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# Agroforestry Contribution to Local Livelihood and Climate Change Mitigation and Adaptation in Southern Shan State and Bago Region

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**Abstract**

Agroforestry, one of the nature-based solutions, is a sustainable landuse management system in which trees, crops and livestock are cultivated together in a land to secure the best profit. We all accepted that agroforestry can contribute to the livelihood development of local community as well as the climate change mitigation and adaptation. But it is still necessary to explore how much it can contribute to a specific region. Therefore, this study learnt about the contribution of agroforestry to the livelihood and climate change mitigation and adaption in southern Shan State and Bago Region of Myanmar. Based on the results, agroforestry in Shan State and Bago Region contributed the livelihood of local community, showing a percentage of 10 to 56 percent of the total coverage of the livelihood identity. Most of the systems found in those regions are two to four stories agroforestry structures expressing five different types. Its contribution to the climate change mitigation is significantly seen in the regions, 10 to 300 tons of carbon. Likewise, the adaptability to the climate change is clearly found in the regions showing the value and components of commodities mixtures. In summary, agroforestry in Shan State and Bago Region showed a significant method of nature-based solutions and is relevant to establish by systematic management approach.

**Key words:** Agroforestry structure, carbon, landuse management, local community, nature-based solutions

# လူမှုဘဝဖွံ့ဖြိုးရေး၊ ရာသီဥတုပြောင်းလဲမှု လျှော့ချရေးနှင့် လိုက်လျောညီထွေဖြစ်စေရေး အတွက် သီးနှံသစ်တောရောနှောစိုက်ပျိုးမှု၏ အကျိုးသက်ရောက်မှုကို လေ့လာခြင်း (ရှမ်းပြည်နယ် (တောင်ပိုင်း) နှင့် ပဲခူးတိုင်းဒေသကြီး)

ဒေါက်တာအင်ကြင်းခိုင်၊ လက်ထောက်ညွှန်ကြားရေးမှူး
ဒေါ်စန္ဒာချစ်ကြည်၊ တာဇုပ်ကြီး

## စာတမ်းအကျဉ်းချုပ်

သီးနှံသစ်တောရောနှောစိုက်ပျိုးခြင်းသည် သစ်တောစီမံအုပ်ချုပ်ခြင်းနှင့် မြေယာ စနစ်တကျ စီမံခန့်ခွဲမှုစနစ် ဖြစ်မြောက်စေဖို့အတွက် ဆောင်ရွက်သည့် သဘာဝကို အခြေခံသည့် ဖြေရှင်းခြင်း နည်းလမ်းတစ်မျိုး ဖြစ်ပါသည်။ သစ်တောသစ်ပင်၊ ရာသီသီးနှံများ စိုက်ပျိုးခြင်းနှင့် တိရစ္ဆာန်များကို မွေးမြူခြင်းလုပ်ငန်းများကို တစ်ပြိုင်တည်း၊ တစ်နေရာ တည်းတွင် အသုံးချဆောင်ရွက်နိုင်သည့် နည်းလမ်းတစ်မျိုးဖြစ်ပါသည်။ သီးနှံသစ်တော ရောနှော စိုက်ပျိုးခြင်းသည် ရာသီဥတုပြောင်းလဲမှု လျှော့ချရေးနှင့် လိုက်လျောညီထွေ ဖြစ်စေရေးအပါအဝင် ဒေသခံများ၏ လူမှုဘဝဖွံ့ဖြိုးမှုကို အထောက်အပံ့ပေးသည်ကို လက်ခံကြပြီး ဖြစ်ပါသည်။ သို့ရာတွင် နေရာဒေသအလိုက် ဖြစ်ထွန်းမှု၊ ကိုက်ညီမှုနှင့် ထောက်ပံ့ပေးနိုင်သည့် ပမာဏ တို့ကို သိရှိရန် လိုအပ်လှပါသည်။ ယခုလေ့လာမှုတွင် ရှမ်းပြည်နယ်နှင့် ပဲခူးတိုင်းဒေသကြီးအတွင်း တည်ထောင်ထားရှိသည့် သီးနှံသစ်တော စိုက်ပျိုးမှု၏ အကျိုးသက်ရောက်မှုများကို ဖော်ထုတ်ထားပါသည်။ တွေ့ရှိမှုများအရ သီးနှံ သစ်တောရောနှောစိုက်ပျိုးခြင်းလုပ်ငန်းသည် ဒေသခံပြည်သူများ၏ လူမှုဘဝအတွက် ၁၀ ရာခိုင်နှုန်းမှ ၅၆ ရာခိုင်နှုန်းအထိ ဖြည့်စွမ်းပေးနိုင် ကြောင်း တွေ့ရှိရပါသည်။ အချို့တွင် ၉၀-၁၀၀ ရာခိုင်နှုန်းအထိ မှီခိုနေထိုင်ကြသည်ကို တွေ့ရှိရပါသည်။ အလွှာ ၂ လွှာ မှ ၄ လွှာ အထိ စိုက်ပျိုးကြပြီး ကာဗွန်ကို ၁၀ မှ ၃၀၀ တန်အထိ သိုလှောင်နိုင်စွမ်းရှိသည်ကို တွေ့ရှိရပါသည်။ ရာသီဥတုပြောင်းလဲမှုဒဏ်ကို ခံနိုင်စွမ်းရှိသည် ကိုလည်း တွေ့ရှိရပါသည်။ အချုပ်အားဖြင့် ဆိုရလျှင် လေ့လာခဲ့သည့်ဒေသများတွင် သီးနှံသစ်တောရောနှောစိုက်ပျိုးခြင်းသည် သင့်လျော်သည့် နည်းစနစ်တစ်ခုဖြစ်ပြီး စနစ်တကျ လုပ်ကိုင်မည် ဆိုပါက အောင်မြင်သော သဘာဝကို အခြေခံသည့် ဖြေရှင်းခြင်း နည်းလမ်း တစ်မျိုး ဖြစ်ပါကြောင်း ဖော်ပြအပ်ပါသည်။

**အထူးပြုစကားရပ်များ:** သီးနှံသစ်တောရောနှောစိုက်ပျိုးခြင်း ပုံစံအလွှာ၊ ကာဗွန်၊ မြေယာ စီမံအုပ်ချုပ်မှု၊ ဒေသခံပြည်သူ၊ သဘာဝကို အခြေခံသည့် ဖြေရှင်းခြင်း နည်းလမ်း

# Agroforestry Contribution to Local Livelihood and Climate Change Mitigation and Adaptation in Southern Shan State and Bago Region

## 1. Introduction

Climate change has been happening and persisting for an extended period of a decade or longer all over the world. Climate change threatens to derail the lives and livelihoods of farmers/cultivators all over the world (more so those in developing countries) if appropriate adaptation measures are not put in place (Khaine and Woo 2015; IPCC 2014; Bryan et al. 2013). In developing countries, local cultivators are at risk because of inherent socio-economic characteristic and environmental factors limiting their capacity to adapt the climate change (Verchot et al. 2007).

Agroforestry, one of the nature-based solutions, is a sustainable landuse management system in which trees, crops and livestock are cultivated together in a land to secure the best profit. We all accepted that agroforestry can contribute to the livelihood development of local community as well as the climate change mitigation and adaptation. Agroforestry can make a substantial contribution to the climate change adaption and the livelihood of local people (Dawson et al. 2012; Nair 2011). Different types of agroforestry systems can provide a wide range of environmental, social and economic benefits to us (FAO). It supports climate-smart production system and gives more productive than mono-cropping system (Charles et.al, 2014; Ogle et al. 2014).

FAO highlighted that trees are a key component in the concept of climate smart agriculture. Permanent tree cover also protects and improves the soil while increasing the carbon stocks and giving income. The various ecological niches allow the presence of different varieties of crops (shade-tolerant, light-demanding, etc). On the other hand, it could give various income sources in all year round by planting/cultivating different varieties of crops in different seasons with permanent tree species.

Therefore, agroforestry could not only enhance the sustainable production, resource management system and sustainable forest management but also increase resilience to climate change, natural disasters and other shocks (Garrity et al. 2010; Khaine and Woo 2018; Nair et al. 2009). In recent years, research studies on agroforestry have been emphasizing in developing countries. Sharing the information on agroforestry systems in different focused areas has been very essential in the agroforestry development because of its roles in climate change mitigation and adaptation and the importance of the right selection of trees and crops in combination. But it is still necessary to explore how much it can contribute to a specific region. For this, most of the studies has been highlighting on the exploration of the structure of agroforestry system and learnt about the contribution of agroforestry to the livelihood and climate change mitigation and adaption in the southern Shan State and Bago Region of Myanmar.

The research questions of the study are as follow:

(1) What are the agroforestry systems distributed in this region?
(2) How much intensity the agroforestry can contribute to the local livelihood?
(3) What extent the agroforestry can contribute to the climate change mitigation and adaptation?

## 2. Objectives

Based on the research questions, the objectives of this research are set as follow:

(1) To investigate the structure of agroforestry system in the study areas,

(2) To explore the contribution of agroforestry to local livelihood in terms of subsistence needs and economic support, and

(3) To examine the role of agroforestry in climate change mitigation and adaptation.

## 3. Materials and Methods

The study site will be selected in Ywar Ngan Township, Taung-gyi Township and Hopone Tawnship in Taung-gyi District of southern Shan State and Paukkhaung Township in Pyay District of Bago Region, Myanmar (Figure 1).

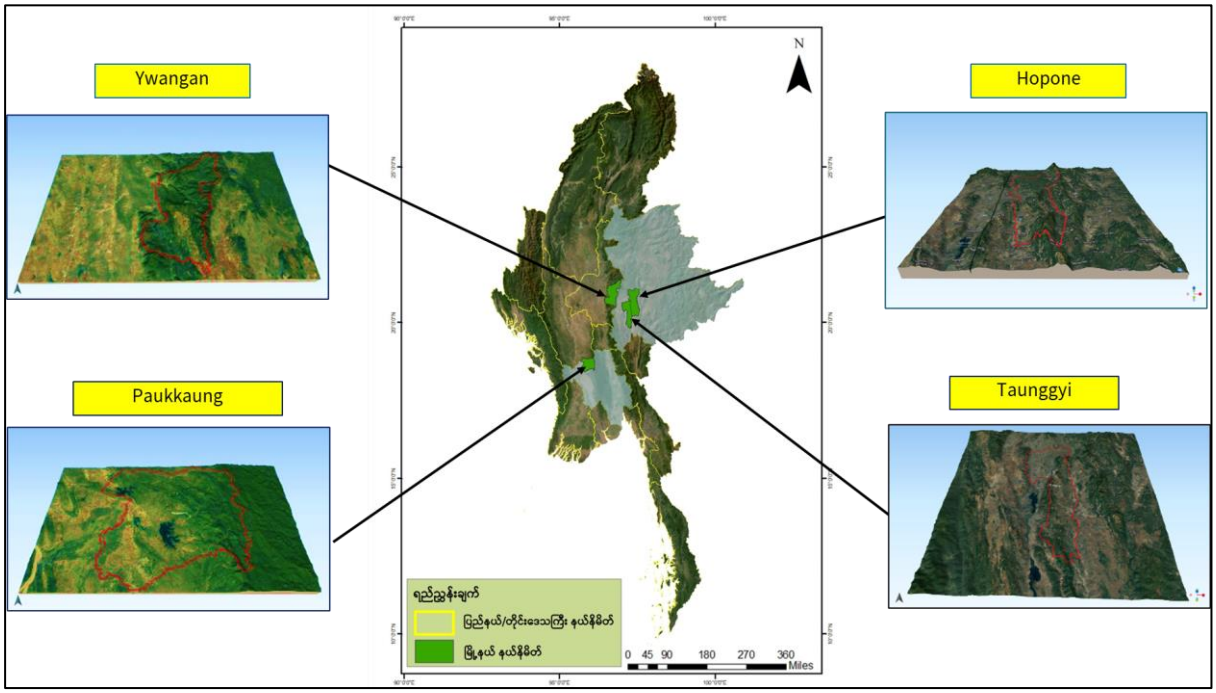


Figure.1: Location Map of the Study Area

The area in southern Shan State is located between the north latitude of 20˚ 15' to 20˚67' N and east longitude of 96˚ 49' to 97˚ 00' E. The area covers 2,982 km$^2$. The altitude of the project site is 1244 m. The humid subtropical climate is found in this region. The average annual temperature is 20.3°C and average annual rainfall is 1,758 mm. The minimum temperature occurs in December around 13˚ to 24˚C while maximum temperature occurs during April within a range of 21˚ to 32˚C.

The humidity ranges from less than 40% in March to 90% in August. In summer, the prevailing winds are southwesterly warm tropical winds, originating from the Bay of Bengal. The Rainy Season occurs during the period from April to November, with maximum rainfall occurring from August to September.

The main occupation is cultivation and most of the local people are relying on the agriculture and forests for their livelihoods. The avocado, coffee, green tea, orange, cabbage, cauliflower, tomato, potato are commonly cultivated in this area. There is no doubt that the local community living in that area has been suffering the impact and climate change and some agroforestry systems have been introduced several years ago.

Paukkhaung Township in Bago Region is located at the average elevation of (241.06) feet above the sea level. It has hot and humid climate with a maximum temperature of 34.25°C and a minimum temperature of 26°C. Rainfall ranges from 45.94 inches to 50.76 inches from 2016 to 2019.

The topography of Paukkhaung township is mountainous in the eastern part where North Nawin, Central Nawin, South Nawin reserved forests are located. About three miles in the west of the town, a small mountain ridge named Taung-Zin-Wa, is running south to north. There has many small hills and SharPyin reserved forest in the south. There are many small hills and Oo-Lal-Swe, Chaung-sauk and Kyat-khon reserved forests in the north. The whole township has little flat land area and mostly hills, mountains and mountain ridges.

Paukkhaung Township is the region with few rivers flowing from north to south. The most prominent rivers are North Nawin river and South Nawin River, which used to flow into the Irrewaddy river near Pyay Township and now into the South Nawin reservoir. Most of water resources in township are fresh water and useful for drinking and agriculture.

The first draft questionnaire was prepared for the assessment of the structure of agroforestry. The preliminary survey was conducted in October and November covering different targeted scopes and the ground situation through consultation with locals and discovering the places. The secondary data was collected during the preliminary survey. Then, a draft questionnaire was revised to be in line with the local condition. The samples were selected and stratified based on the different types of cultivation.

Face to face with semi-structural interview and focused group discussion was conducted in the study area. Based on the field visits and survey, the structure and composition of agroforestry system was explored. The number of respondents for face to face interview is fifty, covering the sample size greater than 10 percent of a population. Focus group discussing is a good way to gather together the people from similar background to discuss a specific topic of interest. We used the focus group discussion method including all stakeholders to get in-depth understanding of the findings relating to the background, the historical changes to adapt climate change and the contribution of agroforestry to livelihood development. For the focus group discussion, a total of twenty respondents were participated. Classification of the structure was done based on the primary function and strata differentiation. The relations of the variables have been done using SPSS software.

## 4. Results and Discussions

The results showed a great useful and contribution of agroforestry practices to climate change adaptation and livelihood development was clearly found in the survey area in this study area. Although the structure and components were different among the conducted

agroforestry practices, their changes of adaptation to climate change were obviously occurred in terms of protection, production and economic value in comparison with simple crop cultivation. Under this study, we focused on five portions as agroforestry practices implementing in that area, agroforestry structure and composition, agroforestry components and interaction, historical change of the pattern, gender consideration and perspective, and contribution to livelihood development.

### 4.1 Agroforestry practices

Agroforestry has been well-defined in various ways. Food and Agricultural Organization of the United Nations (FAO) defines it as "the collective term for land-use systems and technologies in which woody perennials (e.g. trees, shrubs, palms or bamboos) and agricultural crops or animals are used deliberately on the same parcel of land in some form of spatial and temporal arrangement". Likewise, the World Agroforestry Center and FAO also express as "a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels". Although there are several other definitions to demonstrate/manifest the agroforestry practices, the major concept of agroforestry stems from the expectation of on farm and off farm production in consideration with both environmental and economic aspects leading to sustainable land use management and adaptability to climate change as well (Khaine and Woo 2018; Nair et al. 2008; Nair et al. 2009).

In the study area, about 95 percent of the community is mainly depending on agriculture production for their economy. But some villages are obviously change to agroforestry practices as their traditional ways while others are still doing on mono crop cultivation. Those people on mono crop cultivation faced the negative impact of climate change more significantly because of no alternative options from other fruits and trees. Under the three main classifications of agroforestry systems, namely, Agrisilvicultural, Silvopastoral and Agrosylvopastoral systems, the common agroforestry practices in the survey area is under the category of Agrisilvicultural system. A variety of crops and trees as well as fruit trees are mixed in the cultivation land. The land area of agroforestry in each household ranged from 1 to 4 acres.

### 4.2 Agroforestry structure and composition

Different types of agroforestry structure were found in this region ranging from two to three strata to four strata (including homegardens). Some have the same layer but different spacing among tree components. Two stories structure and homegarden types are the major occurrence in this area. There are 5 types of agroforestry observed in this area. The first one is a 3-story type with a mixture of silk oak/ silver oak tree in an alternative position with avocado tree in the top canopy; orange tree (Citrus species)

in the middle layer and bottom layer is composed of agricultural crops such as sesame, cabbage, cauliflower and groundnut. Some agricultural crops like Indian leek, roselle, chilli, Indian saffron, pea, etc. are planted for their subsidiary uses. The spacing of the canopy layer was 18ft x 18ft and that in the middle layer was 7.5ft x 7.5ft. The agroforestry structure and composition is shaped as the following figure (Figure 2). This type was generally found in Southern Shan State. The 3- story structure was very rarely occurred in Bago Region composing Teak (*Tectona grandis* Linn.f) in the top layer; Guava/Lime in the middle layer and agricultural crops like rice, sesame, etc in the lower layer.

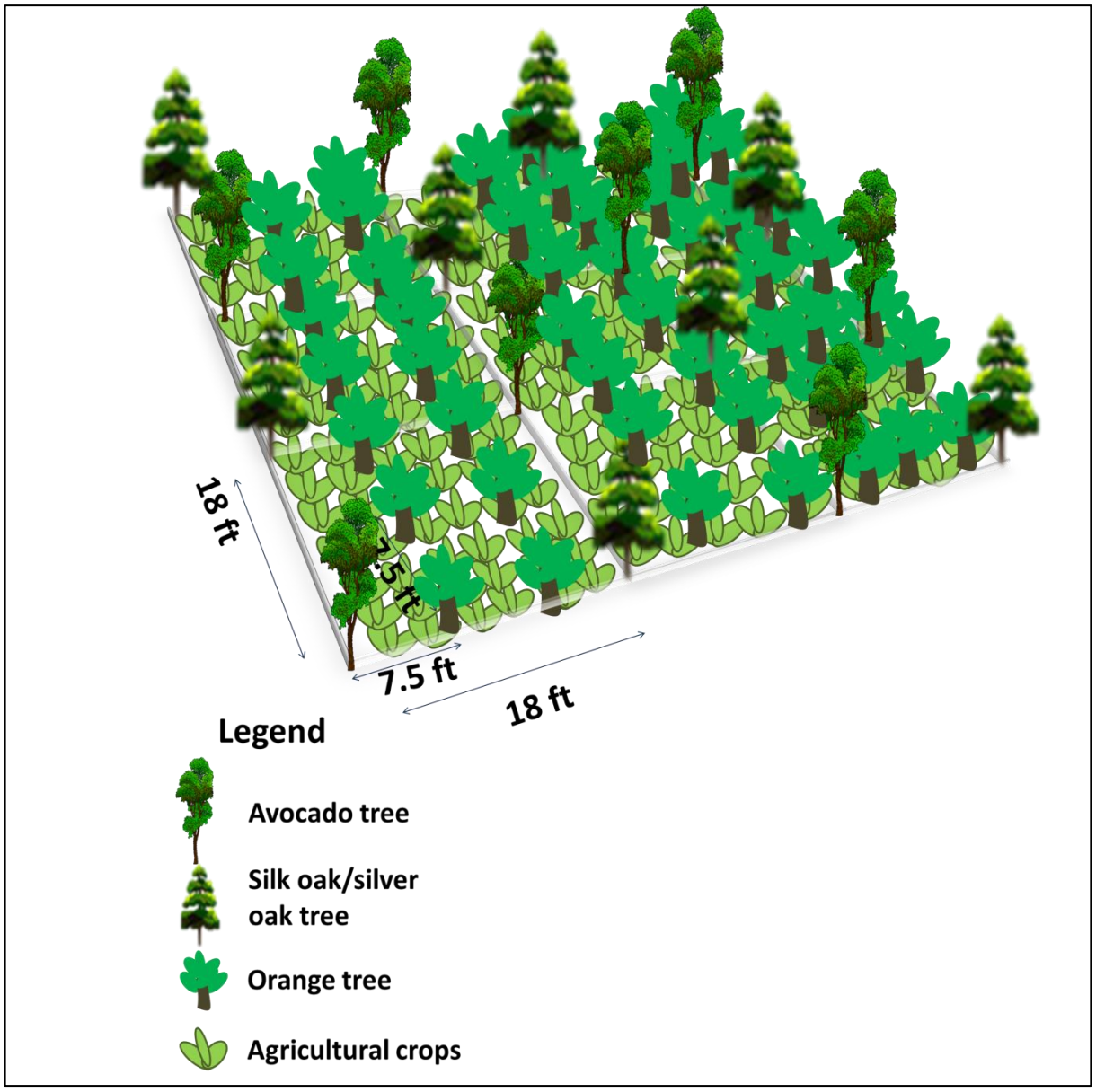


Figure 2. The type-1 agroforestry structure

The second one is a 3-story type with a mixture of silk oak/ silver oak tree and avocado trees line by line in the top canopy; green tea tree or coffee tree planted in the middle layer and sesame is mainly cultivated in the bottom layer. Similar with the first

type, some agricultural crops like Indian leek, roselle, chilli, Indian saffron, pea, etc. are planted for their daily usage in a very small portion of the cultivated area. The spacing of the canopy layer was 24ft x 24ft and that in the middle layer was 10ft x 10ft. The agroforestry structure and composition is shaped as the following figure (Figure 3). This type was occurred in the Southern Shan State.

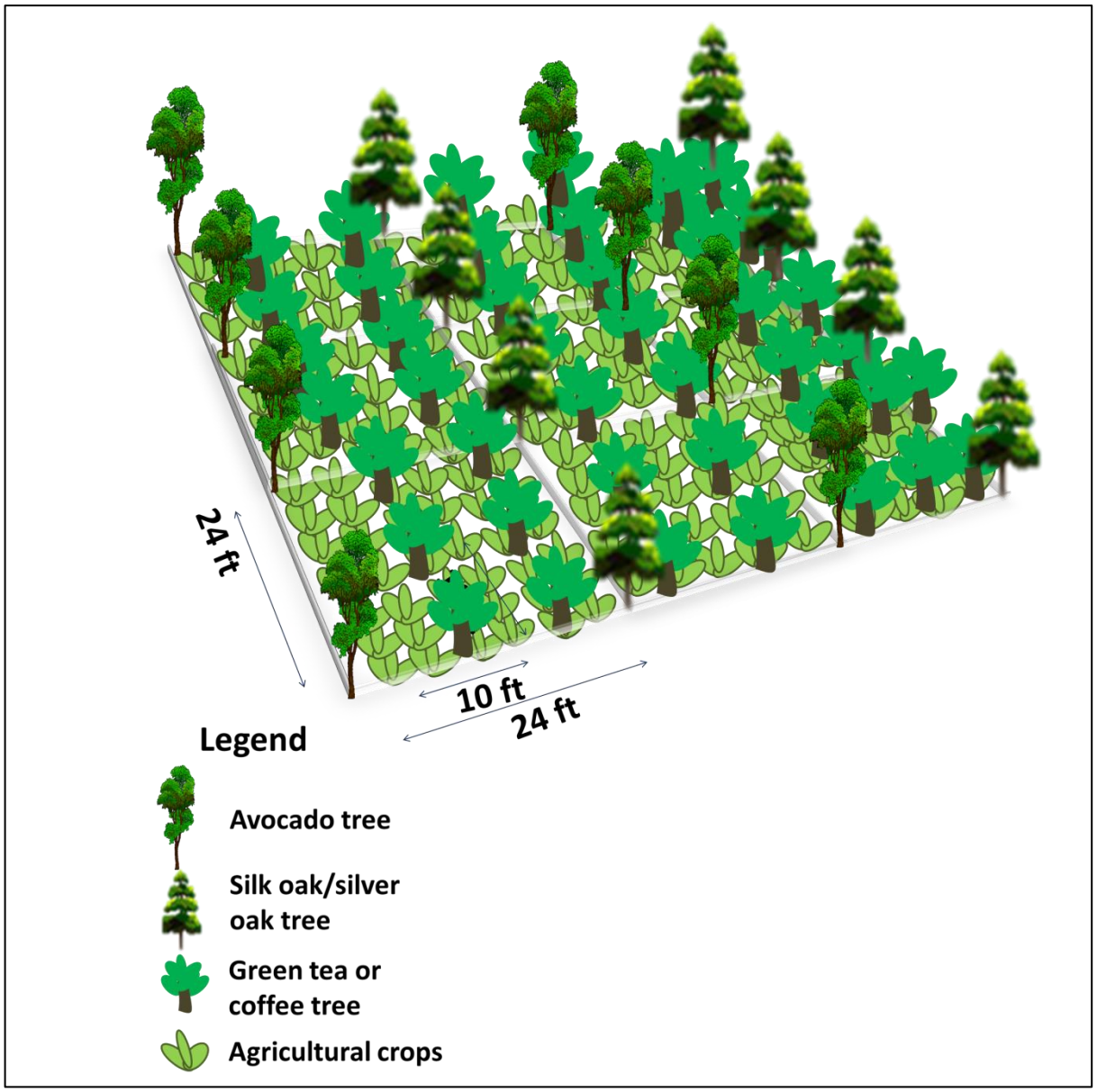


Figure 3. The type-2 agroforestry structure

The third type of structure is a 3-story type in which the top canopy is composed of silk oak/ silver oak tree with a spacing of 30ft x 30ft and avocado trees with a spacing of 18ft x 18ft, setting separate lines of those two species. In the middle layer, green tea trees are planted with a spacing of 4ft x 2ft. In some place, green tea trees are planted with a spacing of 4ft x 4ft. Sesame and dancing ladies ginger are mainly cultivated in the bottom layer. The agroforestry structure and composition is shown in Figure 4. It was occurred in the Shan State.

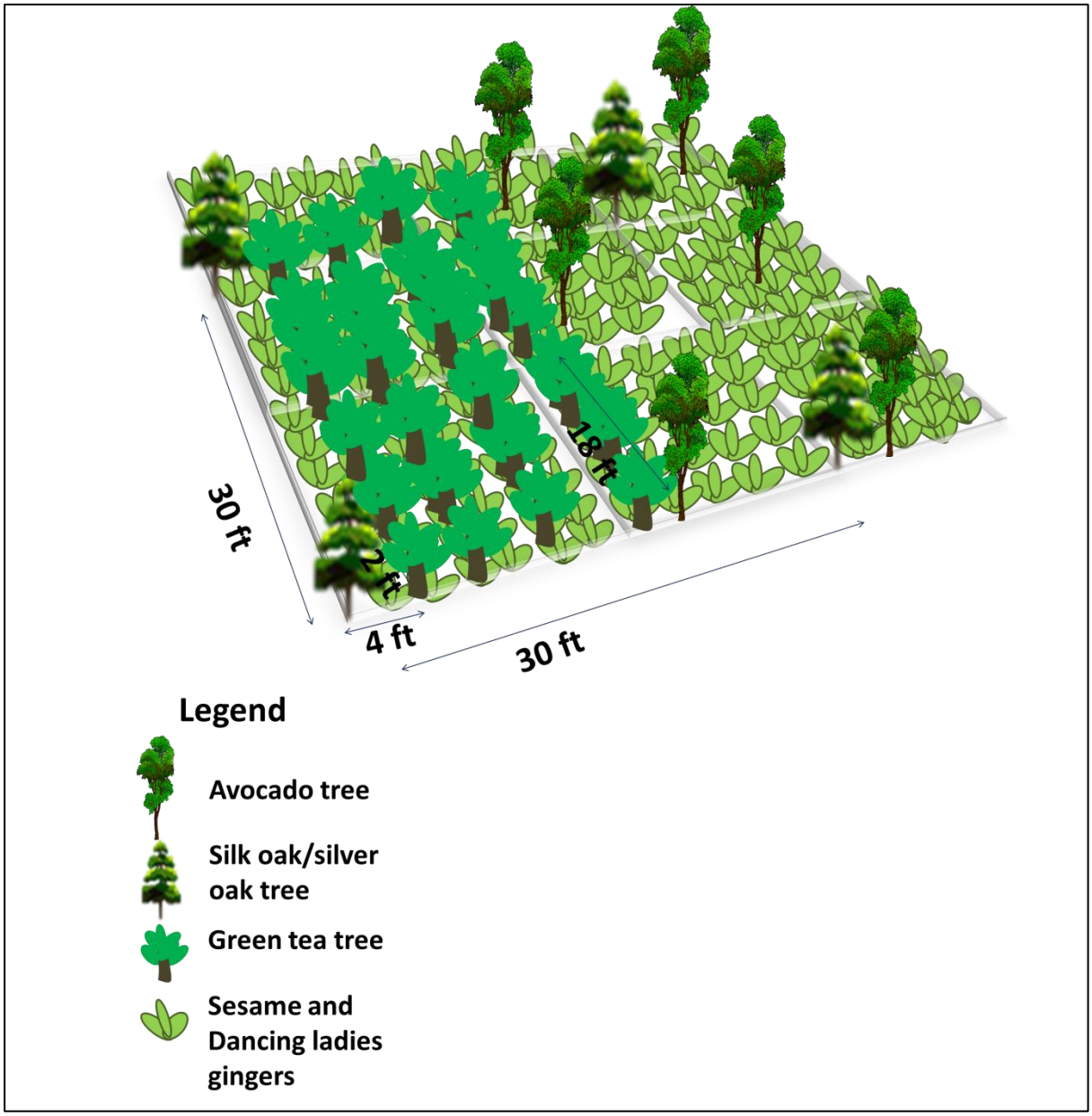


Figure 4. The type-3 agroforestry structure

Another type of structure is a 2-story type in which the top canopy is a mixture of silk oak/ silver oak trees and avocado trees with wide spacing (30ft x 30ft). The composition of avocado trees is more outweigh than that of silk oak/ silver oak trees. A mixture of silk oak/ silver oak and avocado does not follow any systematic rotations. Sesame and dancing ladies ginger are mainly cultivated in the bottom layer.

Similarly, there are plantations with 2-story type where the top canopy is composed of green tea tree by 4ft x 4ft spacing and the understory is with dancing ladies gingers. Those types of plantation are mainly targeted for the production of dancing ladies gingers. There are also plantations with trees planted in the boundary of the area with the aim for not only windbreak but also for productive value from the cultivated land without reducing any area for tree in the cultivated land. The understory crops are

sesame or dancing ladies gingers in that plantation. Figure 5 shows the type and composition of agroforestry type-4 in the study area. This type was occurred in the Southern Shan State.

The 2-story type are also widely occurred in Bago Region. In this type, Teak trees are planted in the top canopy by (9ft x 9ft) spacing and annual or seasonal crops like rice, sesame and peanut are planted in the lower layer. Another 2-story type in which Teak/Eucalyptus/Mango/Jackfruit trees are planted in the boundary line as a wind break and fuelwood and annual or seasonal crops like rice, sesame and peanut are planted in the inside area.

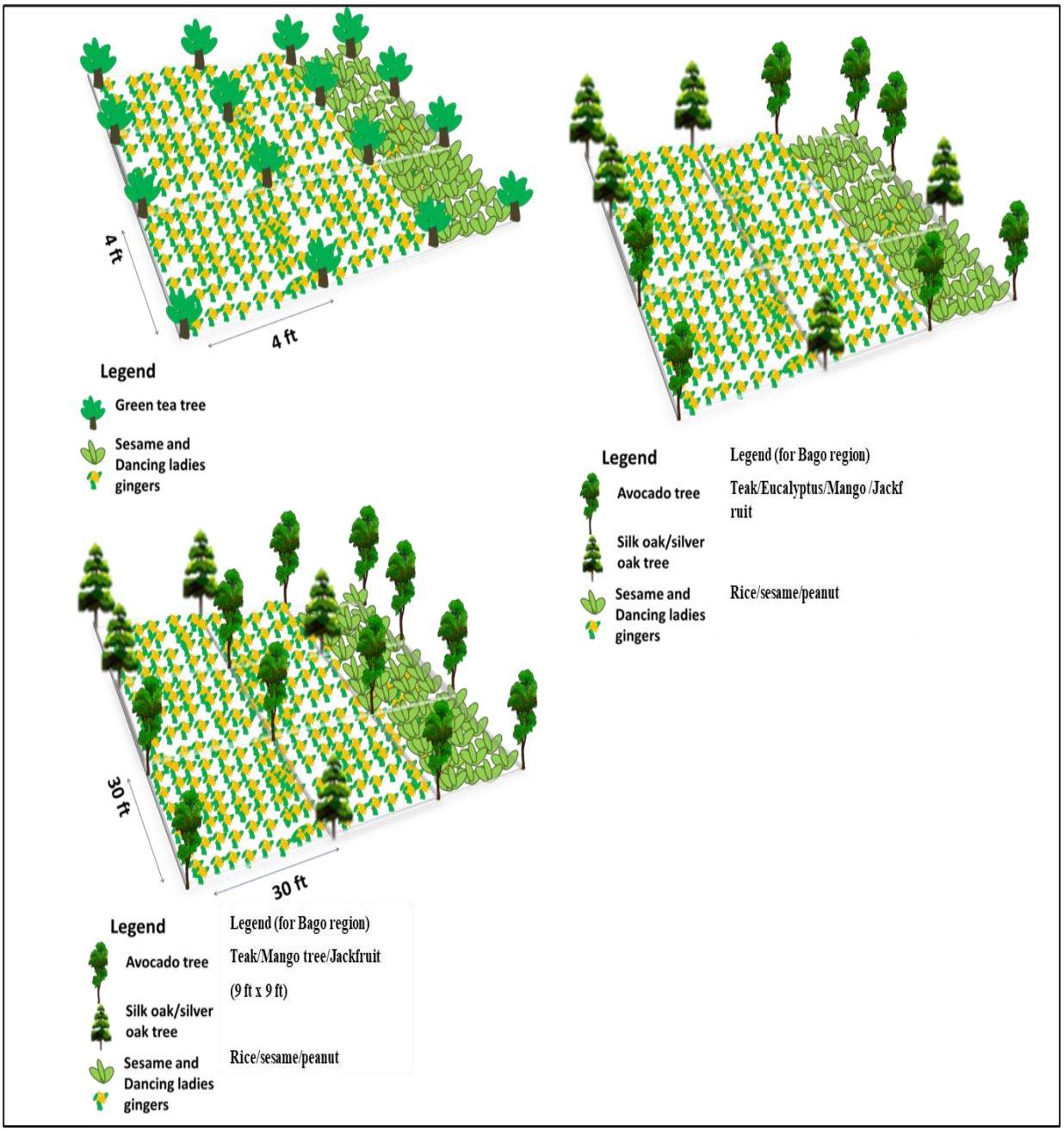


Figure 5. The type-4 agroforestry structure

The other type is homegarden having four stories with the main target of avocado, dancing ladies gingers, coffee and green tea, and other vegetables and fruit trees are planted for their subsistence uses. For overstory tree species, the common occurrence is avocado trees with a very small composition of djankol bean. Under this, banana tree, Guava plants are mainly occurred. Then, coffee tree, green tea tree are largely covered in the homgarden with a small composition of orange and lime plants. In the homegarden, dancing ladies gingers widely cultivated in the underground layer in many places for the economic purposes. It was mostly found in the Southern Shan State.

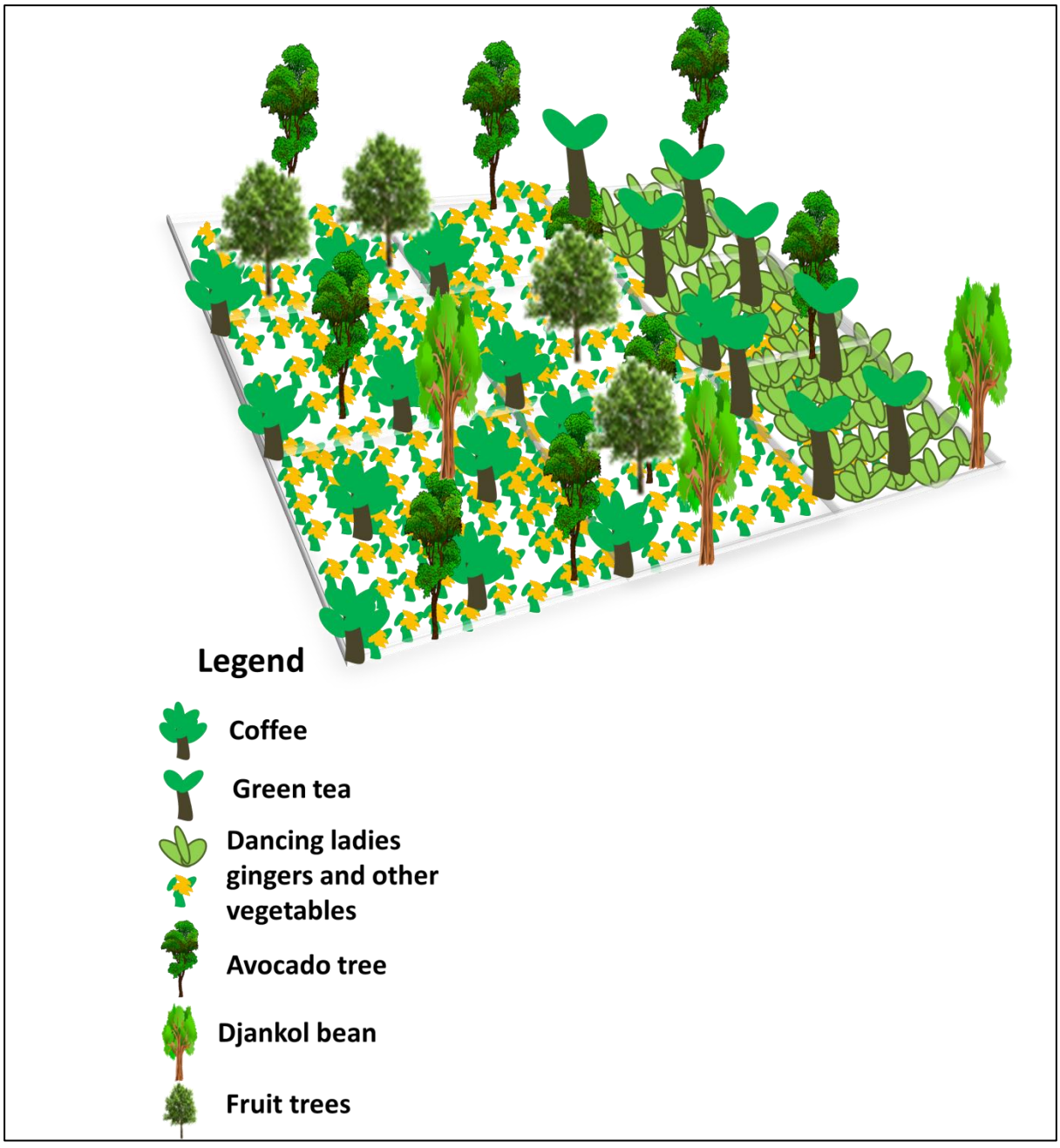


Figure 6. The type-5 agroforestry structure

Other vegetables such as guard, water cress, sweet potato, tomato, leek, eggplant, etc. are also planted in the homegarden for their own use and subsidiary needs. The major productions from the homegarden are avocado, coffee, green tea and dancing ladies gingers. Figure 5 shows an example of homegarden in Southern Shan State. Homegarden is not widely found in the Bago Region but it was found in a small portion in the backyard of the house for their subsistence needs.

### 4.3 Agroforestry components and interaction

Different types of agroforestry structures have different components and arrangement in the selected area. The component and structure will vary depending on the main target they set. Even three-story type varies the proportion and component of tree species. But the same thing is that avocado, silk oak/silver oak, eak trees are used as a top story in those areas.

When the farmers have the target more outweigh on the production of the middle and top story in their long term management, they choose more closed spacing in comparison with those outweigh on agricultural production. Reciprocally, when those farmers are more outweigh on the production of agricultural crops than the tree species, they considered very wide spacing of trees or boundary planting. Regarding agricultural crops, groundnut and cauliflower/cabbage are planted alternatively in different seasons. Groundnuts are cultivated in May and harvested in August, while cauliflowers/cabbages are cultivated in August and harvested in October. Sesame is cultivated in July and harvested in December. In general, silk oak/ silver oak is mainly aim for wind protection and soil fertility improvement from their leaves. Teak is for production purposes in the Bago Region. In some agroforestry plantations, the middle layer species are changed in some periods with the market demand. In case of livestock holding, almost every household possess chicken ranging from 10 to 25 chickens.

### 4.4 Historical change of the pattern for the adaptation of climate change and market flatuation

The results from the focused group discussions indicated that the avocado trees were planted 30 years ago in Shan State. But at that time, only small villagers were interested in planting avocado trees in large numbers in their yards and cultivated lands. Not so much interested by the villagers in establishing agroforestry were found at those previous periods. The local people are interested and implemented the agroforestry system, especially in homegarden, through planting avocado trees by seedlings or grafting method, green tea, coffee and sebesten plants since the last decade. Since then, the environmental and economic out-turn has been significantly seen by the local

community and this could be a great incentive and initiative for the enhancement of community forestry through developing agroforestry practices.

In the study area of Bago Region, teak has been planted few decades ago since shifting cultivation system was started 1856. Growing rice, sesame, groundnut, green mung bean etc. are planted seasonally in the year round. Although a slightly changes of species per area due to the demand of market condition was found, a different change of species was not found in the Bago Region. Until the present, the same system was occurred in the study area of Bago Region. The figure highlights the historical changes of the agricultural crops cultivation in the Southern Shan State.

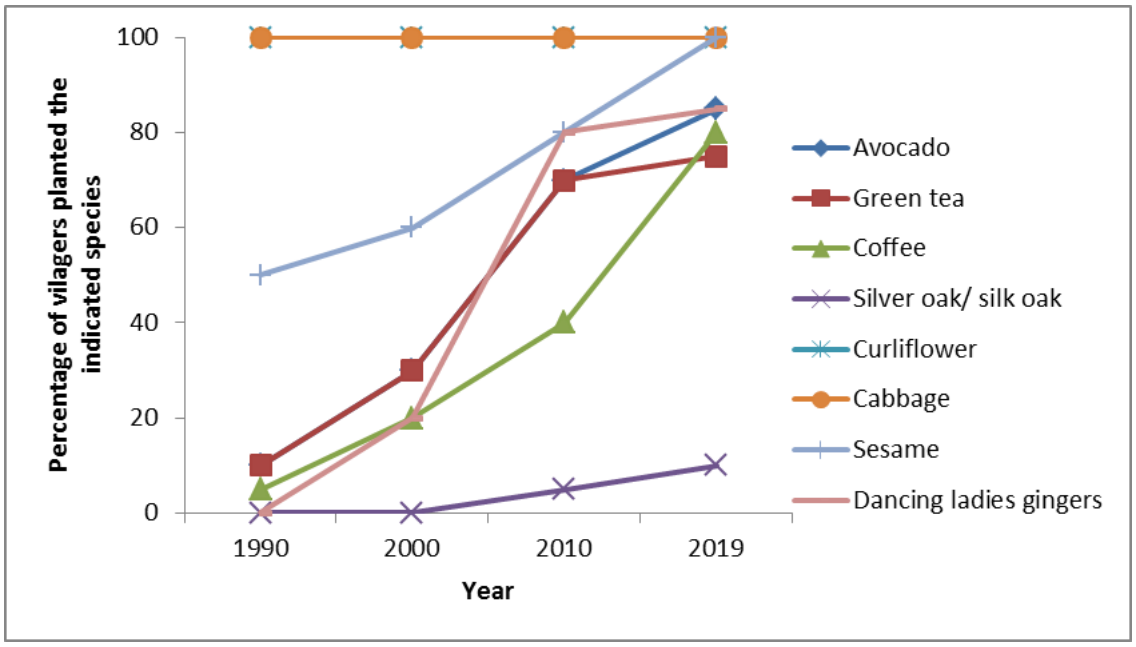


Figure 7. The percentage of villagers planted different plants in agroforestry systems in the study area in Southern Shan State.

In the present in Southern Shan State, avocado, green tea and coffee are very popular in production in that area and there have also a market demand for those species whereas the sebesten production has been reduced and market demand is insignificant. The djenkol beans are planted in a small amount. In the study area in Shan State, rice, potato, sesame and cabbage are seasonally planted in a cultivation land through the past centuries. Since the trend is changing into agroforestry practices, and now sesame, cabbage and cauliflower are currently planting in agroforestry with massive amount. Dancing ladies' gingers are planted in wide ranges and get market demands in recent years.

The economic factor and climate change impact could affect the trend of pattern and species in agroforestry practices. Together with this, the socio-economic condition of the local community is strongly influencing on the practices. We still found the

farmers cultivating agricultural crops only. Home garden and two stories type are more frequently occurred than the others.

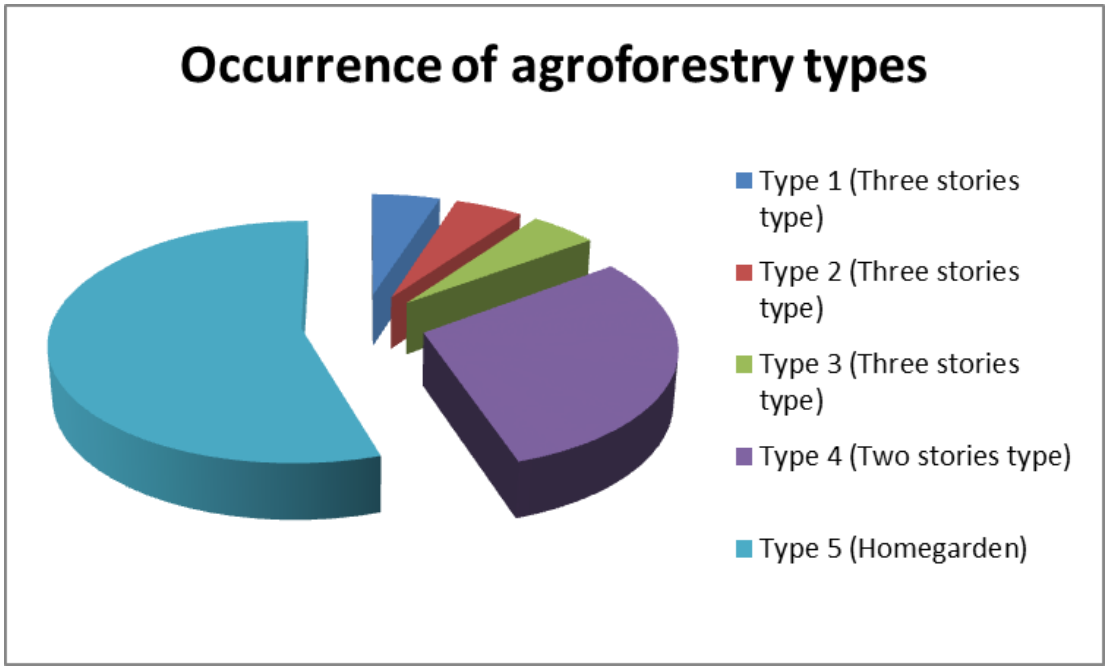


Figure 8. The occurrence of agroforestry types in the study area.

4.5 Gender consideration and perspective

Both men and women noticed the climate change and its impacts to them. The results from group analysis and respondents' responses, both men and women are all participated in all activities. The involvement in cultivation works and harvesting works there may have equal contribution by male and female. However, the female role in decision making is very poor showing the ratio of the involvement in decision making process by male and female is 85 male: 15 female. Most of the female are followed by the male (especially their husband). Not surprisingly, the change of trend is led by the male although some influenced factors by female perspectives and socio-economic conditions. In terms of the sustainability, the role of women is still high for the success and sustainability of those works.

Table 1. Activities and the involvement of male and female

| **No.** | **Activities** | **Involvement in activities (%)** | |
|---|---|---|---|
| | | Male | Female |
| 1. | Involvement in cultivation works | 50 | 50 |
| 2. | Involvement in harvesting | 50 | 50 |
| 3. | Involvement in decision making process | 85 | 15 |
| 4. | Involvement in change of trend | 95 | 5 |

| | | | |
|---|---|---|---|
| 5. | Notice the climate change and its impacts | 52 | 48 |
| 6. | Sustainability | 50 | 50 |

4.6 Contribution to livelihood development

Agroforestry supports their livelihood not only for the subsistence needs (household consumption) but also for the economic return. Different components from agroforestry serve several purposes. All year round supports to local community are found. They also collect the fuelwood particularly from the branches and some dead portions of the trees. The majority of households are depending crop residues and dry branches for fuel. Besides the environmental value of the tree species, fruit trees support the household consumption and commercialization. Altogether, the net annual income from one acre of the agroforestry ranged from 2346 USD to 3800 USD in which the income from homegarden is the highest. Still there will be a higher economic potential in long-term benefits than we estimated in addition to environmental conservation.

Moreover, the work load could be reduced year by year without reducing the income because of the production from perennial tree species including fruit trees in the successive years. Vertical production is higher in agroforestry in comparing the ordinary ways. Regarding the environmental benefits, both soil improvement and water retention are obtained by agroforestry perennial trees. In a sum, based on the results, agroforestry in Shan State and Bago Region contributed the livelihood of local community, showing a percentage of 10 to 56 percent of the total coverage of the livelihood identity.

The study investigate the net profit of the individual crops species for cultivation in agroforesty area to help for the input in the system. The result of net profit of the agricultural crops was shown in the table 2. It was found that the Dancing Lady Ginger has the highest value expressing 4.98 million Kyats, followed by Sebestan expressing 2.69 million Kyats, Sesame expressing 2.17 million Kyats, tea leaves for 1.5 million Kyats and turmeric 1.048 million Kyats. Knowing the expenditure and profit could help for the development of agroforestry.

Table 2. The cultivation and net profits of agricultural crops

| Crops | Expenditure (one acre) | Selling Prices | Net Profit (Kyats) |
|---|---|---|---|
| Sesame | 635,000 | 2,800,000 | 2,165,000 |
| Turmeric | 152,500 | 1,200,000 | 1,047,500 |
| Corn | 565,000 | 1,300,000 | 735,000 |
| Dancing Lady Ginger | 4,024,000 | 9,000,000 | 4,976,000 |
| Tea Leaves | 300,000 | 1,800,000 | 1,500,000 |
| Paddy | 1,566,000 | 1,800,000 | 234,000 |
| Sebesten Leaves | 1,314,000 | 4,000,000 | 2,686,000 |

| Crops | Expenditure (one acre) | Selling Prices | Net Profit (Kyats) |
|---|---|---|---|
| Avocado | 236,000 | 1,200,000 | 964,000 |
| Coffee | 1,706,000 | 2,434,000 | 728,000 |
| Groundnut | 102,000 | 800,000 | 698,000 |

4.7 Carbon storage potential for climate change mitigation

Agroforestry has the potential of carbon sequestration for climate change mitigation. Based on the results, carbon storage capacity of the agroforestry was significantly found showing the range of 10 to 300 tons per hectare starting from 35 percent of trees in an area. Two stories types found 1.5 to 4 tons of carbon per hectare although the variation has been occurred among the systems.

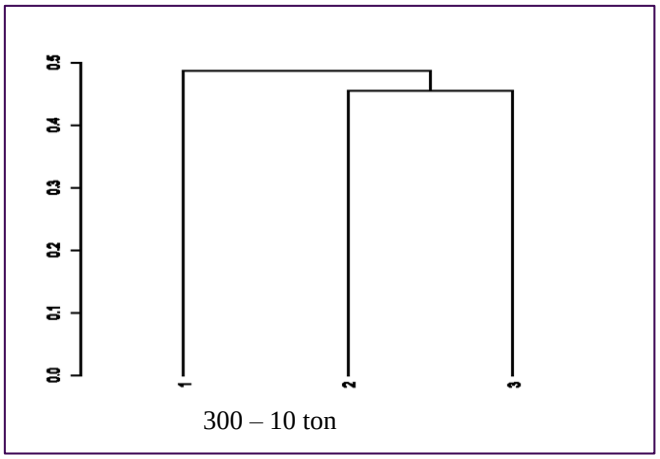


Figure 9. Carbon storage potential of agroforestry types in the study area.

## 5. Conclusions

Five types of agroforestry systems are commonly found in the study area ranging from two stories type to four stories type (homegarden). They are (a) 3-story type with a mixture of silk oak/ silver oak tree in an alternative position with avocado tree (or) teak tree in the top canopy, orange tree (Citrus species) (or) Guava/Lime in the middle layer and bottom layer is composed of agricultural crops such as sesame, cabbage, cauliflower and groundnut; (b) 3-story type with a mixture of silk oak/ silver oak tree and avocado trees line by line in the top canopy, green tea tree or coffee tree planted in the middle layer and sesame is mainly cultivated in the bottom layer; (c) 3-story type in which the top canopy is composed of silk oak/ silver oak tree and avocado trees with different spacing, green tea trees are planted in the middle layer and sesame and dancing ladies ginger are mainly cultivated in the bottom layer; (d) 2-story type in which the top canopy is a mixture of silk oak/ silver oak trees and avocado trees with wide spacing in which avocado trees is more outweigh than silk oak/ silver oak trees in the Southern Shan State and teak trees in the Bago Region, and sesame and dancing ladies ginger are mainly cultivated in the bottom layer; and (e) homegarden having four stories with the main target of avocado, dancing ladies gingers, coffee and green tea, and other vegetables and fruit trees are planted for their subsistence uses. The annual income from one acre of agroforestry

ranged from 2346 to 3800 USD in which type-5 homegarden showed the highest income in this region. Among five agroforestry types, type-5 (homegarden) and type-4 (two-story type) are the most appropriate types in terms of feasibility and economic and environmental point of view in this region. agroforestry in Shan State and Bago Region contributed the livelihood of local community, showing a percentage of 10 to 56 percent of the total coverage of the livelihood identity. Moreover, it was clearly seen the change of cultivation trend to agroforestry during the past decades. The adaptability to the climate change is clearly found in the regions showing the value and components of commodities mixtures. On the other hand, contribution to the climate change mitigation is significantly seen in the regions, 10 to 300 tons of carbon per hectare starting from 35 percent of trees in an area and 1.5 to 4 tons of carbon per hectare in two-story type although the variation has been occurred among the systems. The results from this study pointed out the agroforestry can make an ample contribution to the climate change mitigation and adaptation as well as the livelihood development of local community. Based on the assessment and results, it could be suggested that the initiation to promote or scale up agroforestry area in Shan State for economic/business level with a systematic management while promoting the basic structure in Bago region for the coming five years. But care about the consideration of the factors such as limited knowledge, poverty, urgent needs for life are the difficulties for successful management. The findings from this study could fulfill the information gap and support the development of agroforestry for climate change mitigation and adaptation and livelihood development in the specific region of Myanmar.

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