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# Assessing Local Dynamics Driven Forest Transition: A Case Study in An Upland Village, Southern Chin State, Myanmar

Dr. Nyein Chan, Lecturer

University of Forestry and Environmental Science, Yezin

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# သစ်တောများ တစ်ကျော့ပြန်တက်လာခြင်းအတွက် ဒေသအခြေအနေ ပြောင်းလဲမှုများအား ဆန်းစစ်ခြင်း

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သစ်တောနှင့်ပတ်ဝန်းကျင်ဆိုင်ရာတက္ကသိုလ်

## စာတမ်းအကျဉ်း

တစ်ကမ္ဘာလုံးအတိုင်းအတာဖြင့်ကြည့်လျှင် အပူပိုင်းတောများ ပျက်စီးနှုန်းသည် ဆက်လက်မြင့်များ လျက်ရှိပေသည်။ သို့ရာတွင် အချို့သောလေ့လာတွေ့ရှိချက်များအရ မတူညီသော အကြောင်း အချက် များကြောင့် တောများပျက်စီးခြင်းမှ တောပြန်ထလာသည့် အထောက်အထားများလည်း ဖော်ပြထား သည်ကိုတွေ့ရှိရပါသည်။ ယင်းကဲ့သို့ တောပြန်ထလာသည့်အကြောင်းရင်းများသည် ကျေးလက်ဒေသများတွင် ပြောင်းလဲနေသော အချက်များနှင့် ဆက်စပ်လျက်ရှိရာ အဆိုပါ အကြောင်းအရာများကို နားလည်ရန် လိုအပ်ပေသည်။ သို့မှသာ ကျေးလက်ဒေသများတွင် ပိုမို ကောင်းမွန်သော သစ်တောစီမံ အုပ်ချုပ်မှုများကို အထောက်အကူဖြစ်ပေမည်။ ဤစာတမ်းအတွက် သုတေသနလုပ်ငန်းများကို မြန်မာနိုင်ငံ၊ ချင်းပြည်နယ်တောင်ပိုင်းရှိ ကုန်းမြင့်ကျေးရွာတစ်ခုတွင် အချက်အလက်များတိုင်းတာခြင်း၊မေးမြန်းခြင်းနည်းလမ်းများဖြင့် ဆောင်ရွက်ထားပါသည်။ သုတေ သန တွေ့ရှိချက်များအရ ကျေးလက် ဒေသအဆင့်တွင်ပင် လူဦးရေပြောင်းလဲခြင်း၊ အသက် မွေးဝမ်းကြောင်းလုပ်ငန်းများ ပြောင်းလဲ ခြင်းများကြောင့် သစ်တောဖုံးလွှမ်းသည့် ပမာဏ ပြန်လည် မြင့်တက်လာပြီး၊ သစ်တောဇီဝဒြပ်ထုပမာဏပါ တိုးတက်များပြားလာသည်ကို တွေ့ရှိရပါ သည်။ ထို့ကြောင့် ဤစာတမ်းတွင် ကျေးလက်ဒေသအဆင့် ပိုမိုကောင်းမွန်သော သစ်တော စီမံ အုပ်ချုပ် ခြင်းများအတွက် စီမံချက်များရေးဆွဲရာတွင် ဒေသတွင်း ပြောင်းလဲမှုကို ဖြစ်နေသော အချက် အလက်များအား ထည့်သွင်းစဉ်းစားရန် လိုအပ်ကြောင်း ဖော်ပြထားပါသည်။

# Assessing Local Dynamics Driven Forest Transition: A Case Study in An Upland Village, Southern Chin State, Myanmar

Dr. Nyein Chan, Lecturer

University of Forestry and Environmental Science, Yezin

## Abstract

Tropical deforestation rate remains alarmingly high at global level. However, some studies pointed out that the forest transition occurred in some parts of the world by different pathways. It is important to understand such forest transition driven by changing factors at local level, in order to contribute to better local forest management. This study was conducted in one of the upland villages in southern Chin State, Myanmar by using quantitative and qualitative research methods. In the findings, even at the local level, the changes in demography, livelihood activities seemed to result in an increase in forested area with further biomass accumulation. Therefore, it is recommended that factors at local level dynamics need to be considered in local forestry planning for better local forest management.

# Assessing Local Dynamics Driven Forest Transition: A Case Study in An Upland Village, Southern Chin State, Myanmar

## 1. Introduction

The global rates of tropical deforestation remain alarmingly high (Meyfroidt & Lambin, 2011). However, most of the reviews presented that the declines in forest cover cease and recoveries in forest cover begin (Meyfroidt & Lambin, 2011; Rudel, et al., 2005; Lui, et al., 2017; Souhworth, et al., 2012). Mather (1992) defined the forest transition as the change from decreasing to increasing forest area. According to the reviews by Meyfroidt & Lambin (2011) and Souhworth, et al. (2012), several countries experienced a forest transition as a national-scale shift from a shrinking to an expanding forest area. Lui, et al. (2017) summarized the five basic pathways for forest transition: forest scarcity pathway; economic development pathway; state forest policy pathway; globalization pathway, and smallholder, tree-based use intensification pathway.

According to the Global Forest Resource Assessment 2015, Myanmar stands the third position in deforestation and forest degradation (FAO, 2015). Bhagwat, et al. (2017) reported that Myanmar's forest cover declined by more than 1.5 million ha, with an annual net loss of 0.30% between 2002 and 2014. However, according to the research by Chan & Takeda (2017), forest biomass regain was observed in some parts of Myanmar, especially in southern Chin State.

He, et al. (2014) reported that the state forestry policies (including afforestation policy and land use policy reform) contribute to forest area increase, while local processes (including livelihood change and institutional factors) play an important role in driving and shaping forest transition. Also, He, et al. (2014) recommended to make a local-level studies in forest transitional analysis. This study is one of the efforts to understand the local dynamics which drives the forest transition at village level in Myanmar.

## 2. Objectives

The overall objective of this study is to assess the forest transition driven by local dynamics, contributing to the local forest management.

The specific objectives are:

1. To highlight the local dynamics in an upland village, southern Chin State, and
2. To assess the forest transition in term of biomass by those local dynamics in southern Chin State.

## 3. Study Site and Methods

### 3.1. Study site description

This study was conducted in an upland village (Village T), Matupi Township, southern Chin State, Myanmar. Village T is 25 km far from the town of Matupi (Figure 1). The ethnicity in Village T is Zotung whose staple food has historically been maize, but it has recently changed to rice. The total village territory of Village T is about 2,657 ha. There were 523 people and 88 households in Village T in 2013. The villagers maintain the forests within

1 km of the village and also on the headwater mountain as well as the trees along the streams. The major livelihood activity in the village is swidden agriculture (Chan & Takeda, 2017). This area involves sub-tropical evergreen forest dominated by *Quercus*, *Lithocarpus*, and *Castanopsis* species (Kingdon-Ward, 1958). Secondary forests regenerated in swidden-cultivated areas are found between 600 and 1,200 m above sea level (Fujikawa, et al., 2012). Based on data from the local agricultural and meteorological station, the soil in this area is part of the *Fluvisol* group. The average annual precipitation is about 1,454 mm, and the mean annual temperature is about 21ºC.

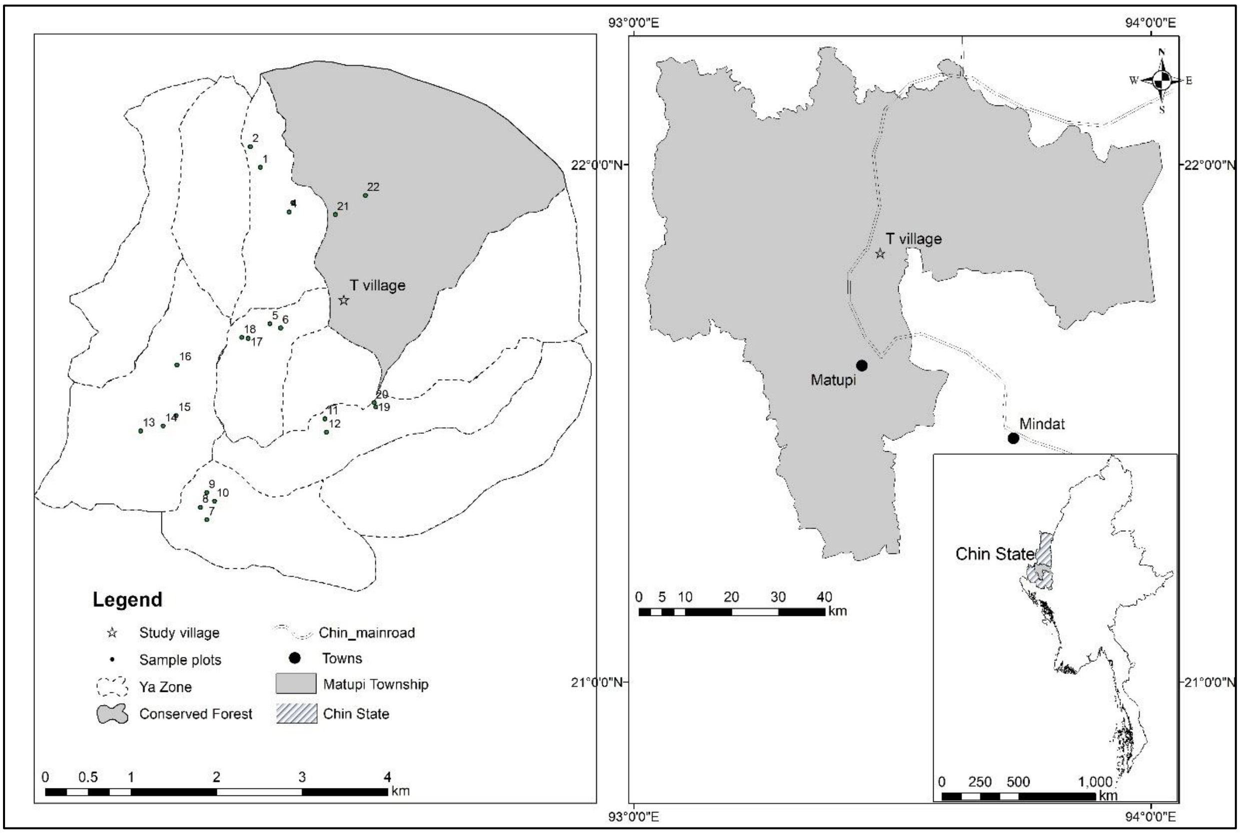


Figure 1. Overview of the study site in Matupi Township, southern Chin State, Myanmar

### 3.2. Methods

To detect the local dynamics and assess the factors affecting such dynamics, Focused Group Discussion (FGD) with key informants was performed, and individual household interview was also conducted by using semi-structured questionnaire. The 26 households (30% of total village population) in Village T were interviewed about the major changes in land use, livelihood activities, and socio-economic conditions. In addition, secondary data such as population data, land registration records were collected from relevant and available sources.

Village population census was conducted by the Immigration Department, Matupi Township, and therefore the updated information was supplemented by village headmen and village health care center at the time of data collection in 2013. Moreover, previous village land registration records were accessed to examine the transformation of land use especially swidden land use. The number of households who mainly engaged in swidden farming was registered in the village land registration records, and converted by using average size of swidden plots by household interview.

Based on the FGD and semi-structured interview, the major local dynamics were described. Some of the dynamics (for example, changes in population, and major land use, as well as present socio-economic condition) were analyzed in descriptive statistics. Based on previous land records and interviews, the land area changes in swidden cultivation zones over a complete rotation were analyzed by maximized utilization approach. In this approach, at the beginning of the rotation to be analyzed (2003–2004 in Village T), all of the fallows were fully used by the villagers. This implies that the use of the old fallows was maximized before the beginning of the analyzed rotation.

To assess the forest transition, previous land registration records were checked and also the biomass growth in forests abandoned after swidden practice was estimated. For biomass survey, sample plots (22 plots in total in both villages) were established by random sampling through a chronosequence approach. Nested sampling design (Figure 2) was used to measure the tree and understory biomass (Chan, et al., 2013).

Measurable parameters such as D130 and H of all trees in each plot were recorded with the species name. To accurately estimate the tree biomass, site-specific allometries established by Chan & Takeda, (2017) were applied. Also, the destructive method was used to estimate the understory biomass. Based on the understory height, harvesting was performed in one 5m x 5m plot or five 1m x 1m plots. All the high understory were harvested in each sub-plot, and the fresh weight, measured. A fresh sample of about 300 g was taken from each sample plot, and the oven-dry weight was measured for further analysis.

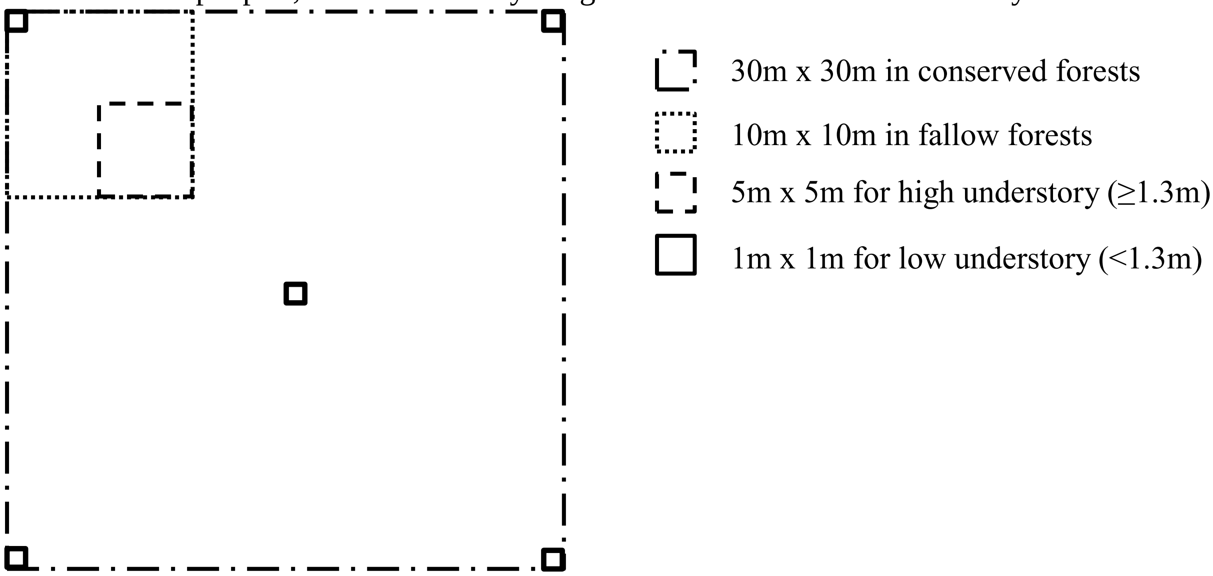

Figure 2: Nested sampling design

By using the best-fit allometry, the total aboveground biomass of individual trees in each plot was estimated. At the plot level, the total aboveground biomass of trees was supplemented by understory biomass. The biomass recovery trend in both villages was also analyzed by regression analysis of total aboveground biomass against fallow age.

As the villagers opened the fields on a rotational basis, the biomass accumulation pattern over a complete rotation in each village was also assessed.

## 4. Results and Discussion

### 4.1. Changes in demography

The study village experienced out-migration of young people to other countries such as Malaysia, the USA, and India, and also to other locations in the country. In the Village T, 110 individuals (21% of total village population) went out for better job opportunities (Figure 3).

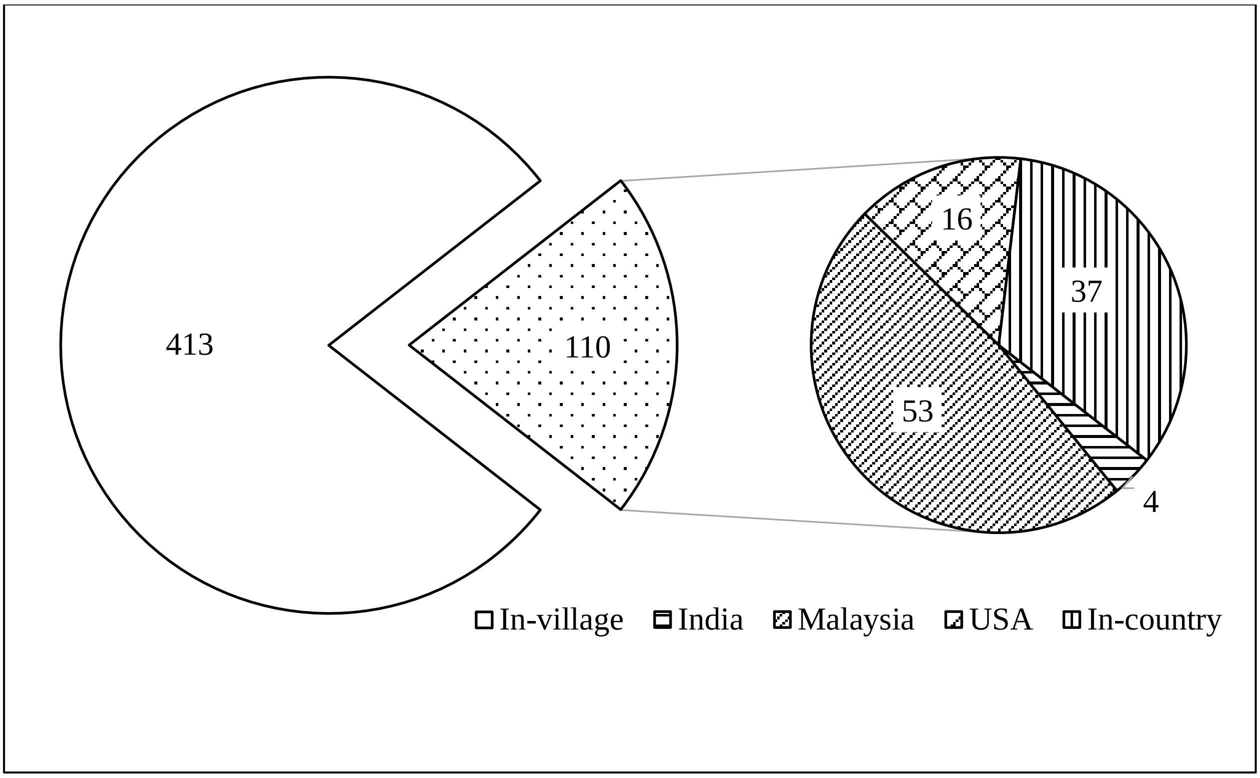


Figure 3. Population status with out-migration in Village T
Source: (Chan & Takeda, 2017)

Out-migration for better job opportunities could be observed elsewhere in Chin State. Takahashi (2007) reported a Malay connection with the Chin people in the northern part of Chin State, which included swidden cultivators. Also, in the national census 2014, it is reported that 51,545 people from Chin State were living abroad (DoP [Department of Population], 2015). One of the major reported factors for the occurrence of out-migration has been insufficient agricultural production (Takahashi, 2007; UNDP [United Nations Development Programme], 2011; Win, et al., 2012; UNDP, 2013) due to harsh climatic conditions in some years and the peripheral effects of a forest-rat outbreak in 2008 (CHRO [Chin Human Rights Organization], 2008). Thein (2012) reported that families in this area depended on remittance money from migrant workers. Because of out-migration, a decrease in demographic figures was occurred, leaving mostly old-aged family members and children. It led to difficulty in continuing the traditional livelihood activities, especially swidden farming.

### 4.2. Changes in livelihood

Swidden agriculture, one of major livelihood activities in the studied village was gradually transformed due to the decreasing number of swidden cultivators and a shift to alternative livelihood activities. The number of swidden cultivators was decreased by 50% in Village T over the previous decade (2003–2013) (Figure 4). Due to a decrease in swidden cultivators, the swidden area became in a gradual decline.

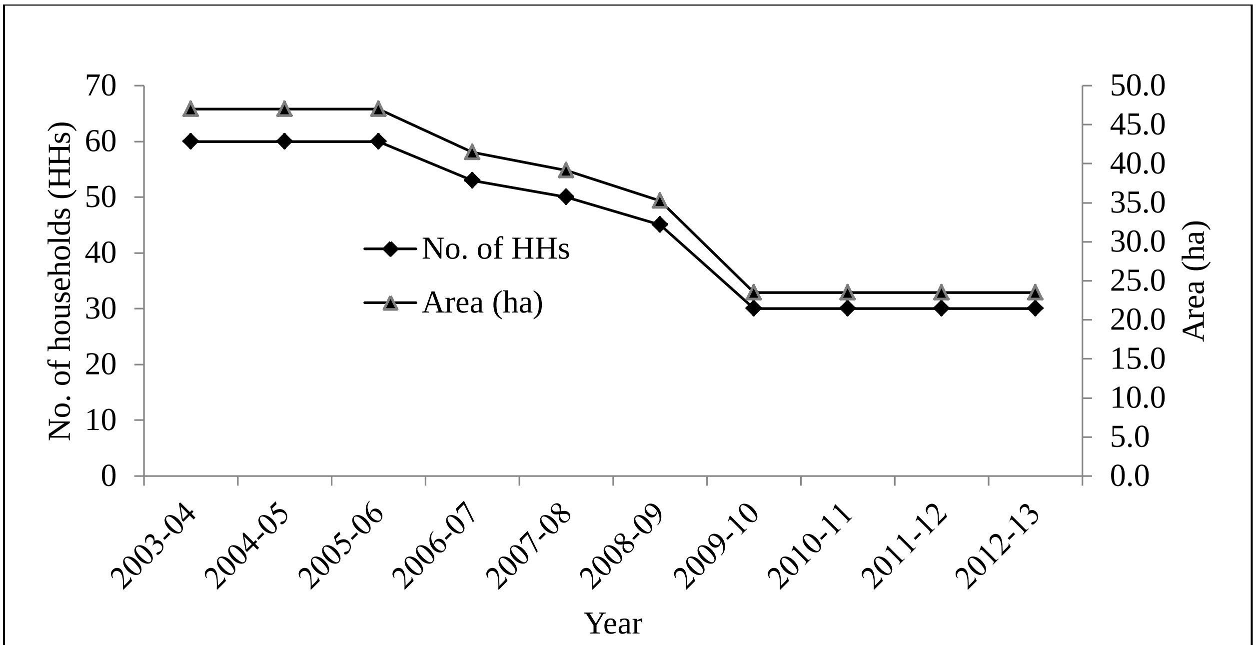


Figure 4.Changes in the extent and demographic dimension of swidden agriculture in Village T
Source: (Chan & Takeda, 2017)

According to household interviews, in the Village T, 22 households (85% of the total respondents), 7 (27%) and 12 households (46%) are engaged in swidden cultivation, terrace farming and gardening in old fallows, respectively (Table 1).

Table 1. Land-use and crop production in 2013 in Village T

| Land-use (Households) | Village T |
|---|---|
| (a) Swidden cultivation | 22 |
| (b) Terrace farming | 7 |
| (c) Garden in old fallows | 12 |

Source: (Chan & Takeda, 2017)

Government policy has also sought to change the swidden practice to permanent agriculture. According to Thein (2012), terrace farming has been developed since the 1960s, but a marked adoption of terraced fields has occurred in the past decade (2001–2010) with assistance from UN agencies, non-governmental organizations (NGOs), international non-governmental organizations (iNGOs), and national governmental organizations (GOs). It made the Chin Hills with a thorough mix of swiddens and terraces. Also, Chan & Takeda (2017) reported that the crop production from swidden practice was found to be limited and insufficient for self-consumption. It is likely to be one of the factors to change the livelihood activities.

Table 2. Average income generated by alternative cash-income activities per household in 2013 in Village T

| | Price per unit | Village T |
|---|---|---|
| Family size (No. of individual per household) | | 6 |
| Supports by out-migrant family members (,000 MMKs) | | 1,250 |
| Animal husbandry | | |
| (a) Gaur (,000 MMKs) | 350 head$^{-1}$ | 603 |
| (b) Buffalo (,000 MMKs) | 330 head$^{-1}$ | 330 |
| (c) Pig (,000 MMKs) | 136 head$^{-1}$ | 237 |
| (d) Chicken (,000 MMKs) | 7 head$^{-1}$ | 35 |
| | | |
| NTFPs (Wa-u[♯]) collection (,000 MMKs) | 4 viss$^{-1}$ | 210 |
| Home business (,000 MMKs) | | 180 |
| Land rental (,000 MMKs) | | 350 |
| Hired labour | | |
| (a) For farming (,000 MMKs) | | 519 |
| (b) Other purpose (,000 MMks) | | 180 |

† Income in Myanmar Kyats (1 USD = c. 980 MMKs)
[♯]Wa-u is local name for elephant yam or elephant foot yam, scientifically *Amorphophallus* spp (Family Araceae). The dry sliced wa-u was produced, and exported to Japan and China.
Source: (Chan & Takeda, 2017)

Takahashi (2007) said that village livelihoods could not be sustained unless the residents earned non-farm and/or off-farm household income. About 32% of household cash income in Village T came from the remittance money from out-migrant family members (Table 2).

In addition, animal husbandry, especially gaur (*Bos gaurus*; locally nwa-nauk in Burmese; commonly mithan, mythun, or gayal) husbandry, which was formerly a part of traditional subsistence system, has been supported by the government since 2003. It accounted for about 45% of total cash income generated in Village T. According to interview, rearing gaur accounted for more than 50% of the total income from animal husbandry in the village (Table 2). The Chin Hills are the natural habitat of gaur (FAO, 2000; Duckworth, et al., 2008; Shisode, et al., 2009; Tanaka, et al., 2011). Furthermore, gaurs are essential to the customs of the local people, as marriage gifts and as sacrificial animals for various cultural rituals and ceremonies (Shisode, et al., 2009).

Moreover, the market development for some non-timber forest products led to changes in livelihood activities. *Wa-u* (*Amorphophallus* spp.; commonly known as elephant foot yam) was collected from the residents' own gardens/old fallows as well as from natural forests as non-timber forest products (NTFPs). *Wa-u* has recently been developed as a cash crop in southern Chin State (Win, et al., 2012). The increase in demand for *wa-u* from China and Japan has led to a semi-commercialized system. *Wa-u* had started to be collected from the natural forests, but at the time of over-harvesting and high market demand, it had started to be grown in the old fallows as a garden. According to the interview, the average income from *wa-u* cultivation accounts for about 5% of the total average cash income.

Other income-generating activities, such as traditional costume weaving as a home business, small-scale retail, short-term land rental, hired labor for farming, and services such as transporting items contribute to some extent to the total average income of households. It is also likely said that the changes in livelihood were occurred due to better communication with low landers.

Hence, the local dynamics in the studied village was observed to be occurring by two means: outside the village, i.e., remittance money from out-migrants; and inside the village, i.e., income derived from animal husbandry, NTFPs, and access to the other cash-earning livelihood activities inside the village.

### 4.3. Estimation of biomass

Average aboveground biomass (AGB) values of 4.24, 14.24, 24.13, 31.43, and 38.65 $Mgha^{-1}$ were estimated in 1-, 3-, 5-, 7-, and 9-year-old fallows of T village (Figure 5).


Figure 5. Average biomass accumulation in swidden-cultivated fallows in Village T

Source: (Chan & Takeda, 2017)

The total accumulated AGB was lower in the studied village than in swidden-cultivated fallows in the Bago Mountains, Myanmar (Chan et al 2013), likely due to differences in forest types. The total AGB accumulation in 7-year-old fallows in this study (31.43 $Mgha^{-1}$) was almost equivalent to that of 5-year-old fallows in the Bago Mountains (31.31 $Mgha^{-1}$).

By considering the total AGB of every sample plot, the biomass recovery trends (the relationship between total AGB accumulation and fallow age) in Village T was established (Figure 6). The variation in biomass accumulation larger in older fallow-aged forests. However, in general, the total AGB accumulation in swidden-cultivated fallows increased with fallow age in Village T ($R^2$ = 0.779, SE = 0.422).

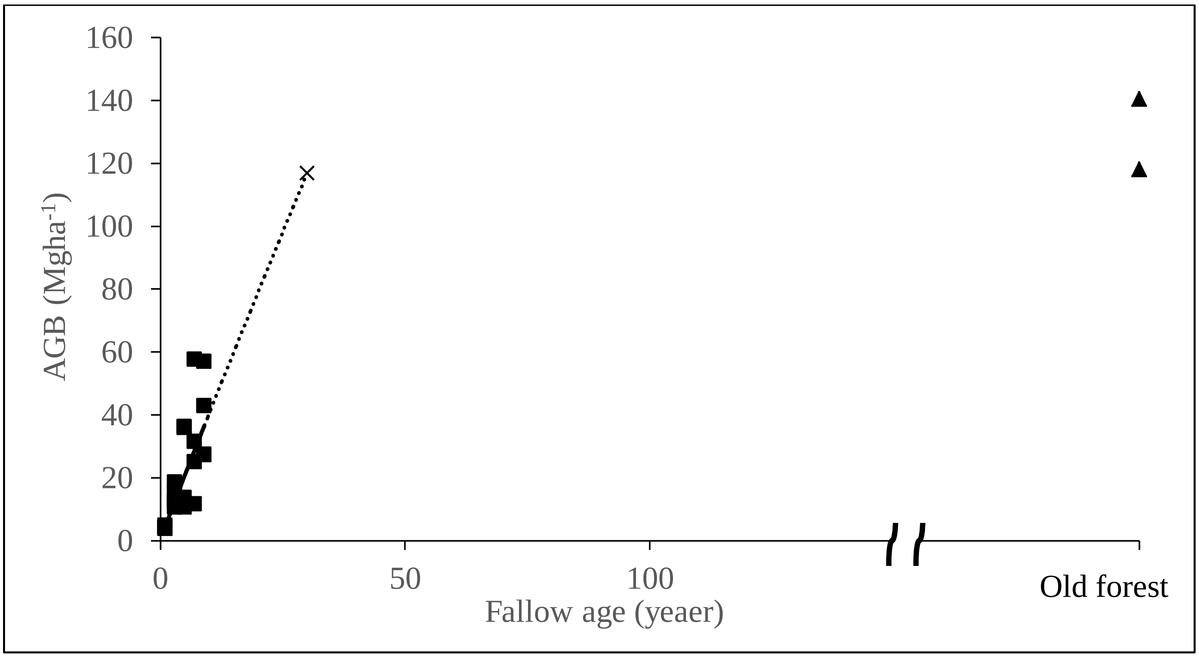


Figure 6. Biomass recovery trends in Village T

Note: Filled square (■) represents the AGB value measured in the fallow forests. Cross (x) represents the estimated value calculated by resulted equations. Filled triangle (▲) represents the AGB value measured in the old conversed forests.
Source: (Chan & Takeda, 2017)

Chan, et al. (2013) reported that average biomass accumulation in swidden-cultivated fallows in the Bago Mountains ranged from 13.91 $Mgha^{-1}$ in 1-year-old fallows to 93.42 $Mgha^{-1}$ in 30-year-old fallows. Similarly, Do, et al. (2010) reported that aboveground biomass ranged from 4.1 $Mgha^{-1}$ in 5-year-old fallows to 108.8 $Mgha^{-1}$ in 26-year-old fallows. Therefore, the analyses of total AGB accumulation in the fallow forests of the studied village identified the estimated range of total AGB accumulation in swidden-cultivated fallows.

**4.4. Fallow land in transition and biomass accumulation potential**

Table 3 showed the area of swidden cultivation zones in Village T over a complete rotation (2003-04 to 2012-13). Of these, the reduction in swiddeners created the increase in the uncut areas in each zone, and consequently increasing fallow forests. Because of the reduction in swidden cultivation and the development of alternative cash-income livelihood activities, the area of swidden cultivation has changed over time. In the analysis, only 350.77 ha (17% of the total swidden-cultivated land) in Village T were currently used for swidden cultivation on a rotational basis (Appendix 1).

Table 3 Swidden area over a complete rotation (2003–04 to 2012–13) in Village T

| Year | Zone | Total area (ha) | Uncut area (ha) |
|---|---|---|---|
| 2003-04 | Phae Khu | 126.13 | 79.15 |
| 2004-05 | Ting Si Mua | 321.48 | 274.50 |
| 2005-06 | Ting Si Lia | 205.44 | 158.46 |
| 2006-07 | Si Ri Tu | 275.49 | 228.51 |
| 2007-08 | Ba Saung Si | 161.81 | 114.83 |
| 2008-09 | Cca Awng Ku | 173.37 | 126.39 |
| 2009-10 | Si Ri | 202.78 | 155.80 |
| 2010-11 | Ma Ma Lein & Si Ri Lo Lan | 255.75 | 208.77 |
| 2011-12 | Si Ri Lan Kaw | 206.18 | 159.20 |
| 2012-13 | Laung Phe Si | 87.21 | 40.23 |

Source: Village land registration record in Village T

With the increasing trend in biomass accumulation by fallow age, the increase in uncut area will lead to increasing biomass accumulation. In this Village T, the analysis indicated that, since 2003–04, 7.6 Gg of biomass (7% of the total AGB accumulation in the swidden-cultivated fallows) had accumulated in the area currently used for swidden cultivation on a rotational basis, and 97.6 Gg of biomass (93%) had accumulated in uncut and/or mature fallows (Appendix 2). Actually, this result produced the minimum accumulation of biomass in the fallow forests. The further biomass accumulation could be expected.

## 5. Conclusion

In this area, local people have out-migrated for better job opportunities, resulting in a decrease in the number of swidden cultivators and consequently in the area of swidden agriculture. The insufficient crop productivity and development of alternative income-sources both outside and inside the villages have contributed to the local dynamics.

The local dynamics led to the increase in area of uncut and/or mature swidden-cultivated fallows, resulting in greater total AGB accumulation in the fallow forests. Following the term "forest transition" by Mather (1992); Rudel, et al. (2005) and Meyfroidt & Lambin (2011), the factors driven at local level could be observed in the study area. As suggested by Lui, et al. (2017), the main pathways observed in this study were smallholder, tree-based use intensification pathway, economic development pathway, state forest policy pathway, and globalization pathway. Therefore, not only deforestation, but also forest transition needs to be taken into account in local forestry planning for better local forest management.

## 6. Acknowledgements

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**References**

Bhagwat, T. et al., 2017. Losing a Jewel – Rapid Declines in Myanmar's Intact Forests From 2002-2014. PLoS ONE, 12(5), pp. 1-22.

Chan, N. & Takeda, S., 2017. The Transition Away From Swidden Agriculture and Trends in Biomass Accumulation in Fallow Forests. Mountain Research and Development, 36(3), pp. 320-331.

Chan, N., Takeda, S., Suzuki, R. & Yamamoto, S., 2013. Establishment of allometric models and estimation of biomass recovery of swidden cultivation fallows in mixed deciduous forests of the Bago Mountains, Myanmar. Forest Ecology and Management, Volume 304, pp. 427-436.

CHRO [Chin Human Rights Organization], 2008. Critical Point: Food Scarcity and Hunger in Burma's Chin State. [Online] Available at: http://www.burmalibrary.org/docs5/ Critical_Point.pdf [Accessed 25 April 2015].

DoP [Department of Population], 2015. The Republic of the Union of Myanmar Population and Housing Census of Myanmar 2014: Provisional Results (Census Report Volume 1), Naypyitaw, Myanmar: Ministry of Immigration and Population.

Do, T., Osawa, A. & Thang, N., 2010. Recovery process of a mountain forest after shifting cultivation in Northwestern Vietnam. Forest Ecology and Management, Volume 259, pp. 1650-1659.

Duckworth, J. et al., 2008. Bos gaurus. In: IUCN red list of threatened species (version 3.1). s.l.:IUCN.

FAO, 2000. World watch list for domestic animal diversity (3rd edition), Rome: Food and Agriculture Organization.

FAO, 2015. Global Forest Resource Assessment 2015, Rome, Italy: UN Food and Agriculture Organization .

Fujikawa, K. et al., 2012. Botanical Expedition to Natma Taung (Mt. Victoria) National Park, Chin State, West-Central Myanmar. Newsletter of Himalayan Botany, Volume 46, pp. 1-12.

He, J., Lang, R. & Xu, J., 2014. Local Dynamics Driving Forest Transition: Insights from Upland Villages in Southwest China. Forests, Volume 5, pp. 214-233.

Kingdon-Ward, F., 1958. A sketch of the flora and vegetation of Mount Victoria in Burma. Acta Horti Gotoburgensis , Volume 22, pp. 53-74.

Lui, J. et al., 2017. Comparative Study of the Forest Transition Pathways of Nine Asia-Pacific Countries. Forest Policy and Economics, Volume 76, pp. 25-34.

Mather, A., 1992. The Forest Transition. Area, pp. 367-379.

Meyfroidt, P. & Lambin, E. F., 2011. Global Forest Transition: Prospects for and End to Deforestation. Annu. Rev. Environ. Resour. , Volume 36, pp. 343-71.

Rudel, T. K. et al., 2005. Forest Transitions: Towards a Global Understanding of Land Use Change. Global Environmental Change, Volume 15, pp. 23-31.

Shisode, M. et al., 2009. Mithun: the pride animal of north-eastern hilly region of India. Veterinary world, 2(12), pp. 480-481.

Souhworth, J., Nagendra, H. & Cassidy, L., 2012. Forest Transition Pathways in Asia -- Studies from Nepal, India, Thailand, and Cambodia. Journal of Land Use Science, 7(1), pp. 51-65.

Takahashi, A., 2007. Swiddens, rice terraces, and Malay connections: Resource use and socio-economic strata in the Chin Hills, Myanmar. Southeast Asian Studies, 45(3), pp. 404-427.

Tanaka, K. et al., 2011. Molecular phylogeny and diversity of Myanmar and Bhutan mithun based on mtDNA sequences. Animal science journal., Volume 82, pp. 52-56.

Thein, S., 2012. Study on the evolution of the farming systems and livelihood dynamics in Northern Chin State, Yangon: Groupe de Recherche et d' Exchanges Technologique (GRET).

UNDP [United Nations Development Programme], 2011. Integrated household living conditions survey in Myanmar: Poverty profile, Yangon: Jointly conducted by Ministry of National Planning and Economic Development and United Nations Development Programme-Myanmar.

UNDP, 2013. A new UNDP for a new Myanmar (annual report 2013), Yangon, Myanmar: UNDP-Myanmar.

Win, T., Lin, K., Aung, P. & Thant, M., 2012. Report on market analysis of agricultural products in southern Chin State, France: Solidarites International.

Appendix 1. Changes in swidden agricultural area over a complete rotation (2003–2004 to 2012–2013) in Village T using maximized utilization approach

| Year | Area (ha) | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-year | 1-year | 2-year | 3-year | 4-year | 5-year | 6-year | 7-year | 8-year | 9-year | 10-year | 11-year | 12-year | 13-year | 14-year | 15-year | 16-year | 17-year | 18-year | 19 |
| 2003-2004 | 46.98 | 87.21 | 206.18 | 255.75 | 202.78 | 173.37 | 161.81 | 275.49 | 205.44 | 321.48 | 79.15 | nd | nd | nd | nd | nd | nd | nd | nd | |
| 2004-2005 | 46.98 | 46.98 | 87.21 | 206.18 | 255.75 | 202.78 | 173.37 | 161.81 | 275.49 | 205.44 | 274.50 | 79.15 | nd | nd | nd | nd | nd | nd | nd | |
| 2005-2006 | 46.98 | 46.98 | 46.98 | 87.21 | 206.18 | 255.75 | 202.78 | 173.37 | 161.81 | 275.49 | 158.46 | 274.50 | 79.15 | nd | nd | nd | nd | nd | nd | |
| 2006-2007 | 41.50 | 46.98 | 46.98 | 46.98 | 87.21 | 206.18 | 255.75 | 202.78 | 173.37 | 161.81 | 233.99 | 158.46 | 274.50 | 79.15 | nd | nd | nd | nd | nd | |
| 2007-2008 | 39.15 | 41.50 | 46.98 | 46.98 | 46.98 | 87.21 | 206.18 | 255.75 | 202.78 | 173.37 | 122.66 | 233.99 | 158.46 | 274.50 | 79.15 | nd | nd | nd | nd | |
| 2008-2009 | 35.23 | 39.15 | 41.50 | 46.98 | 46.98 | 46.98 | 87.21 | 206.18 | 255.75 | 202.78 | 138.14 | 122.66 | 233.99 | 158.46 | 274.50 | 79.15 | nd | nd | nd | |
| 2009-2010 | 23.49 | 35.23 | 39.15 | 41.50 | 46.98 | 46.98 | 46.98 | 87.21 | 206.18 | 255.75 | 179.29 | 138.14 | 122.66 | 233.99 | 158.46 | 274.50 | 79.15 | nd | nd | |
| 2010-2011 | 23.49 | 23.49 | 35.23 | 39.15 | 41.50 | 46.98 | 46.98 | 46.98 | 87.21 | 206.18 | 232.26 | 179.29 | 138.14 | 122.66 | 233.99 | 158.46 | 274.50 | 79.15 | nd | |
| 2011-2012 | 23.49 | 23.49 | 23.49 | 35.23 | 39.15 | 41.50 | 46.98 | 46.98 | 46.98 | 87.21 | 182.69 | 232.26 | 179.29 | 138.14 | 122.66 | 233.99 | 158.46 | 274.50 | 79.15 | |
| 2012-2013 | 23.49 | 23.49 | 23.49 | 23.49 | 35.23 | 39.15 | 41.50 | 46.98 | 46.98 | 46.98 | 63.72 | 182.69 | 232.26 | 179.29 | 138.14 | 122.66 | 233.99 | 158.46 | 274.50 | 7 |
| Total | 350.77 (Currently cultivated area) | | | | | | | | | | 1664.87 (Abandoned area since 2003-2004) | | | | | | | | | |

nd – no data

Appendix 2. Biomass accumulation in swidden cultivated fallows over a complete rotation (2003-2004 to 2012-2013) in Village T using maximized utilization approach

| Year | Above-ground biomass (Gg) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-year | 2-year | 3-year | 4-year | 5-year | 6-year | 7-year | 8-year | 9-year | 10-year | 11-year | 12-year | 13-year | 14-year | 15-year | 16-year | 17-year | 18-year | 19-year |
| 2003-2004 | 0.38 | 1.77 | 3.24 | 3.39 | 3.60 | 4.00 | 7.91 | 6.71 | 11.77 | 3.21 | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 2004-2005 | 0.21 | 0.75 | 2.61 | 4.28 | 4.21 | 4.29 | 4.65 | 9.00 | 7.52 | 11.12 | 3.52 | nd | nd | nd | nd | nd | nd | nd | nd |
| 2005-2006 | 0.21 | 0.40 | 1.11 | 3.45 | 5.31 | 5.02 | 4.98 | 5.29 | 10.08 | 6.42 | 12.19 | 3.82 | nd | nd | nd | nd | nd | nd | nd |
| 2006-2007 | 0.21 | 0.40 | 0.60 | 1.46 | 4.28 | 6.33 | 5.82 | 5.66 | 5.92 | 9.48 | 7.04 | 13.26 | 4.13 | nd | nd | nd | nd | nd | nd |
| 2007-2008 | 0.18 | 0.40 | 0.60 | 0.79 | 1.81 | 5.10 | 7.35 | 6.62 | 6.35 | 4.97 | 10.39 | 7.66 | 14.33 | 4.44 | nd | nd | nd | nd | nd |
| 2008-2009 | 0.17 | 0.33 | 0.60 | 0.79 | 0.98 | 2.16 | 5.92 | 8.36 | 7.42 | 5.60 | 5.45 | 11.31 | 8.27 | 15.39 | 4.74 | nd | nd | nd | nd |
| 2009-2010 | 0.15 | 0.33 | 0.53 | 0.79 | 0.98 | 1.16 | 2.50 | 6.74 | 9.36 | 7.26 | 6.14 | 5.93 | 12.21 | 8.88 | 16.45 | 5.05 | nd | nd | nd |
| 2010-2011 | 0.10 | 0.30 | 0.50 | 0.69 | 0.98 | 1.16 | 1.35 | 2.85 | 7.55 | 9.41 | 7.96 | 6.67 | 6.40 | 13.12 | 9.50 | 17.51 | 5.35 | nd | nd |
| 2011-2012 | 0.10 | 0.20 | 0.45 | 0.66 | 0.86 | 1.16 | 1.35 | 1.53 | 3.19 | 7.40 | 10.32 | 8.66 | 7.21 | 6.88 | 14.02 | 10.11 | 18.56 | 5.66 | nd |
| 2012-2013 | 0.10 | 0.20 | 0.30 | 0.59 | 0.81 | 1.03 | 1.35 | 1.53 | 1.72 | 2.58 | 8.12 | 11.22 | 9.36 | 7.74 | 7.35 | 14.92 | 10.71 | 19.61 | 5.96 |
| Total | 7.64 (AGB accumulated in currently cultivated fallows over a complete rotation) | | | | | | | | | 97.58 (AGB accumulated in uncut area since 2003-2004) | | | | | | | | | |

nd – no data