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Stand Structure and Species Composition of Community Forests under Livelihood Transition in Two Villages in the Inle Lake Region, Myanmar

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***Abstract*:** This study observed the stand structure and species composition of community-managed forests in two villages in the Inle lake region, Shan State of Myanmar. A total of 44 circular plots were established to sample trees ≥ 5cm diameter (DBH) (1.38 ha). Fifty-one species in thirty families are recorded. *Dipterocarpus tuberculatus, Shorea siamensis, Quercus brandisana, Melanorrhoea usitata, and Xylia xylocarpa* were the most important species in these community forests and accounted for about 73.17% of all recorded stems ≥ 5cm DBH. The site had a long history of fuelwood collection for local and regional needs until 2010. The presences of coppice and pollard trees are indicative of past disturbance activities. However, those forests are recovering after the demand for forest resources decreased, the breakdown of the fuelwood market, and applying specific village rules for harvesting. Dependency on the community forest resource was reduced after the electrification of the area, a marked shift to tourism-related livelihoods, and stabilized transportation access to the agricultural market. It can be concluded that livelihood transitions facilitated less dependency on forest resources and supported community forest regeneration.

***Keywords*:** Forest transition, Community-managed forest, Disturbance, Harvesting methods, NTFPs

Nearly one third of tropical forests are now in the hands of local people. This share is likely to succeed in forest conservation, especially in places where deforestation and degradation are accelerated. Moreover, the communal ownership of forest land appears to be more common in developing countries than in developed countries (White and Martin 2002). Decentralized forest management has been introduced in developing countries where rural communities extensively use forest products and play crucial roles in their livelihoods (McShane 1990, De Boer and Baquete 1998 and Thapa and Chapman 2010).

Varying local livelihoods in a different landscape may differ the species composition, diversity, and stand structure of forest conditions. People living within and around forests use forest products for food, fuel, medicine, timber, fodder for livestock, and fallback when agricultural and other economic activities are inadequate to sustain the household economy (Charnley and Poe 2007). Many studies have found that forests near a human settlement with overexploitation of resources induced changes in the forest ecosystem (Thapa and Chapman 2010, Htun et al 2011 and Mon et al 2012).

However, only a few studies have assessed forest disturbances from the social-ecological perspective (Karanth et al 2006, Thapa and Chapman 2010). In our research, we will discuss forest conditions change from the perspective of socio-economic dynamics, and previous forest utilization, by representing the remaining forest stand structure and species composition. Furthermore, this paper examines utilization pattern changes in community forests in the Inle Lake region, where forest restoration and transition have occurred. The objective of this study is (i) to assess the impacts of livelihood transition on community forests (ii) to study localized community management systems, and (iii) to investigate CF's stand structure and species composition after disturbance.

MATERIAL AND METHODS

The selected area is in the Inle Lake region, famous for its broad diversity of cultural and natural assets; it has become one of the country's leading tourism destinations over the last decade. Deciduous forest types dominated the area, with the elevation ranging from 900 to 1100 m. The average temperature of the study area is 30 °C, and the annual precipitation is 1982mm.

Two community forests (CFs) in Nyaung Shwe township were selected because they both have similar histories of human disturbance activities and biophysical conditions (Fig. 1). These forests were heavily disturbed and exploited for commercial fuelwood and non-timber forest products (NTFPs) collection. The selected study villages established community forestry in the early 2000s. The area of the village community forest is 248.81 ha in L village and 511.93 ha in Y village.

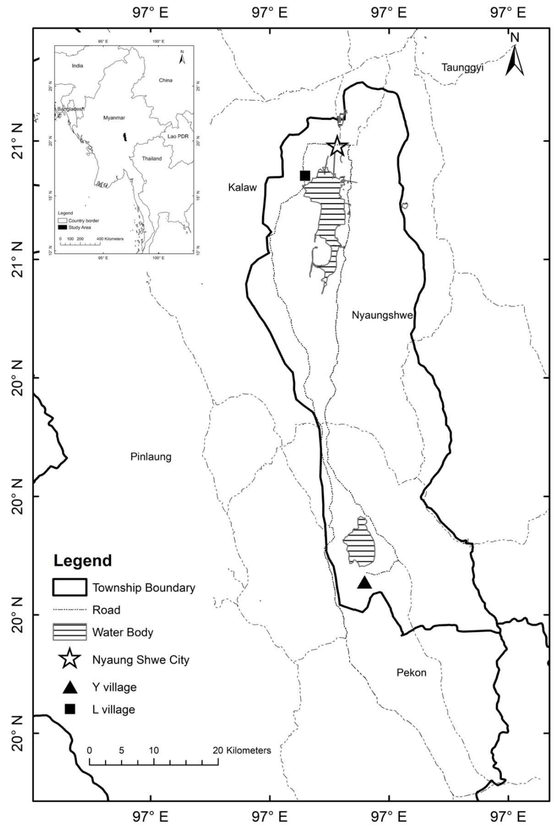

Fig. 1. Two community forest villages in Nyaung Shwe township, Myanmar

Study design: Focus group discussion and key informants with elderly villagers, village leaders, and villagers from different socio-economic backgrounds are conducted to know the history of forest utilization in the past and livelihood transition.

Vegetation was surveyed in 2017 (August- September) and 2018 (July-August). After making a local forest resource map with villagers, 44 sample plots (1.38ha), 0.72 ha in L village, and 0.66 ha in Y village were randomly selected. The layout was a circular plot of 10m, 5m, and 3m radius. The diameter at breast height (DBH) and tree height were measured for trees with a DBH≥5cm in a 10 m plot and 1-5 cm DBH in a 5m plot. Within a 1m plot, the number of seedlings (height ≤ 1.3m) was counted (Kabir and Webb 2006). Tree species, local names, and common usage of the trees were determined. Coppice and pollard trees were documented in a list to know past disturbances. The leaves and flowers of unknown species were sampled and later identified at the Forest Research Institute (FRI) in Naypyidaw, Myanmar.

Data analysis: The importance value index (IVI) is calculated based on relative abundance, relative density, and relative dominance. Abundance (ha^{-1}), basal area (m^2/ha) of each species are calculated and compared to know the past human disturbance activities and species preference. Regression analysis of normal and coppice trees were conducted to know forest recovery condition. The composition and structure of study forests were compared with other published studies with similar forest type.

RESULTS AND DISCUSSION

Stand structure: The percentage of preferred species in particular size and height compared to the total number of trees in two community forests is shown in Table 1. The average tree height of L and Y CF are 4.96± 0.71 m and 10.82 ± 0.24 cm respectively. In these forests, highly exploited species (*Dipterocarpus tuberculatus* in L CF and *Quercus brandisiana* in Y CF) are remained in smaller DBH (5-10 cm). 70% of In (*D. tuberculatus)* trees are less than 3 m in height due to the frequent leave collection in the past. *Q. brandisiana* species are commonly collected as household fuelwood in Y CF and 21% of them are found in smaller DBH class of 5-10cm. However, the recovery condition of *D.tuberculatus* and *Q.brandisiana* trees can be seen in the DBH classes of 11-16 cm with 21% and 15% respectively. *D.tuberculatus* trees were kept at 2-3 m for leave collection before, and now we can see that 17% of them reached between 4-6 m height.

Shorea siamensis in both forests were exploited as subsistence, commercial fuelwood and remained as coppice or pollard tree with smaller DBH class (24% in L CF and 37% in Y CF). The recovery condition of *S.siamensis* trees can be seen in the DBH 11-16 cm class. (44% in L CF and 35% in Y CF). Majority of them are found with bigger DBH ≥28 cm and height ≥10m. This is because the forest itself is Diptrocarpus dominated and some of the trees on pagoda compound were not cut for religious reason. The higher percentage in middle and higher DBH and height classes reflected that the forest conditions is improved. It is generally assumed that the more mature the succession of a forest can be seen, the greater the average height of the forest compared to others (Kijtewachakul et al 2004).

Species composition and diversity: Species composition and diversity is more or less similar in two CFs as both were highly disturbed in the past and have a similar forest type dominated by the virtual presence of Dipterocarpus and associated species. The individual species, abundance, BA(m^2/ha), and IVI are shown in Table 2 and 3. Data were shown into three categories: trees, saplings, and seedlings.

L CF has a higher tree density (1309 trees/ha) than Y CF (1077 trees/ha). A total of fifty-one species in thirty families are recorded. *D tuberculatus*, *S. siamensis, Q. brandisana*, *Melanohorrea usitata*, and *Xylia xylocarpa* trees were the

Table 1. Percentage of preferred species in particular size and height compared to total trees in two CFs

Species	Village	Usage	DBH class				Height class			
			5-10 cm	11-16 cm	17-27cm	≥28 cm	1-3 m	4-6 m	7-9m	≥10m
Dipterocarpus tuberculatus	L	Leaves	28%	21%	2%	10%	70%	17%	12%	2%
Shorea siamensis	L	Fuelwood (pole, post)	24%	44%	47%	52%	11%	33%	32%	63%
Shorea siamensis	Y	Fuelwood (pole)	37%	35%	34%	59%	25%	35%	37%	43%
Quercus brandisiana	Y	Fuelwood (household)	21%	15%	3%	18%	6%	14%	19%	20%

Table 2. List of trees, saplings and seedlings found in L CF in Inle Lake Region, A, abundance(ha^{-1}), BA, Basal Area(m^2/ha), IVI, Importance Value Index

Species	Family	Trees			Saplings			Seedlings
		A	BA	IVI	A	BA	IVI	A
Shorea siamensis	Dipterocarpaceae	546	5.63	102	25	0.47	48	26
Dipterocarpus tuberculatus	Dipterocarpaceae	460	3.19	74	21	2.26	81	24
Melanorrhoea usitata	Anacardiaceae	299	1.92	47	7	0.18	14	6
Quercus brandisiana	Fagaceae	121	0.49	17	28	0.55	54	7
Bombax ceiba	Bombacaceae	33	0.12	8	3	0.04	5	1
Grewia tiliifolia	Malvaceae	40	0.63	5	4	0.05	7	
Sterculia versicolor	Sterculiacea	31	0.20	5				6
Dalbergia cultrata	Leguminosae	25	0.06	4	7	0.14	14	20
Terminalia tomentosa	Combretaceae	27	0.10	4	1	0.01	2	
Morus alba	Lauraceae	25	0.15	3	3	0.07	6	
Croton oblongifolius	Euphorbiaceae	27	0.09	3				6
Buchanania lanzan	Anacardiaceae	23	0.10	3	3	0.02	5	
Strychnos nux-blanda	Loganiaceae	21	0.05	3	1	0.03	3	2
Emblica officinalis	Phyllanthaceae	19	0.04	2	10	0.19	19	1
Dillenia pentagyna	Dilleniaceae	17	0.06	2	1	0.05	3	
Macaranga denticulata	Lauraceae	10	0.04	2	4	0.10	8	
Xylia xylocarpa	Combretaceae	13	0.05	2	4	0.11	9	
Bombax insigne	Bombacaceae	4	0.11	2				
Lannea coromandelica	Malvaceae	10	0.03	1				
Ficus spp	Phyllanthaceae	4	0.03	1				
Sterculia angustifolia	Sterculiacea	8	0.03	1	4	0.08	8	
Litsea glutinosa	Lauraceae	8	0.03	1				
Albizia odoratissima	Mimosaceae	6	0.01	1				
Citrus medica	Rutaceae	6	0.01	1				
Streblus asper	Moraceae	6	0.16	1				
Polyathia simiarum	Annonaceae	4	0.02	1				
Garuga pinnata	Burseraceae	4	0.13	1				
Brassica rapa	Bombacaceae	4	0.02	1				
Antidesma bunius	Euphorbiaceae	4	0.02	0				
Anno spp	Anno spp	2	0.02	0	6	0.14	11	
Schleichera oleosa	Sapindaceae	2	0.02	0	1	0.03	3	
Premna tomentosa	Verbenaceae	2	0.02	0				
Stereospermum neuranthum	Bignoniaceae	2	0.00	0				
Terminalia chebula	Combretaceae	2	0.00	0				

most important species in these community forests and accounted for about 73.17% of all recorded stems ≥ 5cm DBH.

D. tuberculatus (25.4%), *S. siamensis* (30.2%), and *M. usitata* (16.5%) trees have highest IVI in L CF. The three most dominant species in Y CF are *S. siamensis, Q.brandisiana*, and *X.xylocarpa*. Species preference in the past shaped the current species composition (Bunyavejchewin 1983, Miller 1998 and Kabir and Webb 2006). *D. tuberculatus* and *S. siamensis* could easily get cash by selling leaves, fuelwood, pole, and post. *Q. brandisiana* is the most commonly used household fuelwood in both villages. *M. usitata* was used as

Table 3. List of trees saplings and seedlings found in Y CF in Inle Lake Region, A, abundance(ha^{-1}), BA, Basal Area(m^2/ha), IVI, Importance Value Index

Species	Family	Trees			Saplings			Seedlings
		A	BA	IVI	A	BA	IVI	A
Shorea siamensis	Dipterocarpaceae	391	5.69	102	36	0.03	147	40
Quercus brandisiana	Fagaceae	179	1.88	74	11	0.01	44	3
Xylia xylocarpa	Mimosaceae	76	1.00	47	8	0.002	23	4
Shorea obtusa	Dipterocarpaceae	74	0.91	17				10
Melanorrhoea usitata	Anacardiaceae	52	0.88	8				12
Emblica officinalis	Phyllanthaceae	39	0.19	5	3	0.00	13	9
Grewia tiliifolia	Malvaceae	39	0.22	5	15	0.01	50	6
Bauhinia acuminata	Caesalpiniaceae	24	0.23	4				
Morinda tinctoria	Rubiaceae	20	0.28	4				
Dalbergia cultrata	Leguminosae	18	0.31	3	2	0.001	6	1
Garuga pinnata	Burseraceae	18	0.18	3				
Macaranga denticulata	Euphorbiaceae	15	0.11	3				4
Bombax insigne	Bombacaceae	14	0.26	3	3	0.002	11	6
Sideroxylon burmanicum	Sapotaceae	14	0.09	2				
Lannea coromandelica	Anacardiaceae	12	0.09	2				
Strychnos nux-blanda	Loganiaceae	11	0.04	2	2	0.001	6	
Terminalia chebula	Combretaceae	11	0.14	2				
Eugenia spp	Myrtaceae	9	0.06	2				
Schleichera oleosa	Sapindaceae	8	0.08	1				1
Buchanania lanzan	Anacardiaceae	6	0.12	1				
Diospyros burmanica	Ebenaceae	6	0.07	1				
Heterophragma sulfureum	Bignoniaceae	6	0.08	1				
Vitex pubescens	Verbenaceae	6	0.04	1				1
Cassia fistula	Caesalpiniaceae	5	0.02	1				
Anno spp	Anno spp	3	0.01	1				
Dillenia pentagyna	Dilleniaceae	3	0.02	1				
Ficus spp	Moraceae	3	0.08	1				
Lagerstroemia tomentosa	Lythraceae	3	0.01	1				
Sterculia angustifolia	Sterculiaceae	3	0.01	0				
Antidesma bunius	Euphorbiaceae)	2	0.01	0				
Bombax ceiba	Bombacaceae	2	0.01	0				
Bridelia ovata	Euphorbiaceae	2	0.01	0				
Castanopsis armata	Fagaceae	2	0.14	0				
Dioscorea wallichii	Dioscoreaceae	2	0.05	0				
Homalium tomentosum	Flacourtiaceae	2	0.01	0				

lacquer on a boat to protect against water and required very little maintenance. However, due to easy transportation access, the lacquer business disappeared in the early 1990s. In addition, it is no use for fuelwood as it can cause severe irritation to the skin and eyes. *X. xylocarpa* species are commercially important in other parts of the region and are known as ironwood. However, it's not common in Y village as they believed that its wood is difficult to saw when it dries and considered to have a severe blunting effect on the cutting elements. Human disturbance may alter forest succession by giving an advantage to some species or selectively removing others. Dominance by a few tree species rose and stand density and tree diversity declined when a disturbance, primarily due to resource use by local people, increased (Htun et al 2011). Such domination by a few species in highly disturbed sites was found in other studies (Parthasarathy and Karthikeyan 1997, Mishra et al 2004, Brown et al 2006 and Htun et al 2011). The Dipterocarpaceae family composes a high percentage of saplings and seedlings in both forests, and future regeneration is secured in these forests. Fagaceae and Leguimosae families are the second dominant species in these CFs. Seedlings and saplings of *Emblica officinalis* and *Grewia tiliifolia* are found in deciduous forests as associated species.

Livelihood transition in Inle lake region: The site had a long history of fuelwood collection for local and regional needs until 2010. The previous forest utilization in the two villages included fuelwood extraction and NTFPs collection. For L village, previous forest utilization included fuelwood extraction for salt production, traditional snack making (rice crackers), household construction, and collecting *D. tuberculatus* (In) leaves and collection of poles and posts for construction. *D.tuberculatus* leaves were mostly used for fish packaging as Inle Lake was the major fish production area before.

However, Inle Lake experienced a massive tourism boom during the last decade and infrastructure and market conditions are developed. In L village, most villagers abandoned agriculture and forestry-related livelihoods and participated in tourism-related activities (e.g., boat piloting, selling souvenirs and local products to tourists).

Commercial fuelwood exploitation of *S.siamensis* was the major forest utilization in Y village's history. More than 40% of households relied on commercial fuelwood extraction as their primary livelihood in the past. However, in 2010, most villages inside Inle Lake were electrified, and fuel wood demand drastically decreased. Stabilized transportation access for the market attracted villagers to focus more on upland agriculture.

Forest resource use and community managed rules: Both villages have community-managed rules regarding resource utilization. As a result, only fuelwood and NTFPs (leaves, medicinal plants, mushrooms, bamboo shoots) can collect for subsistence use. Harvesting of the pole and fuelwood were also banned for the villagers. However, with the approval of the community forest user group, they are allowed to collect for household use. Penalties and reward system were introduced for the better participation of local people. For example: harvesting tools materials were taken and kept the first time, banned from entering community forests for the second time.

Coppice or pollard trees after livelihood transition: Both villages exploited *S. siamensis* commercially, and most of the remaining stands can be seen as coppice or pollard trees. DBH and height scatter diagrams of normal and coppice trees in both villages indicated that the trees were heavily disturbed in the past Figure 2 and 3. Previously disturbed

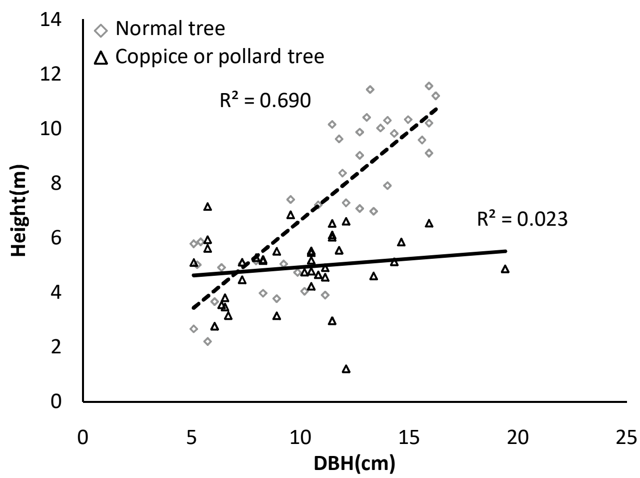

Fig. 2. *Shorea siamensis* normal and coppice or pollard tree in LCF

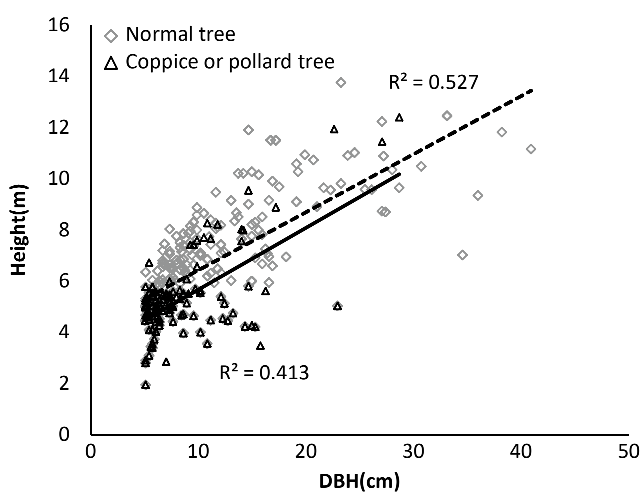

Fig. 3. *Shorea siamensis* normal and coppice or pollard tree in YCF

trees with higher DBH were accumulated under 5m as coppice trees. The R^2 value of the normal trees in L village is 0.69, and those of coppice or pollard tree is 0.02 (Fig. 2). *S. siamensis* trees were heavily exploited as fuelwood for cooking salt, making traditional snacks, and pole and posts for construction. Villagers cut the pole and post size trees for cooking salt as bigger size fuelwood can sustain the heat longer.

In Y village, some coppice trees have grown into DBH more than 10 cm and reached over 10m (Fig. 3). The R^2 value of a coppice or pollard tree is not much different from that of a normal tree. Y CF recovered faster as they only exploited pole-size trees and left the bigger tree as mother trees to reproduce seeds and regenerate the forest. They also shared the forest with nearby village, and resource extraction needs agreement from both parties. Accessing alternative income from agriculture and the breakdown of the fuel wood market speed up the forest regeneration process in Y CF. Different extraction forms may also have different levels of impact (Shaanker et al 2004, Shahabuddin and Kumar 2007 and Thapa and Chapman 2010). Economically valuable and efficient fuel species (*S. siamensis, D. tuberculatus, Q. brandisiana*) mostly remain as coppice and pollard trees in the study area. Repeated exploitation of forest resources has reduced diversity and density and altered structure with lower tree heights and smaller diameters.

The vigorous *S. siamensis* coppice trees in both villages showed a recovery condition after forest product demand decreased, community managed rules were developed and transited into non-forest-related livelihoods. The results showed that the species within this forest show an ability to recover by vegetative regrowth after being cut. Similar observations were made in tropical dry forests by Imbert and Portecop 2008, Lévesque et al 2011 and Van Bloem et al 2005. A similar case study of community forest regrowth conditions was investigated in Northern Thailand (Kabir and Webb 2006 and Chowdhury et al 2018). The forest appears to contain substantial levels of regeneration indicating a potential for structural recovery.

Comparison of different forest management system and disturbances: Table 4 describes tree density and structure according to different management system, and harvested forest products. The comparative studies were chosen based on similar forest types. Abundance and basal area were categorized into ≥2cm, ≥5cm, and ≥10cm to know the forest structure. In two CFs, Y CF regenerated faster than L CF because they only extracted pole-size fuelwood and were difficult to access due to poor transportation access and security reasons. On the other hand, L CF is easily accessible to the market to sell NTFPs and fuelwood. L CF, previously harvested for fuelwood, NTFPs, and household construction, remained with stems smaller than ≥10cm DBH in comparison with Y CF, which was collected for fuelwood alone. The forest condition of L CF is similar to the case study in Thailand (Kabir et al 2006), where forests were heavily harvested for charcoal making, railway sleepers, and construction wood. The abundance (stem/ha) is higher in the early stage of development (≥2cm and ≥5cm DBH) and then later declines in the bigger DBH class (≥10cm). Even with the same management type, the remaining forest structure is differed

Table 4. Comparative vegetation condition with previous studies in terms of forest type, management practice, abundance, and basal area different

Study	Forest type	Management	Harvested forest products	Area sampled(ha)	Abundance (stem/ha)			Basal area (m^2/ha)		
					≥2cm	≥5cm	≥10cm	≥2cm	≥5cm	≥10cm
This study	Mixed deciduous	Community (L)	NTFPs (Leaves) Fuelwood (pole/post)	0.72	1743	1309	339	13.77	13.57	10.49
	Mixed deciduous	Community (Y)	Fuelwood (pole)	0.66	1631	1077	477	13.40	13.34	11.05
Kabir et al (2006)	Deciduous	Community	Charcoal making Railway sleepers Construction wood	0.97	1936	1290	380	10.34	9.60	6.05
Htun et al (2011)	Mixed deciduous	Protected Area	NTFPs	1.68			790			24.47
Webb et al (Unpublished data)	Mixed deciduous and grass land	Protected area annual fires	-	4.0		601	343		21.6	20.6
	Mixed evergreen plus deciduous	Protected area Occasional fires	-	1.0		440	220		18.5	17.9

depending on the disturbance intensity and collection methods. However, we can say both forests' condition is better than the community forest condition in Thailand (Kabir et al 2006) by comparing the basal area of tree ≥10cm. Villagers in the study area did not cut certain species, such as *M. usitata* and *X. xylocarpa*, and they remained as vigorous stands. The basal area(m^2/ha) of bigger DBH class (≥10cm) in disturbed community forests (Kabir et al 2006 and our study) are smaller than that of protected forests.

The long history of human-induced disturbance has resulted in a degraded forest with reduced species diversity and virtually no large trees. Forests harvested for fuelwood, charcoal and NTFPs remained with a smaller basal area. The ownership, management, and utilization shaped the abundance of the remaining stand and basal area. Forest nearby community villages tend to experience more human disturbance than protected and reserved forests because it is challenging to manage shared resources without stakeholder consent. Different extraction forms may have different levels of impact, too (Shaanker et al 2004, Shahabuddin and Kumar 2007 and Thapa and Chapman 2010).

CONCLUSION

The site had a long history of fuelwood collection for local and regional needs until 2010. The presences of coppice and pollard trees are indicative of past disturbance activities. However, those forests are recovering after the demand for forest resources decreased, the breakdown of the fuelwood market, and applying specific village rules for harvesting. Dependency on the community forest resource was reduced after the electrification of the area, a marked shift to tourism-related livelihoods, and stabilized transportation access to the agricultural market. It can be concluded that livelihood transitions facilitated less dependency on forest resources and supported community forest regeneration. However, only this case study cannot represent all community forests in the Inle lake area. Therefore, the accumulation of longitudinal case studies will be required. Furthermore, community forests may vary significantly in forest structure and composition, intensity of use, and trends. Significantly, more research is required on the impacts of livelihoods on forest conditions in different geographic and socio-economic conditions.

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