

Leaflet No- 15/2020

The Republic of the Union of Myanmar
Ministry of Natural Resources and Environmental Conservation
Forest Department



**Analyzing the relationship between household livelihood strategies and
forest dependency - A case study of Shwe Set Taw Wildlife Sanctuary,
Myanmar**

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December, 2020

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Abstract

Forests and natural resources are facing several threats and pressures from external factors and human activities. Protected Areas (PAs) are one of the options to solve these problems. However, PAs are also facing threats from human activities as a consequence of population growth and limited livelihood opportunities in local area. Extraction of forest resources by local households is one of the threats to PAs' natural resources. Forest dependency of households varies depending on their livelihood activities. Thus, Oo Pyin Mel village (Case-I) and Phalan Kyin village (Case-II) in Shwe Set Taw Wildlife Sanctuary (SST) of Myanmar were taken as case studies in order to find out the potential solutions to reduce the forest dependency of households. The main objective of this research is to explore the relationship between household livelihood strategies and forest dependency in SST, specifically, to explore the differences of forest dependency across livelihood strategies. Key informant interviews, focus group discussions, household face to face interviews and final informal workshops were applied with semi-structured questionnaires. Hierarchical and K-means cluster analysis, Kruskal-Wallis test and Mann-U Whitney test were used for statistical analysis.

According to empirical findings in Case-I, households with forest-wage livelihood strategy are the highest forest dependency with the lowest total income. Main forest resources extracted from SST include poles, bamboo, bamboo shoot and fuelwood. Households with livestock-remittance strategy are more dependent on the forest than those with business-agriculture strategy for the extraction of fodder. Households with business-agriculture strategy receive the lowest forest income sharing with the highest total income. Households in both of these strategies use fuelwood for their subsistence due to inaccessibility of electricity. In Case-II, households with forest-remittance strategy are the highest forest dependency with the second-lowest total income. Main forest resources extracted from PA are bamboo. Households with remittance-business strategy are not different in forest dependency compared with those of agriculture-wage strategy, and receive the lowest forest income sharing with the highest total income. Based on these findings, this research proposed recommendations to reduce the restrictions on specific forest resources for the basic needs of local households and to enhance the traditional livelihood strategies in order to reduce the forest dependency of households with rural development. This information can be used as baseline information to develop a management plan or to update the current management plan of SST.

Keywords: livelihood strategies, forest dependency, income, protected areas, Myanmar, cluster analysis

**ရွှေစက်တော်တောရိုင်းတိရစ္ဆာန်ဘေးမဲ့တောဝန်းကျင်ရှိ ဒေသခံအိမ်ထောင်စုများ၏
အသက်မွေးဝမ်းကြောင်းလုပ်ငန်းများနှင့် ယင်းတို့၏ သစ်တောများအပေါ် မှီခိုမှုအကြား
ဆက်နွှယ်မှုအား လေ့လာဆန်းစစ်ဖော်ထုတ်ခြင်း**

စုမွန်မြင့်၊ တောအုပ်ကြီး

သစ်တောဦးစီးဌာန

စာတမ်းအကျဉ်း

သဘာဝသယံဇာတများနှင့် သစ်တောများသည် လူသားများ၏ ပယောဂများနှင့် အခြားသော အကြောင်းရင်းများကြောင့် များစွာသော ခြိမ်းခြောက်မှုများ၊ ဖိအားများနှင့် ကြုံတွေ့ရလျက်ရှိပါသည်။ သဘာဝထိန်းသိမ်းရေး နယ်မြေများသည် အဆိုပါ ပြဿနာများကို ဖြေရှင်းရန် နည်းလမ်းများစွာအနက် တစ်ခုအပါအဝင် ဖြစ်ပါသည်။ သို့သော် လူဦးရေတိုးပွားလာခြင်းနှင့် ဒေသတွင်း အလုပ်အကိုင် ရှားပါးလာမှုတို့၏ နောက်ဆက်တွဲရလဒ်တစ်ခု အဖြစ် သဘာဝထိန်းသိမ်းရေးနယ်မြေများသည်လည်း လူသားများကြောင့် ခြိမ်းခြောက်မှုများ နှင့် ရင်ဆိုင်ကြုံတွေ့ရလျက် ရှိပါသည်။ ဒေသခံအိမ်ထောင်စုများမှ သစ်တောသယံဇာတများ ထုတ်ယူခြင်းသည် သဘာဝထိန်းသိမ်းရေးနယ်မြေများ၏ သယံဇာတများကို ခြိမ်းခြောက်သည့်အရာများအနက် တစ်ခုဖြစ်ပါသည်။ အိမ်ထောင်စုများ၏ သစ်တောများအပေါ် မှီခိုမှု သည် ယင်းတို့၏ အသက်မွေးဝမ်းကြောင်းလုပ်ငန်းများအလိုက် ကွာခြားမှု ရှိပါသည်။ သို့ဖြစ်၍ အိမ်ထောင်စုများ၏ သစ်တောများအပေါ် မှီခိုမှုကို လျှော့ချနိုင်မည့် ဖြစ်နိုင်ချေရှိသော နည်းလမ်း များကို ဖော်ထုတ်နိုင်ရန်အတွက် ရွှေစက်တော်တောရိုင်းတိရစ္ဆာန်ဘေးမဲ့တော ဝန်းကျင်ဒေသရှိ အိုးပြင်မဲကျေးရွာ (Case-I) နှင့် ဖလံကျင်းကျေးရွာ (Case-II) တို့ကို case studies များအဖြစ် ရွေးချယ်ခဲ့ပါသည်။ ယခုဆောင်ရွက်သည့် သုတေသန၏ အဓိကရည်ရွယ်ချက်မှာ ရွှေစက်တော် တောရိုင်းတိရစ္ဆာန်ဘေးမဲ့တောဝန်းကျင်ရှိ ဒေသခံအိမ်ထောင်စုများ၏ အသက်မွေးဝမ်းကြောင်း လုပ်ငန်းများနှင့် သစ်တောများအပေါ် မှီခိုမှုအကြား ဆက်နွှယ်မှုကို ဖော်ထုတ်သွားရန်ဖြစ်ပြီး အထူးသဖြင့် အသက်မွေးဝမ်းကြောင်း လုပ်ငန်းများအလိုက် သစ်တောများအပေါ် မှီခိုမှုကွာခြား ချက်များကို ဖော်ထုတ်ရန်ဖြစ်ပါသည်။ အဓိကသတင်းအချက်အလက်ပေးနိုင်သူများအား မေးမြန်းခြင်း (Key informant interviews)၊ အုပ်စုဖွဲ့ ဆွေးနွေးခြင်း (focus group discussions)၊ အိမ်ထောင်စုများအား

မျက်နှာစုံညီမေးမြန်းခြင်း (household face to face interviews) နှင့် အလုပ်ရုံဆွေးနွေးပွဲများ ကျင်းပခြင်းတို့ကို မေးခွန်းလွှာများ အသုံးပြု၍ ဆောင်ရွက်ခဲ့ပါသည်။ Hierarchical နှင့် K-means cluster analysis၊ Kruskal-Wallis test နှင့် Mann-U Whitney test များကို သုတေသနပြုဆန်းစစ်ရန်အတွက် အသုံးပြုခဲ့ပါသည်။ သုတေသနတွေ့ရှိချက်များအရ Case-I တွင် သစ်တောသယံဇာတများ ထုတ်ယူခြင်းဖြင့် အဓိကအသက်မွေးဝမ်းကြောင်းပြုသည့် အိမ်ထောင်စုများသည် သစ်တောများ အပေါ် မှီခိုမှုအမြင့်ဆုံးဖြစ်ပြီး စုစုပေါင်းဝင်ငွေ အနည်းဆုံးရရှိသည့် အိမ်ထောင်စုများ ဖြစ်ပါသည်။ ရွှေစက်တော်ဘေးမဲ့တောမှ ထုတ်ယူသည့် အဓိက သစ်တော သယံဇာတ များတွင် မျော၊ ဝါး၊ မျှစ်နှင့် ထင်းတို့ ပါဝင်ပါသည်။ အိမ်မွေး တိရစ္ဆာန် များ မွေးမြူခြင်းဖြင့် အဓိက အသက်မွေးဝမ်းကြောင်းပြုသည့် အိမ်ထောင်စုများသည် မြက်နှင့် အသီးအရွက်များ ကဲ့သို့ တိရစ္ဆာန် အစားအစာများ ထုတ်ယူရသည့်အတွက် စီးပွားရေးလုပ်ငန်းဖြင့် အဓိက အသက်မွေးဝမ်းကြောင်းပြုသည့် အိမ်ထောင်စုများထက် သစ်တောများအပေါ် ပိုမိုမှီခိုကြပါသည်။ စီးပွားရေး ဖြင့် အသက်မွေးဝမ်းကြောင်းပြုသည့် အိမ်ထောင်စုများသည် သစ်တော သယံဇာတ ထုတ်ယူခြင်းမှ ဝင်ငွေအနည်းဆုံး ရရှိပြီး စုစုပေါင်းဝင်ငွေအများဆုံး ရရှိသည့် အိမ်ထောင်စု များ ဖြစ်ပါသည်။ အဆိုပါ အသက်မွေးဝမ်းကြောင်းလုပ်ငန်းများနှင့် အိမ်ထောင်စုများသည် လျှပ်စစ်ဓါတ် မရရှိသည့်အတွက် လောင်စာအဖြစ် အသုံးပြုနိုင်ရန် အတွက်သာ ထင်းကို အိမ်သုံးအဖြစ် ထုတ်ယူကြပါသည်။ Case-IIတွင် သစ်တောသယံဇာတများ ထုတ်ယူခြင်းဖြင့် အဓိက အသက်မွေးဝမ်းကြောင်းပြုသည့် အိမ်ထောင်စုများသည် သစ်တော များအပေါ် မှီခိုမှုအများဆုံးဖြစ်ပြီး စုစုပေါင်းဝင်ငွေ ဒုတိယအနည်းဆုံး ရရှိသည့် အိမ်ထောင်စု များဖြစ်ပါသည်။ သဘာဝထိန်းသိမ်းရေးနယ်မြေမှ ထုတ်ယူသည့် အဓိက သစ်တောသယံဇာတမှာ ဝါးဖြစ်ပါသည်။ ရွှေပြောင်းလုပ်သားထံမှ ဝင်ငွေရရှိခြင်းဖြင့် အသက်မွေးဝမ်းကြောင်းပြုသည့် အိမ်ထောင်စု များသည် စိုက်ပျိုးရေးလုပ်ငန်းဖြင့် အဓိကအသက်မွေးဝမ်းကြောင်းပြုသည့် အိမ်ထောင်စုများနှင့် နှိုင်းယှဉ်ပါက သစ်တောများအပေါ် မှီခိုမှုတွင် ကွာခြားမှု မရှိသည့်အပြင် သစ်တောသယံဇာတများ ထုတ်ယူခြင်းမှ ဝင်ငွေအနည်းဆုံးရရှိပြီး စုစုပေါင်းဝင်ငွေ အများဆုံးရရှိသည့် အိမ်ထောင်စုများ ဖြစ်ပါသည်။ အဆိုပါသုတေသန တွေ့ရှိချက်များအပေါ် အခြေခံ၍ ဒေသဖွံ့ဖြိုးမှုနှင့်အတူ သစ်တောသယံဇာတများအပေါ် မှီခိုမှုလျော့နည်းစေရန် အတွက် သီးခြားသစ်တောသယံဇာတများထုတ်ယူခြင်းအပေါ် တားမြစ်ချက် များကို ဒေသခံ အိမ်ထောင်

စုများ၏ အခြေခံလိုအပ်ချက်များအတွက် ဖြေလျှော့ပေးရန်နှင့် မိရိုးဖလာအရ လုပ်ကိုင်သည့် အသက်မွေးဝမ်းကြောင်းလုပ်ငန်းများကို မြှင့်တင်ရန်အကြံပြုပါသည်။ ယင်း သတင်း အချက် အလက်များကို လက်ရှိအကောင်အထည်ဖော်ဆောင်ရွက် လျက်ရှိသည့် ရွှေစက်တော် ဘေးမဲ့ တော၏ အုပ်ချုပ်လုပ်ကိုင်မှု စီမံချက်ကို update ပြုလုပ်ရာတွင် သော်လည်းကောင်း၊ အုပ်ချုပ် လုပ်ကိုင်မှုစီမံချက် အသစ်တစ်ခုရေးဆွဲရာတွင် သော်လည်းကောင်းအသုံး ပြုနိုင်ပါ သည်။

Analyzing the relationship between household livelihood strategies and forest dependency - A case study of Shwe Set Taw Wildlife Sanctuary, Myanmar

1. Introduction

Forests and natural resources are facing several threats and pressures from human activities and external factors such as climate change, natural disasters. Establishing protected areas (PAs) is one of the options to solve these problems. According to IUCN (2008, p. 1), PA means “a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values”. This is one of the most effective strategies not only for biodiversity conservation but also for other benefits such as protection of water supplies, cultural values and contribution to local people’s basic needs (Possingham, H. P., Wilson K. A., 2006).

Regarding PAs management, there are two common types; complete restriction of resource extraction and allowing resource extraction with sustainable use (Possingham, H. P., Wilson K. A., 2006). One of the most effective factors in PA management is the ability of managers to negotiate with local communities for social and economic issues concerning resource utilization (Andrade & Rhodes, 2012). In the cases of forbidding the resource extraction, this may result in conflicts between local communities and park managers (Andrade & Rhodes, 2012). Restrictions may also lead to illegal activities such as illegal forest extraction, hunting and poaching because local households depend on the forest resources in order to fulfil their basic needs and cash income.

In Myanmar, PA system was initiated since 150 years ago mainly for biodiversity conservation and ecosystem protection (Aung, 2007). Myanmar Forest Policy (1995) targeted to establish PA systems to cover at least 5% of total land area. The target has increased to 10% in 30-year Forestry Sector Master Plan (2001 to 2030). A total of 46 PAs have been established in 2020 and occupied about 6.08% of total land area (FD, 2020). Since PAs have been established for nature and wildlife conservation, local communities are restricted to extract natural resources and other activities such as hunting, grazing (The Protection of Wildlife and Protected Areas Law, 1994). However, local communities living around PAs are still extracting forest resources for their basic needs and cash income. Nevertheless, local authorities and communities are not included in PA management planning process. This has created problems between park managers and local people (Aung, 2007). Thus, alternative solutions are required to justify the gap between resource conservation of PA and the basic needs of local households.

Objectives

PAs are mainly designated for biodiversity conservation and natural habitat protection in Myanmar. However, the interest to extract the natural resources from PAs may lead to the degradation of the parks (Aung, 2007). Rao, M, Rabinowitz A., (2002) found that non-timber forest products (NTFP) such as honey, bamboo, rattan, medicinal plants, and orchids have been extracted in 85% of 20 PAs in Myanmar. More than 50% of PAs have been experiencing grazing, hunting, fuelwood extraction and permanent settlements (Rao, M,

Rabinowitz A., 2002). For instance, in Kyeikhtiyoe Wildlife Sanctuary of Myanmar, collection of NTFPs is also a common livelihood activity (Aye T. H., 2018). Istituto Oikos and BANCA (2011) also reported that the most common threats recorded outside of PAs include logging, wood harvesting, hunting and collecting terrestrial animals. Thus, the extraction of natural resource in PAs is the most common threat caused by local people for subsistence needs as well as by non-local people for commercial interests.

The population growth and high poverty levels in Myanmar increase the pressure on natural resources and PAs (Lwin et al., 1990, cited in Aung (2007)). Since around 75% of populations live in rural areas, park resources in Myanmar have already degraded due to resource extraction by local people. This is due to limited alternative livelihoods of rural people (Aung, 2007). However, the range of dependency level between rural households varies depending on livelihood strategies (Chilongo, 2014). Nevertheless, identifying differences in forest dependency across household livelihood strategies is an important step in order to find out the solutions to reduce the forest dependency. Chilongo (2014) stated that understanding livelihood strategies helps policy makers achieve PA management effectively by equalizing forest protection with households needs.

Although several researches which are assessing forest dependency of local communities have been done at the global scale such as the PEN project, there are a few research regarding the relationship between forest dependency and household livelihood strategies in Myanmar. Similarly, there are researches regarding rural forest dependency which have been conducted in the mountainous forest and moist deciduous forests in Myanmar (Aung et. al., 2015; Hlaing, et. al., 2017; Moe and Junchang , 2016); however, no such research has been done in dry zone forests. Amid the dry zone of Myanmar, Shwe Set Taw Wildlife Sanctuary (SST) is selected as a study area for this research because the ecosystem of SST is also facing a couple of threats due to human activities as well as natural disasters such as forest wildfire, livestock grazing, agricultural expansion and human encroachment, extraction of forest resources for subsistence and cash income.

The presence of several threats has called for conservation managers to develop the management strategies that promote not only conservation but also to reduce the conflicts with local people. To achieve these targets, it is important to understand the underlying causes of threats and possible pathways to minimize them. Thus, this research aims to explore the relationship between household livelihood strategies and forest dependency by taking a case study of Shwe Set Taw Wildlife Sanctuary (SST) in Myanmar. The specific objectives are:

- 1) To identify the livelihood strategies of households living around the SST
- 2) To analyze the differences in forest dependency across livelihood strategies of local households
- 3) To propose the development options to reduce the forest dependency of local households

Materials and methods

Study area

Shwe Set Taw Wildlife Sanctuary (SST) which is a study area of this research is located in Minbu district, Magway region, Myanmar and is in dry zone area of Myanmar. The lowest and highest temperature is around 11°C and 45°C according to Department of Meteorology and Hydrology of Minbu Township. It is located at 20°06.485' N and 94°31.100'E with an altitude of 183 m above sea level (Figure 1) and the area is about 464.39 km² (FD, 2019). SST is established within three reserved forests: *Shwe Set Taw*, *Kyaut Owe* and *Kywe Takar*, and two protected public forests: *Myot Sapho* and *Shwe Set Taw-Kyee Kan*. The main forest types are dry forests and deciduous forests (Istituto Oikos and BANCA, 2011), which can be found abundantly *Tectona grandis*, *Tectona hamiltoniana*, *Dipterocarpus tuberculatus*, *Shorea siamensis*, *Terminalia oliveri*, and *Terminalia tomentosa*. Moreover, three kinds of bamboos including *Dendrocalamus strictus*, *Thyrosostachys oliveri* and *Bambusa polymorpha* can be found in SST.

Around SST, more than 40 villages are depending on the natural resources of protected area (PA). Of these villages, 2 villages, namely, Oo Pyin Mel (Case-I) and Phalan Kyin (Case-II) villages were taken as case studies with the criteria such as the location of village to PA, closeness to religious festival of SST, historical background and market accessibility.

Case-I is situated in Min Bu township, Magway Region, Myanmar. It is located at latitude of 20°06.485' N and longitude of 94°37.068' E with an altitude of 85 m above sea level (Figure 1). Case-I lies inside of the PA and next to Mann stream which serves as a recreational place during the SST religious festival. Case-I is far approximately 6.5 km from the main road (Pathein - Monywa road) which is passing through the PA. This road is used for several purposes such as transportation to extract forest resources from PA or to access to neighbor cities for selling forest and agricultural products. A total of 201 households with 697 population are in Case-I.

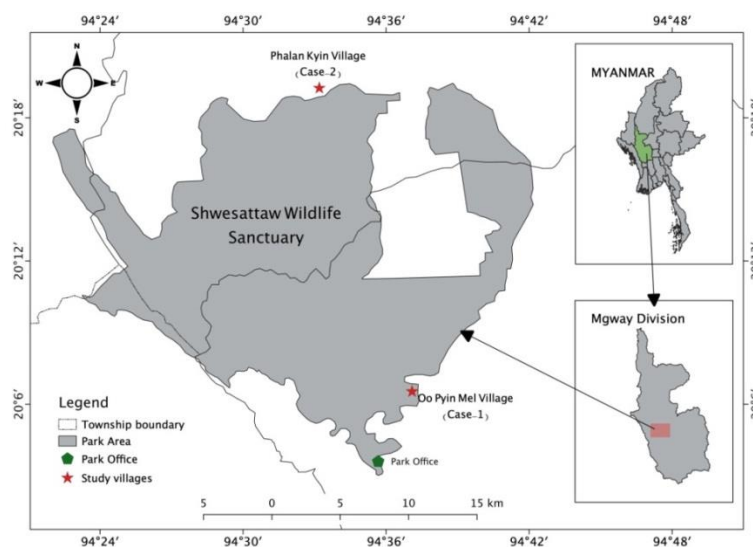


Figure 1 Location of Shwe Set Taw Wildlife Sanctuary and case study areas

Case-II is situated in Pwint Phyu township, Magway Region. It is located at latitude 20°19.198' N and longitude 094°33.246' E with an altitude of 68 m above sea level (Figure 1). It is 13 km away in between Pwint Phyu city in the east of village and Pathein-Monywa main road in West. Local products such as agricultural products, value-added forest products are normally transported to Pwint Phyu city for commercial trade. This village lies next to the boundary of SST. There are a total of 305 households in the village with 1,305 populations. Table 1 shows the number of households and sample size of case studies.

Table 1 Number of households and sample size of case studies

Case studies	Number of HH	Number of sample HH	% of sample HH
Case-I	201	105	52
Case-II	305	105	34
Total	506	210	42

*HH = households

Data collection

In data collection, direction observation, key informant interview, focus group discussion and informal small workshops were used to acquire the qualitative data for the research as well as household surveys for quantitative data. Direct observation is to understand insights about the geographical condition of village, wealth status of households, water availability, agricultural uses, forest types around village and transportation conditions.

Key informant interview was applied with semi-structured questionnaires in order to acquire qualitative data for specific topics. The key informants included village leaders, park manager and rangers, local authorities, farmers, forest resource collectors and people who are grazing in the forest for their livestock. Park authorities were asked for threats/challenges of PA caused by natural or human-induced activities, types of forest extracted by local people, management and conservation activities by authorities and future plan. The general information of village such as common livelihood activities of households, income per day per person and wealth status of village was explored by asking for village leader.

Focus group discussion was conducted with semi-structured questionnaires in order to acquire different opinion of actors for specific topics. Each group is organized with 4-6 people who are more or less homogenous for each topic (Bernard, 2006). Specific topics mainly include agriculture production, forest resource extraction and mapping of village to get a whole picture of agricultural farms, water availability for farms and houses, transportation to cities and accessibility to the forest.

Household face-to-face survey was conducted with semi-structured questionnaires after selecting sample households randomly. The questionnaires were structured based on the PEN project such as recalling period, measuring forest income and other variables. Regarding the income of livelihood activities, respondents were asked to recall for the last 12 months. In addition, future prospects of livelihood prospects in next 10 years were explored to find out the potential solutions to balance village development and conservation of forest resources. Informal small workshops were conducted in each case study village in order to explore the expectation on livelihood activities in next 10 years, difficulties of each livelihood activity and the potential solutions to promote the livelihood activities.

In order to achieve the research objectives, a list of variables to measure in the field survey were outlined based on existing literatures. Table 2 shows the variables which include income sources from different livelihood activities and future expectations of households, data collection method and data analysis.

Table 2 Variables, data collection method and data analysis based on research objectives

Research objectives	Variables	Data collection method	Data analysis
1. To identify the livelihood strategies of local households living around PA	- Agricultural income - Livestock income - Forest income - Others (salary, remittance, etc.)	Household survey, Key informant interview, Focus group discussion	Cluster analysis - Hierarchical analysis - K-means analysis
2. To analyze the differences in forest dependency across livelihood strategies of local households	- Forest income - Total income	Household survey, Key informant interview, Focus group discussion	- Kruskal-Wallis test, - Mann-Whitney U test
3. To propose the development options to reduce the forest dependency of local households	- Future options	Informal workshop	Qualitative analysis

Data analysis

Estimating income of livelihood activities

For identifying the livelihood strategies of local households by using income sharing of total household income, the income of household livelihood activities was estimated. Income from agriculture, forest resource extraction and livestock activities were considered for both own consumption and sale of associated products. However, family labor was excluded due to extremely low wage-price. Input costs such as hired labor, seeds, and chemicals were considered in estimating income of livelihood activities. Thus, the income of livelihood activities which have input costs was estimated as net income from the sum of gross income from subsistence use and associated sale of products deducted by associated input cost. For instance, agricultural subsistence income was estimated by multiplying the quantity of agricultural products consumed by households and reported price for sale. Agricultural cash income was estimated by multiplying the quantity of agricultural products sold and reported price for sale. Total agricultural income was the net income from the sum of gross income from both subsistence and cash income deducted by associated input costs. Forest income was estimated in the same way. Estimating income from poultry is excluded from this study because households could not estimate the amount of consumption and sale for poultry due to using poultry depending on ad hoc situation. Livestock cash income was estimated by multiplying the number of livestock and household's reported price. Income from business, remittance and wage activities was asked monthly based on the types of activities. Total household income was estimated by the sum of all livelihood income.

Analysis of the differences in forest dependency across livelihood strategies

In order to explore the differences in forest dependency across livelihood strategies, households were firstly clustered based on the income sharing of total household income by applying hierarchical cluster analysis and K-means cluster analysis (Table 2). Agglomerative hierarchical cluster analysis was applied using Ward's method in order to identify the ideal number of clusters from dendrogram. Dendrogram shows some households as outliers in each case. After checking the income structure of these outliers, one household in Case-I and two households in Case-II were removed throughout analysis due to an unusual income structure. Thus, the total numbers of sample households are 104 households in Case-I and 103 households in Case-II. After recognizing the households as outliers, hierarchical cluster analysis was re-run; and three clusters were identified for each case based on the dendrogram. K-means analysis was applied in order to define the final cluster membership of each household (Table 2).

After exploring the cluster membership of households, clusters were named based on the mean income sharing of total household income. Non-parametric Kruskal-Wallis test was applied to test whether there is a statistically significant for the contribution of forest income across livelihood clusters. The reason for using Kruskal-Wallis test is due to income data which are deviating from normal distribution. Test results show that there are significantly different for forest income across livelihood clusters in both cases. Thus, non-parametric Mann-Whitney U test was applied for the pairwise comparison between livelihood clusters (Table 2). From this test, the differences in forest dependency across livelihood strategies were acquired. IBM SPSS statistical software version-20 with the aid of Microsoft Excel version 2010 was used for all the statistical analysis of this research.

Results

Livelihood activities in Case-I

Livelihood activities are categorized into six including agriculture, forest, livestock, business, wage and remittance. About 87% of households extracted forest resources for both subsistence and cash income. Average total forest income is about 681.81 US dollar per household with 37.89% of total household income (Table 3). Forest resources extracted from PA for subsistence and cash income include bamboo, fuelwood, poles, fishes, fodder, bamboo shoot, and other non-timber forest products (NTFP). Bamboo is one of the main forest resources extracted from PA. Most poor people extract bamboo (*D. strictus*) to make value-added products such as bamboo thatch, which is commonly used as roof for livestock and house construction in Min Bu and neighbouring cities. Fuelwood is also extracted for both cash and subsistence income.

Table 3 Income structure of livelihood activities in Case-I (n=104)

Category	No. of HH	% of HH	Share income (%)	Mean (US dollar)	SD
Total No. of sample HH	104	100	100	2,225.35	1,615.87
Agriculture income	42	40	9.38	297.60	837.48

Category	No. of HH	% of HH	Share income (%)	Mean (US dollar)	SD
• Subsistence	16	15	2.79	85.04	350.12
• Cash	42	39	6.59	212.56	625.43
Forest income	90	87	37.89	681.81	834.33
• Subsistence	87	84	16.35	283.98	373.77
• Cash	75	72	21.54	397.83	559.55
Livestock income	29	28	6.18	172.04	394.78
• Subsistence	0	0	0.00	0.00	0.00
• Cash	29	28	6.18	172.04	394.78
Business income	38	37	16.57	441.96	1017.98
Wage income	63	61	13.80	203.69	347.18
Remittance income	41	39	16.18	428.25	995.12

*1 US dollar= 1511.4 Kyats on 26-07-2019. HH=households

Clustering livelihood strategies and income distribution in Case-I

According to hierarchical and K-means cluster analysis, three livelihood clusters were produced and they are named based on the relative income sharing of total household income such as business-agriculture (cluster I), livestock-remittance (cluster II) and forest-wage (cluster III) (Table 4). Of these clusters, forest-wage livelihood strategy (cluster III) is pursued by 73% of households which is the largest strategy and these households are highly dependent on forest resources with 48.67% of total income. Unlikely, business-agriculture strategy (cluster I) is pursued by 13% of households which is the smallest strategy and households are less dependent on forest resources with 0.93% of total household income.

Table 5 Identifying clusters with relative income sharing of each category in Case-I

Category	Business-Agriculture	Livestock-Remittance	Forest-Wage
	Cluster I	Cluster II	Cluster III
Agriculture income (%)	35.42	11.85	4.43
Forest income (%)	0.93	15.32	48.67
Livestock income (%)	0.12	34.23	1.67
Business income (%)	39.55	10.18	13.91
Wage income (%)	0.73	8.73	17.03
Remittance income (%)	23.24	19.68	14.29
Average total income (US dollar per household)	4,655	3,232	1,611
% of households	13	14	73

Analyzing the difference of forest dependency across livelihood strategies in Case-I

Table 5 shows that the distribution of total forest income, subsistence forest income and cash forest income are significantly different across livelihood strategies. Pairwise comparison shows that forest dependency are significantly different between cluster I (business-agriculture) and II (livestock-remittance), between cluster I (business-agriculture) and III (forest-wage) for receiving total forest income, subsistence forest income and cash forest income, but are only significantly different between II (livestock-remittance) and III (forest-wage) for cash forest income. Mean rank scores indicate that cluster III (forest-wage)

has a highest score suggesting that households with cluster III (forest-wage) receive more forest income than cluster I and cluster II and is the highest forest dependency among clusters.

Table 5 Differences of forest dependency across livelihood clusters in Case-I

Income category	Comparison between clusters (two-tailed, 95%)				Multiple comparisons (two-tailed, 95%) Man-Whitney U test		
	Clusters	Total hh	Mean rank	K. Wallis Test	I & II	I & III	II & III
Total forest income	I	13	17.81	0.000**	0.001**	0.000**	0.91
	II	15	46.57	$X^2 = 22.044$	9.19	15.62	35.47
	III	76	59.61	df = 2	19.10	50.03	48.08
Subsistence forest income	I	13	19.15	0.000**	0.001**	0.000**	0.369
	II	15	51.60	$X^2 = 18.870$	9.08	17.08	40.40
	III	76	58.38	df = 2	19.20	49.78	47.11
Cash forest income	I	13	21.77	0.000**	0.017**	0.000**	0.042*
	II	15	43.07	$X^2 = 19.615$	10.85	17.92	33.40
	III	76	59.62	df = 2	17.67	49.63	48.49

Note: X^2 = Chi-squared, **= p-value is significant at <0.01, *= p-value is significant at <0.05.

Livelihood activities in Case-II

Livelihood activities are categorized into six including agriculture, forest, livestock, business, wage and remittance. Of these activities, the highest income sharing is received from agriculture and forest income is the second highest income sharing of total household income (Table 6). Forest resources extracted from PA include fuelwood, bamboo, fodder, poles, timber and fish. Fuelwood is mainly collected for subsistence use for cooking due to a lack of electricity supply in this village. Bamboo including *D. strictus* and *T. oliveri* are a major forest resource extracted to make value-added products such as bamboo matting, bamboo mat for livelihoods of local households.

Table 6. Income structure of livelihood activities in Case-II (n=103)

Category	No. of HH	% of HH	Share income (%)	Mean (US dollar)	SD
Total No. of sample HH	103	100	100	2,121.94	1,491.23
Agriculture income	53	51	23.75	530.36	942.35
• Subsistence	23	22	3.45	61.71	149.14
• Cash	51	50	20.30	468.65	895.11
Forest income	88	85	22.54	331.47	523.22
• Subsistence	87	84	11.70	161.28	203.45
• Cash	30	29	10.84	170.20	354.68
Livestock income	38	37	4.82	127.35	316.92
• Subsistence	0	0	0.00	0.00	0.00
• Cash	38	37	4.82	127.35	316.92
Business income	34	33	15.75	489.49	1092.68
Wage income	54	52	14.15	187.45	390.61
Remittance income	39	38	18.99	455.82	898.71

*1 US dollar= 1511.4 kyats on 26-07-2019. HH=households

Clustering livelihood strategies and income distribution in Case-II

According to hierarchical and K-means cluster analysis, three livelihood clusters were produced which are named as agriculture-wage (cluster I), forest-remittance (cluster II) and remittance-business (cluster III) (Table 7). Of these clusters, forest-remittance livelihood strategy (cluster II) is pursued by 17% of households which is the smallest strategy and these households are highly dependent on forest resources with 75.60% of total income. Unlikely, agriculture-wage strategy (cluster I) is pursued by 59% of households which is the largest strategy and households are less dependent on forest resources with 15.08% of total household income.

Table 7. Identifying clusters with relative income sharing of each category in Case-II

Category	Agriculture-Wage	Forest-Remittance	Remittance-Business
	Cluster I	Cluster II	Cluster III
Agriculture income (%)	39.21	0.77	1.66
Forest income (%)	15.08	75.60	4.67
Livestock income (%)	2.59	6.74	8.95
Business income (%)	11.47	2.97	34.88
Wage income share (%)	16.89	5.10	13.60
Remittance income (%)	14.76	8.81	36.24
Average total income (US dollar per household)	1,629	1,841	3,515
% of households	59	17	24

Analyzing the difference of forest dependency across livelihood strategies in Case-II

Table 8 shows that the distribution of total forest income, subsistence forest income and cash forest income are significantly different across livelihood strategies. Pairwise comparison shows that forest dependency are significantly different between agriculture-wage (cluster I) and forest-remittance (cluster II), between forest-remittance (cluster II) and remittance-business (cluster III) but not between agriculture-wage (cluster I) and remittance-

business (cluster III). Mean rank scores indicate that forest-remittance (cluster II) has a highest score suggesting that households with cluster II (forest-remittance) receives more forest income than cluster I and cluster III, and is the highest forest dependency among clusters.

Table 7. Differences of forest dependency across livelihood clusters in Case-II

Income category	Comparison between clusters (two-tailed, 95%)				Multiple comparisons (two-tailed, 95%)		
	Clusters	Total hh	Mean rank	K. Wallis Test	I & II	I & III	II & III
Total forest income	I	61	43.43	0.000** $X^2 = 42.088$ df = 2	0.000**	0.970	0.000**
	II	17	94.88		31.00	43.43	33.88
	III	25	43.74		70.00	43.66	13.08
Subsistence forest income	I	61	44.33	0.000** $X^2 = 37.926$ df = 2	0.000**	0.849	0.000**
	II	17	92.68		31.50	43.83	33.47
	III	25	43.06		68.21	42.70	13.36
Cash forest income	I	61	44.02	0.000** $X^2 = 62.069$ df = 2	0.000**	0.709	0.000**
	II	17	93.85		31.12	43.90	33.29
	III	25	43.00		69.56	42.52	13.48

Note: X^2 = Chi-squared, **= p-value is significant at <0.01, *= p-value is significant at <0.05.

Synthesis of results in two case studies

Household income structure of livelihood activities in two case studies

Figure 2 shows the average total household income and income structure of livelihood strategies in two case studies. Average total household income is not different significantly in two cases. Regarding income structure, in Case-I, the major relative income sharing is received from forest resource extraction with 37.89% of total household income and the second major activity is business with 16.57% of total household income. In Case-II, agriculture contributes as a major income source of households with 23.75% of total household income and forest resource extraction is second major income source with 22.54% of total household income. Thus, Case-I is more dependent on the forest than Case-II for their livelihoods due to agricultural income contribution. Agricultural households in Case-I faced a deficit situation from low agricultural crop production due to low rainfall and drought and also receive inadequate income for their basic needs due to cultivating two main crops in a year (sesame and green gram). In Case-II, agricultural households also faced low water availability due to low rainfall and have lost their agricultural crop production, especially sesame. However, they use to cultivate more than two crops in a year and thus, income from other crops could cover the lost from sesame crops. As a result, these households can pursue the agricultural activity.

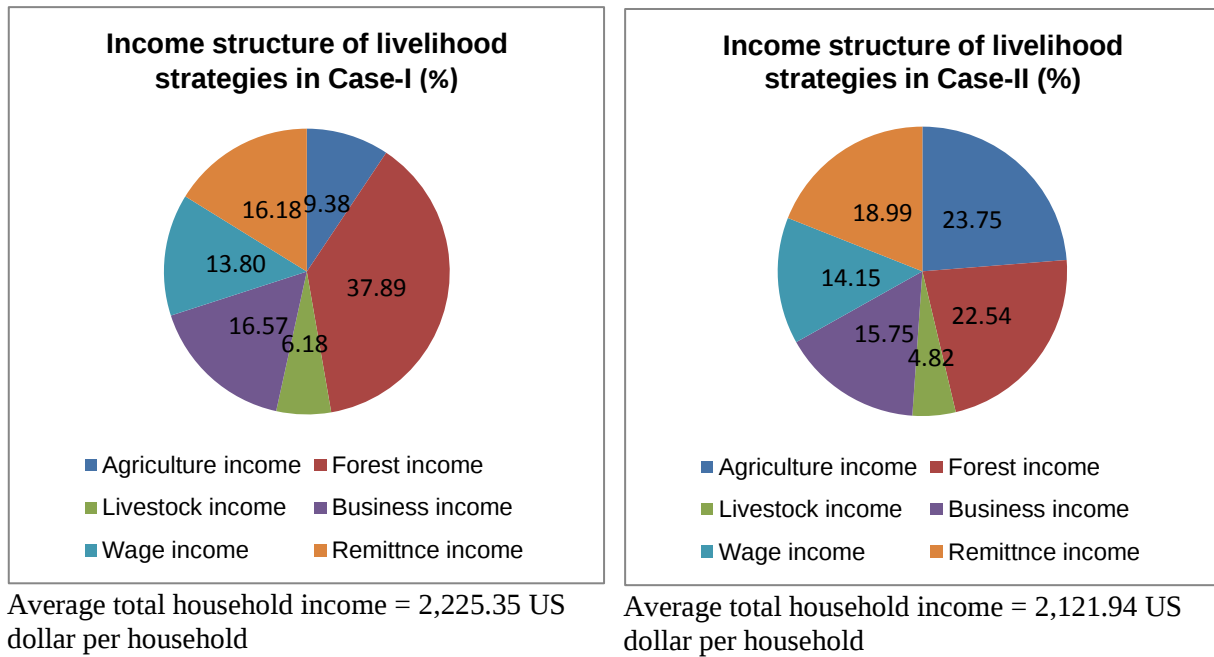


Figure 2. Relative income sharing of household livelihood activities
Income contribution across livelihood strategies in two case studies

Across livelihood strategies in Case-I, business-agriculture strategy (cluster I) contributes the highest average total income of 4,655 US dollar per household to about 13% of households (Figure 3). Pursuing this strategy with the highest total income by lower households may be due to the requirements of high initial investment and high input costs. However, forest-wage strategy (cluster III) contributes only 1,611 US dollar per households to about 73% of households. Pursuing this strategy with the lowest total income by the highest percentage of households may connect with agricultural strategy. Most of households with this strategy are mainly due to facing the agricultural deficit, and they change to other livelihood strategy such as forest extraction. Livestock-remittance strategy (cluster II) contributes an average total income of 3,232 US dollar per household to about 14% of total households. Livestock income is mainly used as an initial investment to send a family member to abroad to find jobs and most of these households are dependent on remittance income. Although these households tried to engage in forest resource extraction when they face difficulties in agriculture, insufficient income encourage them to change into migration of labour for remittance income.

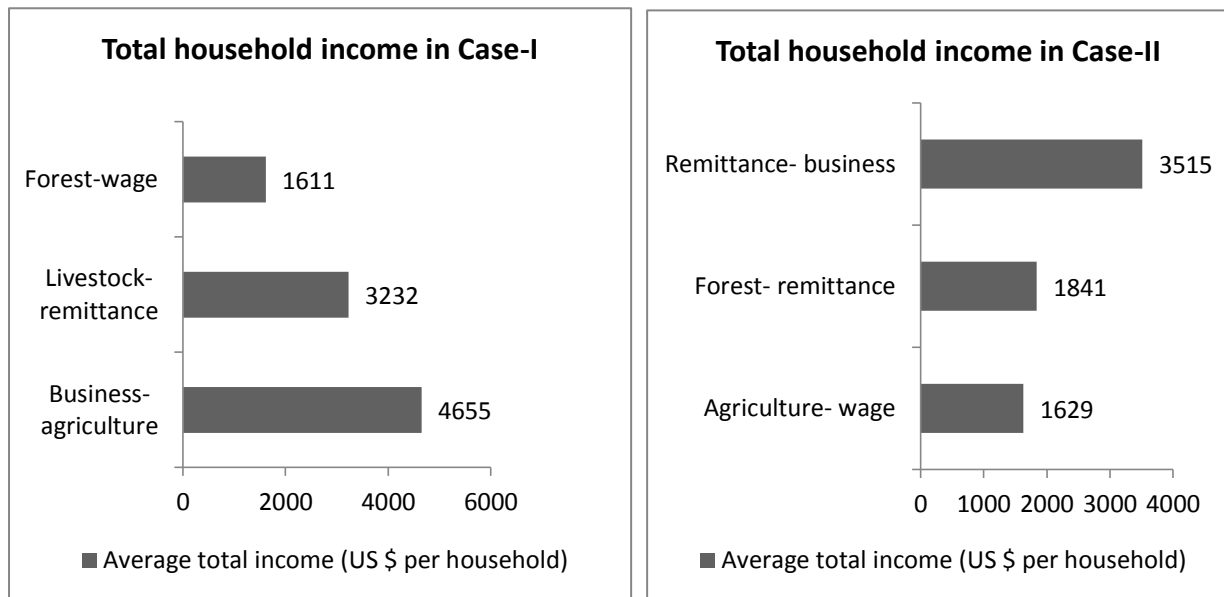


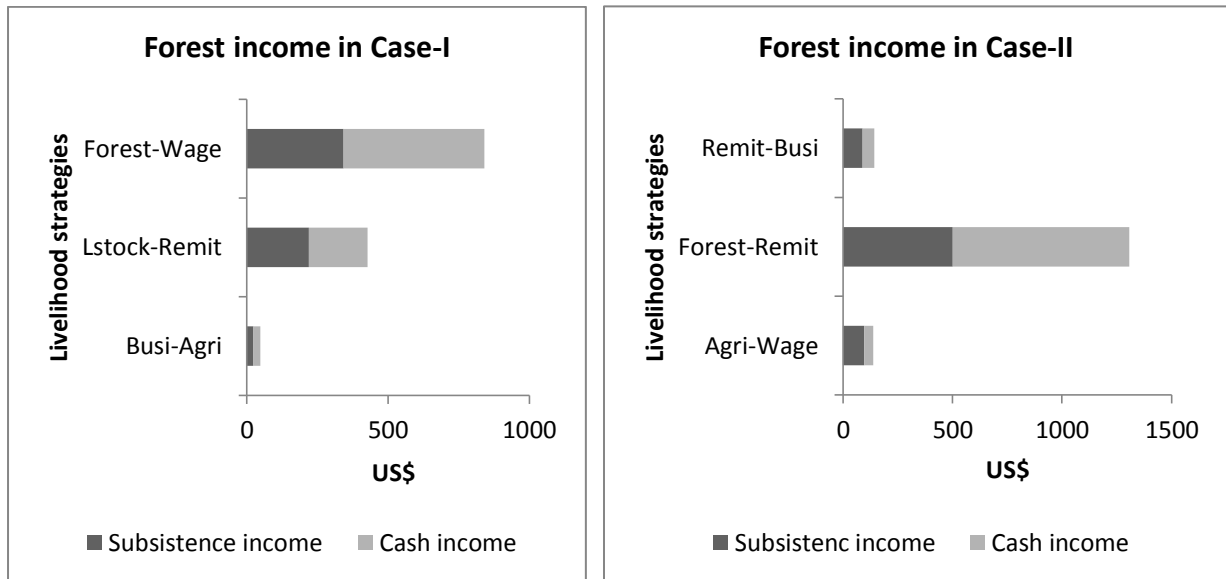
Figure 3 Average total income of household livelihood strategies in two cases

In Case-II, agriculture-wage strategy (cluster I) contributes about 1,629 US dollar per household to about 59% of households (Figure 3). Pursuing this strategy with the lowest total household income by the highest percentage of households is contradict to Case-I that they cultivate several crops in a year, and crops which have high production with the high markets may cover the lost of the input costs, especially sesame. Thus, although there are some difficulties to implement agriculture, most households can survive by pursuing agriculture. Moreover, these agricultural households can offer wage labour opportunities in the village. They can also work agricultural wage activities which offer by others in their free time. Forest-remittance strategy (cluster II) contributes about 1,841 US dollar per household to about 17% of total households which is the lowest households across the three strategies. This may be because agriculture contributes enough income for basic needs but also due to the history of receiving punishments by Forest Department (FD) for extracting poles or timber from PA. These households are mainly relying on making bamboo value-added products which do not need high investment throughout the year. About 24% of total households rely on remittance-business strategy (cluster III). These households receive about 3,515 US dollar per households which is the highest total income across the three strategies. These households mainly rely on remittance income due to limited job opportunities in the local area and insufficient income from the other strategies.

Differences in forest dependency across livelihood strategies

Figure 4 shows that not only total forest income but also forest subsistence income and forest cash income are significantly different across livelihood strategies. In Case-I, business-agriculture strategy (cluster I) receives a lower forest income than those of livestock-remittance strategy (cluster II) due to the differences in the collection of fuelwood and fodder for subsistence income and in the extraction of bamboo to make value-added

products for cash income (Figure). Forest-wage strategy (cluster III) receives a higher forest income than agriculture-business strategy (cluster I) due to the collection of fuelwood, edible leaves and bamboo shoot for subsistence use and the extraction forest resources such as poles, fuelwood, bamboo shoot and bamboo to make value-added products for cash income. Total forest income and subsistence forest income do not differ between livestock-remittance (cluster II) and forest-wage strategy (cluster III) strategies. However, households with forest-wage strategy receive higher forest cash income than those with livestock-remittance strategy due to the extraction of several types of forest resources such as poles and bamboo for cash income as the main livelihood strategy.



*Lstock = livestock, Remit = remittance, Busi = business, Agri = agriculture

Figure 4 Forest income contributions in two case studies

In Case-II, forest-remittance strategy (cluster II) receives a higher income than agriculture-wage strategy (cluster I) due to the extraction of fuelwood and bamboo for subsistence forest income and the extraction of bamboo to make value-added products for cash income due to lack of investment to pursue agriculture, livestock or business activities. In agriculture-wage (cluster I) and remittance-business strategy (cluster III), the contribution of forest income does not differ significantly between these two strategies due to extracting a similar amount of fuelwood and fodder for own consumption and not extracting forest resources for cash income (Figure). In forest-remittance (cluster II) and remittance-business strategy (cluster III), the contribution of forest income is significantly different between the strategies due to the differences in the extraction of fuelwood and bamboo for subsistence forest income and in the extraction of bamboo to make value-added products for cash income.

Livelihood prospects of local households in the next ten years

Figure 5 shows the livelihood prospects of households in next ten years by categorizing their responses as change of their livelihood strategies, no change, no idea and extent current strategies. Households mentioned that they will change their livelihood activities to have better livelihoods in future, will not change strategies due to limited investment to engage in better business opportunities or limited job opportunities in the local

area, and will extend current livelihood activities for receiving appropriate income for their basic needs when they can save high investment from current activities.

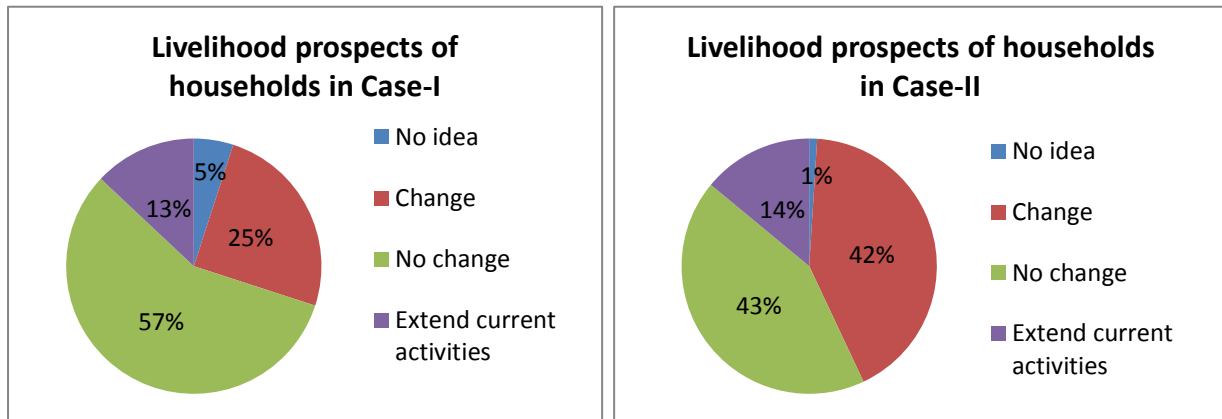


Figure 5 Livelihood prospects of households in two case studies

Livelihood scenarios of households were figured out by comparing current livelihood activities of households (Figure 6). Rural households usually have a diversification of strategies for their livelihoods due to insufficient income with one livelihood strategy. The main livelihood activities that households prospected for their livelihoods in the next ten years have been explored without considering ad hoc activities for their livelihoods. Thus, there is a different pattern between current livelihood activities pursued by households for cash income and the prospected activities for the future.

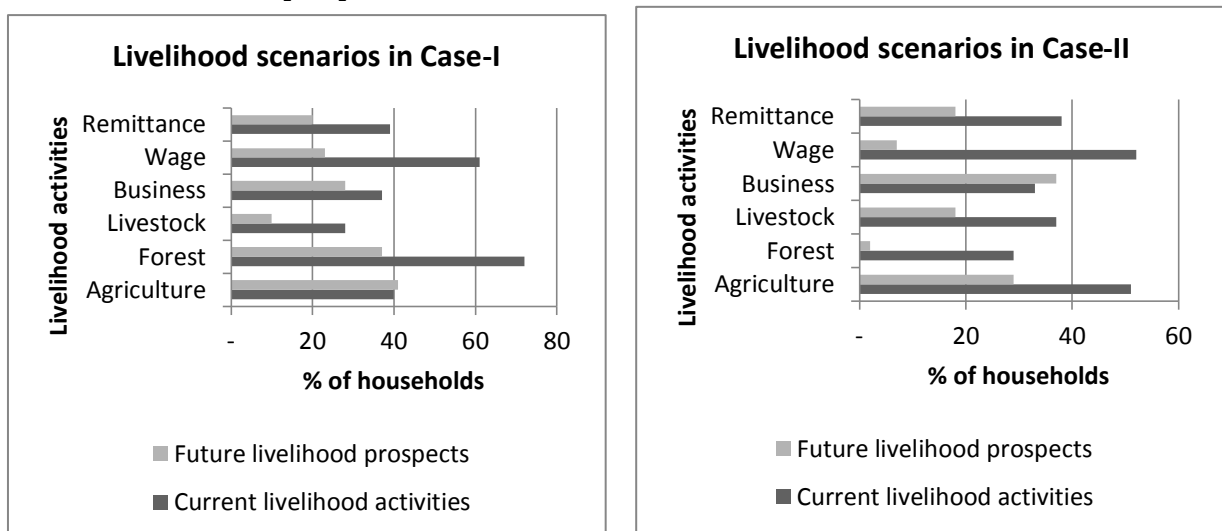


Figure 6 Livelihood scenarios of two cases in the next 10 years

Figure 6 gives important information to consider in management and conservation of protected area, particularly for the conservation of forest ecosystem. In Case-I, forest extraction is the second-highest livelihood prospects of households following to agriculture. It suggests that the extraction of forest resources will be pursued by most households due to limited job opportunities and lack of investment to engage in other business activities. In Case-II, forest extraction is the lowest livelihood prospects of households. This is a good prospect for protected area conservation. Different scenario of forest extraction between

Case-I and Case-II may be that Case-I extracts several types of forest resources for cash income throughout the year while Case-II extracts only bamboo for their livelihood which is hard in long term survival and thus, may prospect to change extraction of bamboo to diversify with other livelihood activities.

Expectation on the livelihood activities in next ten years

Local households expect livelihood activities to have an appropriate condition in the next ten years. Regarding agriculture, the highest expectation is to create market networks for agricultural crops, to change from manual farming to mechanized farming to be more efficient and to have higher crop production than manual farming, to access electricity in order to support agricultural activities, to get advice and knowledge regarding agricultural activities by resource persons and to acquire good quality seeds for high production.

Households relied on forest resource extraction for their basic needs due to limited job opportunities and lack of investment to engage in other activities. They expect to reduce the restriction on bamboo extraction and dry fuelwood collection for cash and subsistence use, to restrict overexploitation of bamboo shoot and fresh fuelwood collection not to affect bamboo population and forest degradation, to provide technical trainings for marketable bamboo value-added products to receive higher income, and to promote ecotourism based on religious festival and endemic species in SST in order to create job opportunities. Regarding other livelihood activities such as livestock, business and remittance, the main difficulty is lack of investment to implement these activities and households expect external supports for initial investment such as credit services with low-interest rate.

Discussion

Complex links between forest dependency and income level of livelihood strategies

Forest dependency with different income levels differs across livelihood strategies. In Case-I, business-agriculture strategy receives the highest total income across livelihood strategies with the lowest forest income. Zenteno et al. (2013) found similar results that households with livestock strategy received the highest income with the lowest forest dependency. However, the forest-wage strategy of this research receives the lowest total income with the highest forest income. This finding supports the previous findings (Babulo et al., 2008; Chilongo, 2014; Tesfaye et al., 2011) that the low-income level is associated with high forest dependence and vice versa. Moreover, findings by Moe and Junchang (2016) support that households with medium and low-income level receive high absolute forest income, particularly from NTFP. In contrast, Case-II has a different range of forest income contribution with different total income level. Agriculture-wage strategy receives the lowest total income with the lowest forest income. However, remittance-business strategy which receives the highest total income has the second-lowest forest income. This finding disagrees the relationship between forest dependency and income level; however, it supports findings by Chilongo (2014) who stated that this relationship may not always be as straightforward. Zenteno et al. (2013) also found that households with intermediate total income are the highest forest dependency across livelihood strategies.

In Case-I, forest-wage livelihood strategy with the lowest total income receives the highest relative forest income. In Case-II, forest-remittance strategy with the second-lowest total income receives the highest relative forest income. Agricultural-wage strategy has the lowest total income. The reason for receiving higher total income by forest-remittance strategy than agricultural-wage strategy may be due to higher remittance income generated to forest-remittance strategy. Agricultural households in rural areas include better-off or medium wealth status in general. However, receiving the lowest total income by agriculture-wage strategy is due to low agricultural products by irregular events, particularly drought and flooding. The findings of this research can be generalized that poor households, as well as households that are closer to a poor level, receive higher relative forest income than the households with higher total income. This finding supports the results of Babulo et al. (2008) that poor households have higher relative forest income than rich households. In contrast, Aung, P. S. et. al. (2015) mentioned that poor households are not always collecting the forest resources and better-off households may use more forest resources than medium and poor households. However, Chilongo (2014) found different results regarding the relationship between income level and forest dependency. In taking two cases in Malawi to examine the livelihood strategies and forest reliance, it is found that the highest relative forest income is received by low-income livelihood strategy in one case and received by the highest income strategy in another case. Chilongo (2014) mentioned that this may be due to the context of methodology for clustering households and hiding of some characteristics.

Forest dependency differs depending on the function of forest resources in each village. In Case-I, forests serve as safety nets because households that faced an agricultural deficit or economic crisis due to climate change rely more on forest resources for their basic needs. This is mainly because collecting forest resources do not need high initial investment. For some households, they left their agricultural land as a fallow and change their current strategies into forest resource extraction or wage activities. In Case-II, forests serve more as gap-filling because forest resources, particularly fuelwood are collected as regular subsistence uses. The other forest resources, especially bamboo are only extracted by some households for their livelihoods. This is because most households are still pursuing agriculture although they face irregular events similar to Case-I. The main reason may be that agriculture is a family tradition and provides income for basic needs by cultivating several crops in a year.

Types of forests used in case study villages and differences in forest dependency

Case study villages in SST extract fuelwood for subsistence use, particularly for cooking due to lack of other alternative energy sources. In Case-I, both dry and fresh fuelwood are extracted for cash income. Similarly, previous researches in other types of forests in Myanmar (P. S. Aung et al., 2015; Hlaing et al., 2017; Htun, T. T., Wen, Y., Ko, 2017) mentioned that fuelwood is the most collected product for subsistence use by rural households due to electricity constraints. Chilongo (2014) also mentioned that fuelwood includes the top forest products for all livelihood clusters in Malawi.

Regarding bamboo, both case studies extract bamboo to make value-added products for their livelihoods. Value-added products such as bamboo thatch in Case-I and bamboo

matting and bamboo mat in Case-II, are made for cash income. However, the market prices of these products are not high. Although local people are aware that bamboo extraction is an illegal activity, they keep extracting bamboo for their basic needs due to lack of investment and other job opportunities. Moe and Junchang (2016) found that bamboo collection is the most important product for cash income in rural areas. Regarding other forest resources, bamboo shoot, poles, mushroom and fish resources are extracted for cash income in Case-I while only bamboo and fishes in Case-II. Of these resources, bamboo shoot collection is leading to overexploitation not only by Case-I but also by other villages living around SST. As a result, rural people who are depending on bamboo for basic needs may be affected. In terms of poles, Case-I extracts for cash income by trading to cities. Overexploitation of poles in dry zone may lead to forest degradation in PA for long-term conservation.

The types of forest resources used by two case study villages differ with different purposes for their livelihoods. Likewise, forest dependency differs across household livelihood strategies due to the reasons behind pursuing the strategies. In both case studies, households with forest-related strategies are the highest dependency on forests for cash income across livelihood strategies. However, the reasons for depending on forests are different in two case studies. In Case-I, forest households include the ones who changed the livelihood strategies from agriculture to forest extraction due to agricultural conditions. In Case-II, forest households depend on the forest, especially bamboo since long time ago. All of these households depend on the forest resources for cash income as the main strategy due to the limited job opportunities in the local area and the lack of investment to engage in better livelihood strategies. Regarding livestock and business strategy, households with livestock strategy are more dependent on the forests than those with business strategy due to collecting fodder for their livestock in addition to fuelwood for own consumption. Regarding agriculture and remittance strategy, forest dependency in both strategies are not different due to collecting fuelwood for own consumption. The result implies that the differences in forest dependency depend on household livelihood strategies.

Conclusion

Protected areas (PAs) are facing several threats due to human activities and natural disasters. This research explores the livelihood strategies of households living around PA and the differences in forest dependency across these livelihood strategies. As a result, households with different livelihood strategies vary significantly in forest dependency.

Regarding the complex links between total household income and forest dependency, household livelihood strategies with the low total income receive the highest forest income. These strategies are forest-wage strategy in Case-I and forest-remittance strategy in Case-II. There is a different approach to pursuing these strategies with low total income. In Case-I, households that faced agricultural deficit due to climate change shifted their livelihood strategy into forest extraction strategy or remittance strategy by leaving agricultural land as a fallow or selling cows. In Case-II, households that experienced failure in agriculture due to climate change keep pursuing agriculture for their basic needs by cultivating several types of crops in a year. However, these agricultural households receive a low total income with the lowest forest income while households with forest-remittance strategy with second-lowest

total income receive the highest forest income. Thus, this research proposes a couple of hypothesis for future researches based on the empirical findings of case studies:

- (a) “Household livelihood strategies that receive the low total income have both the highest absolute and relative forest income sharing of total household income.”
- (b) “Households with livestock strategy are more dependent on forest resources than those with business strategy due to collecting fodder for their livestock while households with business strategy do not need to collect fodder”.

This research proposes some of the interventions to consider in developing management strategies of PA for the conservation of forest ecosystem along with the rural development. These interventions are to reduce the restriction on specific forest resources such as collection of dry fuelwood and bamboo extraction, to be balance between forest conservation and rural development, however, the products such as bamboo shoots, poles and fresh fuelwood should be limited for commercial purposes. Moreover, making sure to enhance the traditional livelihood strategies, especially agriculture, livestock and making value-added products can reduce the forest dependency in long term.

Acknowledgement

I would like to express my profound gratitude to my supervisor Prof. Dr. Jürgen Pretzsch, Institute of International Forestry and Forest Products, for his academic guidance not only in writing thesis but also in my two-year study in master course of tropical forestry at the TU Dresden, Germany. I also would like to thank my second supervisor Dr. Nyein Chan, University of Forestry and Environmental Sciences, Yezin, Myanmar for his detailed and invaluable comments for this thesis. I do thank Deutscher Akademischer Austausch Dienst (DAAD) for granting me the scholarship and continuous support during my stay in Germany.

It is also my great pleasure to acknowledge deeply to the staff of Shwe Set Taw Wildlife Sanctuary, especially U Ohn Lwin (Park warden), U Thein Lwin (Staff Officer) and Daw Tin Moe Swe (Range Officer) for their cooperation and assistance during my field survey. Special thanks are due to the Forest Department, Ministry of Natural Resources and Environmental Conservation, Myanmar for permitting me to participate in this postgraduate course at TU Dresden in Germany. My special thanks also go to U Pyi Soe Aung for his kind support, guidance, advice and help in both academic and daily life during my stay in Germany.

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