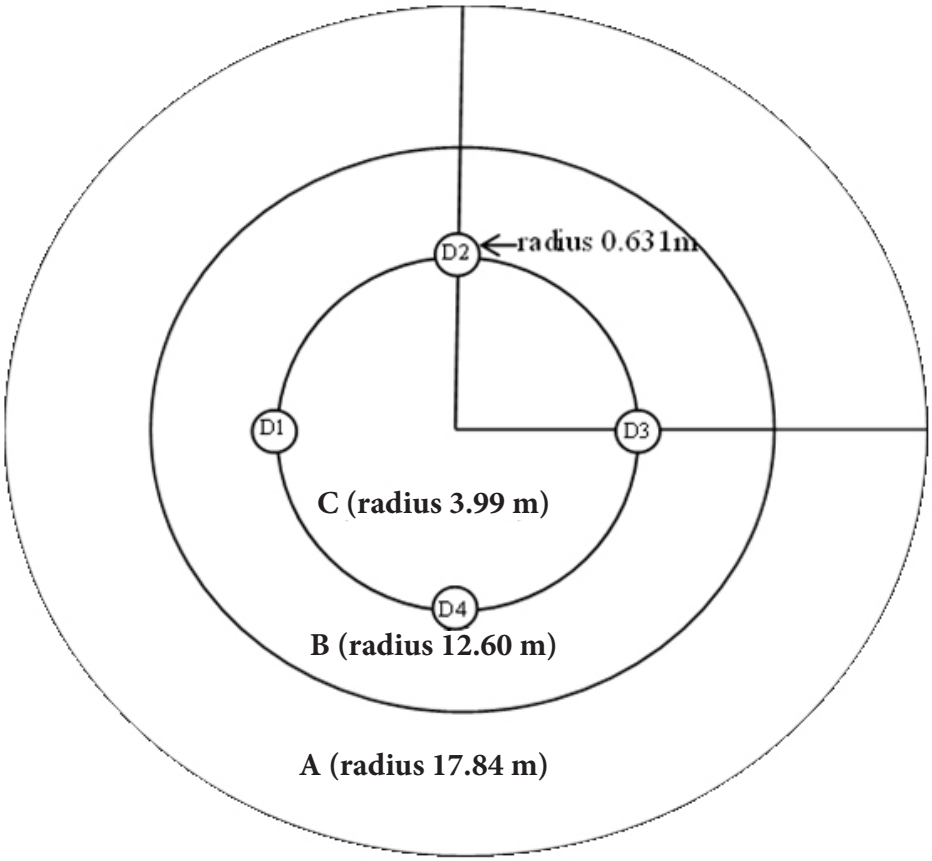

Figure 2 Layout of inventory plots used in the study.

Source: Department of National Parks Wildlife and Plant Conservation (2013)

Species identification was carried out with the assistance of the villagers and the local staff of the Forest Department. Common names were recorded and changed to the correct botanical names by reference to Kress *et al*. (2003). The information on bamboos was recorded on a plot enumeration form. The name of the bamboo species, the number of clumps, and the number of culms in each clump by age were recorded in each sample plot.

Data analysis

Descriptive statistics was used to analyze the socio-economics data. Data obtained from the vegetation survey were entered into a database specially constructed on the Look Forest Group (LFG) website (www.lookforestgroup.com). The parameters related to tree species composition, such as relative frequency, relative dominance, relative density, important value index (IVI), Shannon-weiner index, and Simpson index for diversity were generated and analyzed using the procedures listed on the LFG website. Correlation analysis was performed to identify the relationships between bamboo clump density and tree density.

RESULTS AND DISCUSSION

Socio-economic characteristics of the local people living around the mixed deciduous forest

Among the 83 households samples, 73 households were headed by a male (equivalent to 88% of the sample households) while only 12% were headed by a female. Among the five villages, the 10 Mile village had the highest number of female-headed households (5). The minimum age of a household head was 16 years and the maximum age was 80 years with a mean value of 40.4 years. Education level of the household head was classified into five groups, namely none, monastic, primary, middle, and high school levels. Among the 83 households, 53% received education till the primary level and only 1.2 % had received a high school education and this level was the highest education level amongst the local people who were interviewed. The average family size was 3.9 (±1.7) persons per household with the range being from 1 to 8 persons per household. The mean agricultural land holding size per household was 0.30 (±0.08) ha and ranged from 0 to 4 ha. Local people have a secured right on the area of their house yard and agricultural land, which is legally transferred by the Forest Department, excluding the area under the Reserved Forest. In the sampled households, there were 72.3% who did not own land for agriculture. Local people stated that bamboo production was their main livelihood activity. Among the five villages, the 9 Mile village had the highest number of households owned for agricultural land. All households in the 7 Mile village were landless. Some households reported that they had stopped agricultural activity as the cost of growing crops was much higher than the returns.

Major livelihood activities of the local people were bamboo production, agricultural production, livestock production, charcoal production, and wage labor. Local people did not mention timber extraction from the forest as one of the activities, although illegal timber extraction was found in the study area. Illegal timber extraction may also generate income to sustain the livelihood of the local people. Although income and livelihood have different meanings, income is often used to measure the outcome of the livelihood process (Kamanga *et al*., 2009; Moe, 2016). The total annual household income systematically accounts for all the household income from all sources for the preceding 12-month period. All the income of the sampled households reported in the study was gross income, since the processing cost was not excluded. The income sources were grouped into four different types based on the survey, namely forest income, agricultural income, livestock income, and wage labor income. Forest income was calculated for all the products that were sold based on an average market price. In this study, the major forest products generating income for the household were bamboo culms, bamboo shoots, bamboo mats, and charcoal. Forest income was obtained by multiplying the locally set price and the quantity of the product by the frequency of collection in a year. Income from agriculture was estimated based on the reported amounts of goods produced and average market prices. A simple measure of economic dependence

on bamboo is the share of income derived from bamboo relative to that from all other sources. According to descriptive statistics, the average total income of a household per year was 4,437 USD (±3953) (1 USD= 1,333 MMK, using the exchange rate from the Central Bank of Myanmar on 5 February 2018). In this study, the standard deviation of average annual household income was very high. Because the households, who extracted timber illegally, did not mention this income and so reported a lower household income. Table 1 showed the average income of a household from different income sources. Forest income made up 96.61% of the total household income followed by wage labor income representing 4.38% of the total income. Income from bamboo culm production contributed to 89.64% of the total forest income while charcoal production constituted only 6.24% of the total forest income. However, from a legal point of view, cutting down trees for charcoal making by local communities is prohibited under forest law (The State Law and Order Restoration Council, 1992).

Table 1 Average annual income of a household from different income sources in five villages at the Yedashe Township, Bago Region.

Income source	Income (USD)		% of total income
	Average	Standard deviation	
Forest	4,286.62		96.61
- *Bamboo culm production*	3,842.46	3,963.36	89.64
- *Charcoal production*	267.49	581.86	6.24
- *Bamboo shoot production*	7.30	31.39	3.95
- *Bamboo mat production*	169.37	530.92	0.17
Wage Income	98.48	194.23	2.22
Livestock income	29.91	77.10	0.67
Agricultural production	24.56	66.79	0.55
Total	4,437.00	3,963.36	100.00

The average total annual household income in the five villages were statistically different at $F_{(4,78)}=9.918$, $p<0.001$ at 0.05 significant level as shown in Table 2. The total annual income of 6 Mile, 7 Mile, 8 Mile, and 9 Mile villages were not significantly different. 7 Mile and 9 Mile had the highest average total household income (3754.89 USD and 6021.91 USD, respectively). The total annual income of 7 Mile, 9 Mile, and 10 Mile villages were not significantly different. These three villages corresponded to a higher average total household income. This was because the villagers from 10 Mile village had the highest number of bamboo culms, while the villagers from 9 Mile village received a higher wage income.

Table 2 Average total annual household income in the five villages.

Village	Income (USD)	
	Average	Standard Deviation
6 Mile	2141.47[a]	1622.02
7 Mile	3754.89[ab]	1838.74
8 Mile	2492.12[a]	1565.06
9 Mile	6021.91[ab]	3302.26
10 Mile	2141.47[b]	1622.02

Remarks: a and b represent post-hoc comparison means. Figures followed by the same letters in a column indicate that the numbers are not statistically different from each other according to the Bonferroni test**.**

Amount of Bamboo Culms Harvested Annually by the Local People

Three bamboo species namely *Bambusa polymorpha* Munro, *Cephalostachyum pergracile* Munro, and *Dinochloa maclellandii* (Munro) Kurz naturally grow in the study area. Among the three bamboo species found in the mixed deciduous forest near the villages, local people cut the culms of only two bamboo species (*B. polymorpha* and *C. pergracile*). The local people did not harvest *D. maclellandii* for culms due to lack of market demand for the species, but collected the shoots mainly for household consumption. The average number of bamboo culms cut by a household in a year was 24,589.30 (± 17,986.41) culms, with the villagers from 10 Mile village cutting the highest number of bamboo culms in a year (39,615.00 culms per year). This may have been because the 10 Mile village is located near a water way and villagers can use that to transport the harvested culms to a site where the middle agent could buy and transport their culms easily. ANOVA was performed to quantify the variations in the number of bamboo culms cut per household with different number of bamboo cutters. The results showed that the amount of bamboo harvested by a household depended on the number of bamboo cutters in the household. The number of bamboo culms harvested by a household was significantly different among the households having different number of bamboo cutters with a p value of 0.003 at 0.05 significant level. The number of bamboo cutter in a household was the only factor which had a relationship with the number of bamboo culms harvested from the forest. Table 3 shows the number of bamboo culms harvested by a household in a year according to the number of bamboo cutters.

Table 3 Mean (± standard deviation) of number of bamboo culms annually cut by one household in 5 villages of the Yedashe Township, Bago Region.

No of bamboo cutters in one household (persons)	Mean (±standard deviation)	No of households	%
1	22,244.00 (±16,346.85)	57	68.67
2	24,808.00 (±12,805.03)	21	25.30
3	50,400.00 (±34,054.74)	5	6.03
Total	24,589.30 (± 17,986.41)	83	100.00

By assuming that all households in the five villages harvested bamboo culms from the mixed deciduous forest, the total number of culms needed in all five villages in a year was 7,351,890 culms. According to the questionnaire survey, only 37.3% of the total numbers of culms were harvested from the studied forest. Therefore, it can be assumed that only 2,742,255 culms were cut annually by the villagers who lived near the forest. The average number of bamboo culms required for household consumption was 148.07 (±102.93) culms per year. The number of bamboo culms for household consumption was much higher than the number estimated by the Forest Department. The Forest Department estimated that the annual bamboo consumption for one household was 120 culms. Local people use bamboo culms for household construction, such as walls, floors, roofs, and fences. A majority of the households reported that the construction material made from bamboo culms needs to be reacquired every 3 years and not annually.

Bamboo Harvesting Method

Small community meetings were conducted in each village to determine the existing bamboo harvesting method. Currently, no specific rules are imposed by the Forest Department for harvesting bamboo from natural forests in Myanmar. Local people have free access to the natural forests to collect non-timber forest products including bamboo. As a reference, the investigation was carried out using the rules for bamboo culms felling suggested by Chaturvedi (1988) for obtaining high productivity with the desired quality of culms. These rules suggested by Chaturvedi (1988) are: (1) bamboo culms older than 3 years should be harvested, (2) harvesting should preferably be done each year, (3) congested culms must be removed leaving only the culms from the current year, (4) where young culms are twisted from the top, they should be cut so that new culms can grow freely, (5) no felling operation should be carried out between April and October, (6) areas under bamboo should be strictly protected from grazing, (7) mounding or heaping earth around the bamboo culms should be carried out each year before the rainy season, (8) trees providing shading from sunlight to bamboos should not be removed, and (9) in no case should bamboo clumps be cleared felled. Questions were developed based on the methods of local people to determine if they were harvesting bamboo in line with the guidelines. Most of the local

people said that they never followed the rules except Rule 2, indicating that harvesting should preferably be done each year. Rule 1 was not followed by most villagers, because they cut the bamboo culms found at the periphery of the clump, and these culms are normally one or two years old. Rules 3, 4, 6, and 7 aimed to obtain high quality culms. Operations such as heaping earth around the bamboo culms and congested clump thinning need to be undertaken. However, the local people stated that they had never conducted any operations for improving the quality of bamboo clumps because they did not own the clumps and if they took any steps to improve the bamboo clumps, they would not be the direct beneficiary. Therefore, it can be concluded that they did not cut the bamboo culms according to Rules 3, 4, 6, and 7. Since the local people depend on bamboo production for their livelihood and they cut bamboo culms throughout the year, they could not follow Rule 5. The reasons for not following Rules 8 and 9 were related to charcoal production. When the local people cut trees for charcoal production, they sometimes clear-felled bamboo clumps for construction of a charcoal kiln.

Problems or difficulties faced by the local people related to bamboo harvesting, such as marketing and utilization, were also discussed during the meetings. Difficulties in bamboo harvesting include accessibility to bamboo resources, risk of injury, difficulty in extraction of the cut culms from the clumps, and weather conditions. Accessibility to market is also a problem, according to the respondents. There was difficulty in transporting the collected bamboo culms to the market directly. Bamboo culms were inevitably sold to agents at a relatively lower price. In order for local people to follow the 9 rules and to do some silvicultural operations for bamboo clump improvement, community forest management practice should be enforced in such a way that specific households would own a certain number of bamboo clumps. Such a step would ensure that they are motivated enough to practice activities related to clump improvement. Bamboo harvesting techniques practiced by local people are not systematic. The local people stated that they had never received any kind of training related to systematic bamboo harvesting or on bamboo handicraft making.

Bamboo Production in the Mixed Deciduous Forest

According to the inventory data, there were three main bamboo species in the study area, namely *B. polymorpha*, *C. pergracile,* and *D. maclellandii*. There was no significant difference in the number of clumps per plot among the five blocks ($p > 0.5$). The average number of clumps per plot (500 m^2) was 26.80 (±10.62) clumps. The number of bamboo clumps and culms per hectare was estimated and shown in Table 4. There were 536 clumps per hectare whereas there were 7,000 culms per hectare. According to bamboo experts, bamboo culms aged 3 years and above could be harvested. In this study, only 2,292 culms aged three years and above (33%) were extracted per hectare. The dead culms and stumps need to be removed to increase the growth of new culms. Among the three bamboo species found in the study area, the two bamboo species preferred by the local people were *B. polymorpha* and *C. pergracile*.

Table 4 Mean (± standard deviation) of number of bamboo culms annually cut by a household in 5 villages of the Yedashe Township, Bago Region.

No. of bamboo cutters in a household (persons)	Mean (±standard deviation)	No of households	%
1	22,244.00 (±16,346.85)	57	68.67
2	24,808.00 (±12,805.03)	21	25.30
3	50,400.00 (±34,054.74)	5	6.03
Total	24,589.30 (± 17,986.41)	83	100.00

The total number of estimated culms that could be harvested from the entire forest area of 200 ha was 458,400 culms for the three species. The total number of extractable culms for the two species preferred by the local people (*B. polymorpha* and *C. pergracile*) was 381,600 and 65,800 culms, respectively. During field study, it was noticed that bamboo clumps were very crowded, which could also cause the bamboo to flower easily compared to an uncongested clump (Dwivedi, 1988), and so clump management is urgently required in the study area. The dead culms and stumps need to be removed to increase the growth of new culms. Most authors recommended that culms aged 3 years and above could be harvested while culms below 2 years of age should be maintained (Suwannapinunt, 1988; Lwin and Thet, 2006; Moe and Gyi, 2010). However, harvesting should retain not more than one-third of the culms. Lwin and Thet (2006) also stated that 3 years is the most appropriate time to harvest bamboo, including *B. polymorpha* and *C. pergracile,* to be utilized in weaving, handicraft, and ply bamboo processing. The local people in the study area do not cut culms of *D. maclellandii,* although the species is commercially important among the various bamboo species occurring in Myanmar. Cho *et al*. (2009) found that *D.maclellandii* has mechanical properties which are high enough to safely use in construction and many other applications such as furniture making. *D. maclellandii* can also be used for charcoal production. If the local people use *D.maclellandii* for charcoal production, it would generate household income and reduce illegal cutting of trees.

Bamboo Management by the Local People

Five villages with 402 households were located near the studied mixed deciduous forest with an area of 200 ha. The forest area is part of Saiya Reserved Forest, which was not included in the plantation area established by the Forest Department or private companies. Local people had the right to access the forest area for collecting NTFPs, including bamboo. Out of the three bamboo species found in the mixed deciduous forest, the local people cut the culms of only two bamboo species (*B. polymorpha* and *C. pergracile*). From the mixed deciduous forest**,** 37.3% of the total households collected bamboo culms for both household consumption and income generation. Based on the results from the social survey and inventory, it can be assumed that the local

people harvested the culms from the periphery of the clumps which were normally aged one or two years. Culm selection for harvesting was made based on the size of the culms and not on their age. The area allocated for bamboo harvesting was not specific and the local people harvested the culms throughout the year. The number of bamboo culms which were harvested by the local people was considerably higher than the number of extractable culms that could be produced by the forests. All these factors have led to the deterioration of bamboo forest in the study area, and it is likely that the bamboo forest will be diminished at the current rate. The local people must change their way of bamboo harvesting by following the suggested bamboo felling rules to keep the bamboo forest sustainable. The local people must recognize that bamboo is a non-timber forest product and that the forest is owned by the state which provides free access for the local people to the resources (The State Law and Order Restoration Council, 1992). The Forest Department is responsible for bamboo management in Myanmar. The local people have never conducted any kind of operations to improve the condition of bamboo clumps; consequently, the bamboo clumps in the study area were congested and the growth was not as good as it could have been which in turn has resulted in an increased difficulty in extracting the cut culms out of the clump. Consequently, the local people refuse to harvest culms from the congested clumps and go deeper into the forest for bamboo culm collection.

Tree Species Composition of the Mixed Deciduous Forest

There are 53 species belonging to 45 genera and 25 families identified in the mixed deciduous forest. Among the 53 species, only 49 show the habits of trees and one species (*Chromolaena odorata* (L.) R.M. King & H. Robinson) can be regarded as a shrub. The two identified herbs species are *Boesenbergia rotunda* (L.) Mansf. and *Cuminum cyminum* L. One grass species called *Setaria verticillata* (L.) P. Beauv also occurs in the study area. There are 298 trees per hectare, 824 saplings per hectare, and 8,160 seedlings per hectare. *Tectona grandis* L.f. had the highest number of trees per hectare. The highest number of saplings and seedlings per hectare were of *Grewia hirsuta* Vahl and *Dalbergia fusca* Pierre, respectively. Among 49 species which showed the habits of trees, *Albizia lebbekoides* (DC.) Benth and *T. grandis* were the most dominant species representing 15.83% and 8.29% and also had the highest Important Value Index (IVI) of 25.30 and 24.18, respectively. *Ficus glomerata* Roxb. and *Lannea coromandelica* (Houtt.) Merr. had the highest mean DBH value (32.50 cm) followed by *Artocarpus chaplasha* Roxb. (30.30 cm). Table 5 provides information on the mean DBH, density (D), relative dominance (RDo), relative frequency (RF), relative density (RD), and IVI of the 10 most important tree species (DBH > 4.5 cm) found in the mixed deciduous forest at Saiya Reserved Forest, Yedashe Township, Myanmar. Since the species with a high IVI are considered more important than those with low IVI, the most important species

in the mixed deciduous forest in this study was *A. lebbekoides* and second most important species was *T. grandis*. In this study, the Shannon-Weiner index and Simpson index were both calculated at 3.22. Correlation analysis was performed based on the clump density of the 25 plots as the dependent variable and tree density, sapling density, and seedling as the independent variables. However, no correlation was found between the dependent and independent variables. Therefore, the occurrence of bamboo clumps did not depend on the density of the tree species in the area.

Table 5 Mean DBH, density (D), relative dominance (RDo), relative frequency (RF), relative density (RD), and IVI of the 10 most important tree species (DBH > 4.5 cm) found in the mixed deciduous forest at Saiya Reserved Forest, Yedashe Township, Myanmar.

No	Species	Mean DBH (cm)	Density (trees/ha)	RDo (%)	RF (%)	RD (%)	IVI
1	*Albizia lebbekoides* (DC.) Benth	23.50	18.38	3.30	6.17	15.83	25.30
2	*Tectona grandis* L. f.	13.00	31.63	5.28	10.60	8.29	24.18
3	*Adina cordifolia* Hook. f.	12.50	27.63	4.62	9.26	6.75	20.64
4	*Grewia hirsuta* Vahl	12.20	20.00	5.94	6.71	4.60	17.25
5	*Anogeissus acuminata* Wall	15.50	14.81	6.27	4.97	5.51	16.75
6	*Croton oblongifolius* Roxb	10.00	23.63	4.62	7.92	3.69	16.23
7	*Garuga pinnata* Roxb.	20.00	11.19	4.62	3.76	7.00	15.38
8	*Xylia xylocarpus* (Roxb.) Taub	13.50	16.00	5.28	5.37	4.54	15.19
9	*Terminalia chebula* Retz.	17.00	9.63	6.27	3.22	4.34	13.83
10	*Cratoxylum ligustrinum*(DC.) Benth	11.70	15.63	4.95	5.23	3.30	13.49

Previous studies showed that *T. grandis* was the most dominant species followed by *X. xylocarpus* in the same forest type (Tun, 2013; Win, 2015). The present study revealed that the dominant species had changed to *A. lebbekoides* and the number of trees attaining a minimum exploitable size was below the desirable range. Some economically important species were not represented by seedlings and saplings. This alarming fact highlights the need for restoration measures in the surveyed area and for appropriate silvicultural treatments such as enrichment planting as well as other treatments to encourage natural regeneration and sustainable management.

CONCLUSION

Sustainable management of bamboo is urgently needed in Myanmar as timber yield is decreasing annually due to forest degradation and deforestation. Bamboo is the most important non-timber forest product in Myanmar that can be used in place of timber. This study assessed the status of bamboo management in mixed deciduous forest at Yedashe Township, Bago Region, Myanmar, to provide recommendations for a sustainable bamboo

management. Local communities in the study area mainly depend on the bamboo resources for income and almost all the respondents indicated that the resources were declining. Forest income constituted 96.61% of the total household income of the local people. Existing bamboo harvesting methods practiced by the local people were not sustainable. The total number of extractable culms from the entire mixed deciduous forest area of 200 ha was 458, 400 culms for the three bamboo species. The number of bamboo culms harvested annually by the local people who lived near the mixed deciduous forest was 2,742,255 culms. The number of bamboo culms harvested by the local people was considerably higher than the number of bamboo culms that could be sustainably produced by the forest. There were 53 species belonging to 45 genera and 25 families in the mixed deciduous forest, which is composed of economically important tree species. The Shannon-Weiner index and Simpson index (both 3.22) indicated that the mixed deciduous forest has a high tree species diversity. In the past, this forest had been dominated by teak (*T. grandis*), but in this study, the most dominant species was *A. lebbekoides*. To achieve sustainable bamboo management in the mixed deciduous forest, the local people should follow the felling rules outlined by Chaturvedi (1988), for a proper management of the natural mixed bamboo forests. The local people also need to perform some silvicultural operations for bamboo clump improvement. Training the local people on systematic bamboo harvesting techniques should be provided so that the bamboo resource can be managed sustainably.

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