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Smallholder Farmers' Adaptation Strategies under Challenges of Climate Change in Dry Zone, Myanmar: Case study in Pakokku District

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မြန်မာနိုင်ငံ၊ အပူပိုင်းဒေသတွင် ရာသီဥတုပြောင်းလဲလာမှုနှင့်အညီ တောင်သူလယ်သမားများ၏ သီးနှံများကို လိုက်လျောညီထွေစွာ ပြောင်းလဲစိုက်ပျိုးလာသည့် နည်းလမ်းများကို လေ့လာခြင်း

ဖြူဖြူသင်း၊ မဟာသိပ္ပံကျောင်းသူ
ဒေါက်တာအစ်အစ်ရွှေစင်၊ ကထိက
မျိုးမင်းလတ်၊ ကထိက
သစ်တောနှင့်ပတ်ဝန်းကျင်ဆိုင်ရာတက္ကသိုလ်

စာတမ်းအကျဉ်း

သီးနှံသစ်တော ရောနှောစိုက်ပျိုးခြင်းသည် ရာသီဥတုနှင့် လိုက်လျောညီထွေ ဖြစ်နိုင် မည့် စိုက်ပျိုးထုတ်လုပ်မှု နည်းလမ်း တစ်မျိုးဖြစ်သည့်အပြင် တောင်သူလယ်သမား များ၏ လူမှု စီးပွား ရေး အကျိုးကျေးဇူးများကို ရေရှည်ရရှိစေနိုင်မည့် စနစ်တစ်ခုဖြစ်သည်။ ထို့ပြင် ရာသီဥတု ဆိုးရွား ပြင်းထန်မှုဒဏ်ကို သီးနှံတစ်မျိုးတည်းစိုက်ပျိုးသည့် နည်းလမ်း ထက် ပိုမိုခံနိုင်ရည်ရှိ သည်။ ယခုလေ့လာမှုသည် မြန်မာနိုင်ငံ၊ အပူပိုင်းဒေသတွင် ရာသီဥတု ပြောင်းလဲ မှုကို တားဆီး ရာ၌ တောင်သူ လယ်သမားများ၏ လိုက်လျောညီထွေဖြစ်စေရန် အသုံးပြုသည့် နည်းလမ်းများ ကို လေ့လာရန်ဖြစ်ပါသည်။ သုတေသနနည်းလမ်းများ အနေဖြင့် စာတမ်းများပြန်လည် လေ့လာ ခြင်း၊ မေးခွန်းလွှာများဖြင့် စစ်တမ်းကောက်ယူခြင်း၊ အုပ်စုဖွဲ့ဆွေးနွေးခြင်းများ၊ ကွင်းဆင်း လေ့လာမှုများ ပါဝင်ပါသည်။ ပခုက္ကူခရိုင်၏ မြို့နယ် (၂)မြို့နယ်မှ ကျေးရွာ(၄)ရွာကို သုတေသန စစ်တမ်း ကောက်ယူခဲ့ပြီး သီးနှံသစ်တော ရောနှော စိုက်ပျိုးခြင်းကို လုပ်ဆောင်နေသူ အိမ်ထောင်စု (၁၀၈) အိမ်အား ရွေးချယ်မေးမြန်း သည့်နည်းလမ်းဖြင့် မေးမြန်းခဲ့ပါသည်။ တွေ့ရှိ ချက်အနေဖြင့် ရာသီဥတုပြောင်းလဲမှုနှင့် ဆက်စပ်နေသော အကြောင်းအရာများသည် သီးနှံ စိုက်ပျိုး ထုတ်လုပ်မှုကို အနှောက်အယှက် ဖြစ်စေသည့်အချက်များဖြစ်ပြီး ၎င်းတို့၏ သက်ရောက်မှုအရကြည့်လျှင် (၁) မိုးရွာသွန်းမှု ပုံမှန်မရှိခြင်း၊ (၂) ရာသီဥတုပူနွေးမှုကြောင့် ပိုးမွှားနှင့်ရောဂါများကျရောက်ခြင်း၊ (၃)ရေရရှိမှု မလုံလောက်ခြင်းနှင့် (၄)မြေဆီလွှာညံ့ဖျင်း လာမှုကြောင့် သီးနှံအထွက်နှုန်းလျော့ကျလာခြင်း တို့ဖြစ်ကြသည်။ ဖြေရှင်းသည့်နည်းလမ်းများ အနေဖြင့် တောင်သူလယ်သမားများအနေဖြင့် ၎င်းတို့၏ယာခင်းများတွင် စိုက်ပျိုးထားသော နှစ်ရှည်သစ်ပင်များမှ ဝင်ငွေရရှိခြင်း၊ သီးနှံများစုံလင်ကွဲပြားစွာစိုက်ပျိုးခြင်းနှင့် စိုက်ပျိုးသည့်ရာ သီချိန်ပြောင်းလဲခြင်းတို့ ဖြစ်ကြသည်။ ယခုလေ့လာမှုအရ သီးနှံရောနှော စိုက်ပျိုးခြင်းစနစ်သည် သီးနှံအမျိုးအစားများ စုံလင်ကွဲပြားစွာ ပါဝင်သည့်အတွက် ရာသီဥတုပြောင်းလဲမှုဒဏ်ခံနိုင်သည့် နည်းလမ်း တစ်ခု ဖြစ်သည့်အပြင် တောင်သူလယ်သမားများ၏ အခြေခံစားဝတ်နေရေး လိုအပ်ချက်များကို ဖြည့်ဆည်းနိုင်သည့် နည်းလမ်း တစ်ခုဖြစ်ကြောင်း သိရှိရသည်။

အဓိကစကားလုံးများ- လိုက်လျောညီထွေဖြစ်စေသည့် နည်းလမ်းများ၊ ရာသီဥတုပြောင်းလဲမှု၊ သီးနှံသစ်တောရောနှောစိုက်ပျိုးခြင်း၊ အကျိုးသက်ရောက်မှုများ၊ အပူပိုင်းဒေသ။

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Abstract

Agroforestry is a climate-smart production system that sustainably diversifies environmental and socio-economic benefits of subsistence farmers, and is therefore considered more resilient than monocropping to increased intensity of extreme weather events. This study was conducted to assess smallholder farmers' adaptation strategies in buffering against climate variability in dry zone of Myanmar. Research methodologies used included literature review, questionnaire, focus group discussion and direct field observation. A sample of 108 households engaged in agroforestry was selected with purposive sampling method from four villages of two townships in Pakokku district. Findings show that climate change related factors are the most important constraints to crop production. Ranked in the order of their importance are: (1) Irregular/ unpredictable rainfall (unclear onset and ending of rains), (2) Increasing disease and pest incidences linked to warming, (3) Inadequate water availability, and (4) Drought and declining crop production associated with low soil fertility. Results revealed that the adaptation strategies involved was cash income from trees on their farmlands in order to meet their basic needs, diversification of crop varieties and change time of sowing. The study revealed that agroforestry, that crops are diverse, can serve as insurance against rainfall variability and practice that sustainably diversifies environmental and socio-economic benefits of farmers. The study concluded that, the wealth of knowledge on coping and adaptation that farmer has should form a foundation for designing agricultural innovation systems to deal with impacts of climate change and variability.

Key Words: Adaptation Strategies, Climate Change, Agroforestry, Impacts, Dry Zone.

Smallholder Farmers' Adaptation Strategies under Challenges of Climate Change in Dry Zone, Myanmar: Case study in Pakokku District

1 Introduction

Climate change and variability is rapidly emerging as one of the most serious global problems affecting many sectors in the world and is considered to be one of the most serious threats to sustainable development with adverse impact on environment, human health, food security, economic activities, natural resources and physical infrastructure (IPCC,2007; Huq et al., 2006). Agriculture is one of the most important economic sectors in Myanmar as it is essential for national food security and a major source of livelihood for its people (MOAI, 2015). But this sector is now facing the impacts of climate change and is expected to further impact directly and indirectly on food production. Increase variability both in temperature and raining patterns; changes in water availability, sea level rise etc., all will have profound impacts on agriculture, forestry and fisheries (FAO, 2013). The adverse impacts of climate change on agriculture and forestry are identified as follows: endangerment of natural assets; prevalence of pests, diseases and invasive species; agriculture and forest damage; and high levels of food insecurity (Mangala De Zoysa and Makoto Inoue, 2014). Consequently, the impacts of climate change are expected to severely threaten the livelihoods of people living in rural areas with limited adaptive capacity (Moe Swe Yee, 2015). Climate change will require an agriculture that is more resilient and adapted to changing conditions, as well as contributes to the mitigation of climate change (Eva Wollenberg et al., 2011). Therefore, it is urgently needed to adopt farming practices compatible with climate-smart agriculture so that its production could sustain in the future.

Over the past 4-5 decades, Myanmar has experienced an upward trend in air temperatures, and decreases in the raining season duration (Baroang, 2013). Since most of the Dry Zone was under rainfed conditions, crop production was determined by rainfalls (DAP, 2007) and inadequacy and uncertainty of rainfall often caused partial or complete failure of the crops (Peprah, 2014), which led to instable and/or low production in this area. Therefore, the local people could not produce crops as expected and accordingly faced problems, such as insufficient income for foods and financial safety. To increase agricultural productivity and reduce risks caused by the production under rainfed conditions, (Lasco et al., 2011) recommended the introduction of new crops and crop diversification. Diversification of agriculture with the introduction of new crops and changes in cropping systems had been practiced in many tropical countries.

Agroforestry is a climate-smart production system that sustainably diversifies environmental and socio-economic benefits of subsistence farmers, and is therefore considered more resilient than monocropping (the growing of only one crop on a piece of land year after year) to increased intensity of extreme weather events (Richard.L.Charles et al., 2013). The diversification of crops provides a number of resilience and adaptation benefits, including an economic buffer in case of crop failures (Claire Kremen et al., 2012).

2 Rationale of the Study

In Myanmar, the Dry Zone located in the central part of the country is the main area affected by droughts and desertification. Droughts mostly occur in the early monsoon period causing a shortage of soil moisture adversely affecting crop productivity (MOAI, 2015). From time to time, notably when rains fail for several consecutive years, desertification becomes extremely serious and causes decline in food production (Palmer, 2003). In dry zone area, the average annual rainfall is less than 1000 mm (1997-2006) and unstable during the early monsoon season. The soil fertility is very low as an upland area for monsoon crops and thus the yield per unit area of early monsoon crops is unpredictable. The Dry Zone is characterized by clay and sandy soils with areas at high risk of water and wind erosion leading to land degradation and declining agricultural production due to high temperature and erratic rainfall (MOAI, 2015).

To become more resilient and better able to adapt to changing conditions, the resilience and adaptive capacity of agricultural production systems and agricultural landscapes will become more important (FAO-PAR, 2011). Diversification can improve resilience in a variety of ways: by engendering a greater ability to suppress pest outbreaks and dampen pathogen transmission, which may worsen under future climate scenarios, as well as by buffering crop production from the effects of greater climate variability and extreme events (Lin, 2011). In contrast to monocropping that makes farmers extremely vulnerable to climate-induced shocks, multi-cropping still has potential to be up-scaled as an adaptation practice across the Dry Zone (WFP, 2009). Besides, in order to maintain agro-ecosystem resilience and to meet the agroforestry products for requirements of the people during stress of climatic hazard like drought, flood, pest; scientific information is required (Linger, 2014). Climate change is a global phenomenon, while adaptation is largely site-specific. Therefore, it is important to ensure that changes in farming systems and technologies are suited to the specific environmental and socio-economic conditions of local farmers, without increasing risk or dependence on external input. Therefore, area-specific agricultural systems are needed to secure the livelihoods of rural farm households in those resource poor regions like dry zone. Research into the contributions of agroforestry in buffering against climate variability is not well advanced. Agroforestry is only one best alternative to cope these situations and the indigenous and traditional knowledge of agroforestry practices is very essential to explore and document for its betterment. Since investigation of local practices would be a powerful and efficient means of extending the scientific understanding (Shrestha, 1997), the identification and dissemination of existing practices will make easy in extending scientific intervention. Therefore, area-specific agricultural systems are needed to secure the livelihoods of rural farm households in those resource poor regions.

3 Objectives of the Study

The main objectives of research are;

1. To identify the existing cropping systems in the study area
2. To determine the challenges caused by climate change on traditional agricultural cultivation and local coping strategies of farmers under climate change
3. To determine tree species and uses in agroforestry that reduce vulnerability to climate change

4 Research Methodology

4.1 Study Area

The study areas were selected from Pakokku Distirct, Magway Region. The rationale for choosing Pakokku District for the study is three-fold. First, it is the core region of the hottest area in the dry zone (MOAI, 2015), which is facing irregular climatic impacts, and therefore it is more vulnerable to impact of climate change. Secondly, its annual average rainfall is 686 mm (1997-2006) (Office of Pakokku District, 2007), it is therefore representative of the dry zone area and biophysical and socio-economic characteristics in that district are assumed to be typical and representative for the whole area of dry zone. Thirdly, poverty and food insecurity is a problem for many villages in the townships (FAO, 2014). It has an area of 3205 square miles and is situated between North Latitude 20° 45' and 21° 45' and East Longitude between 94° 20' and 95° 35'. There is an important need to try to stabilize the environment and farming systems in the region, as a result of climate change and increasing population pressure of both human and livestock (FAO, 2014).

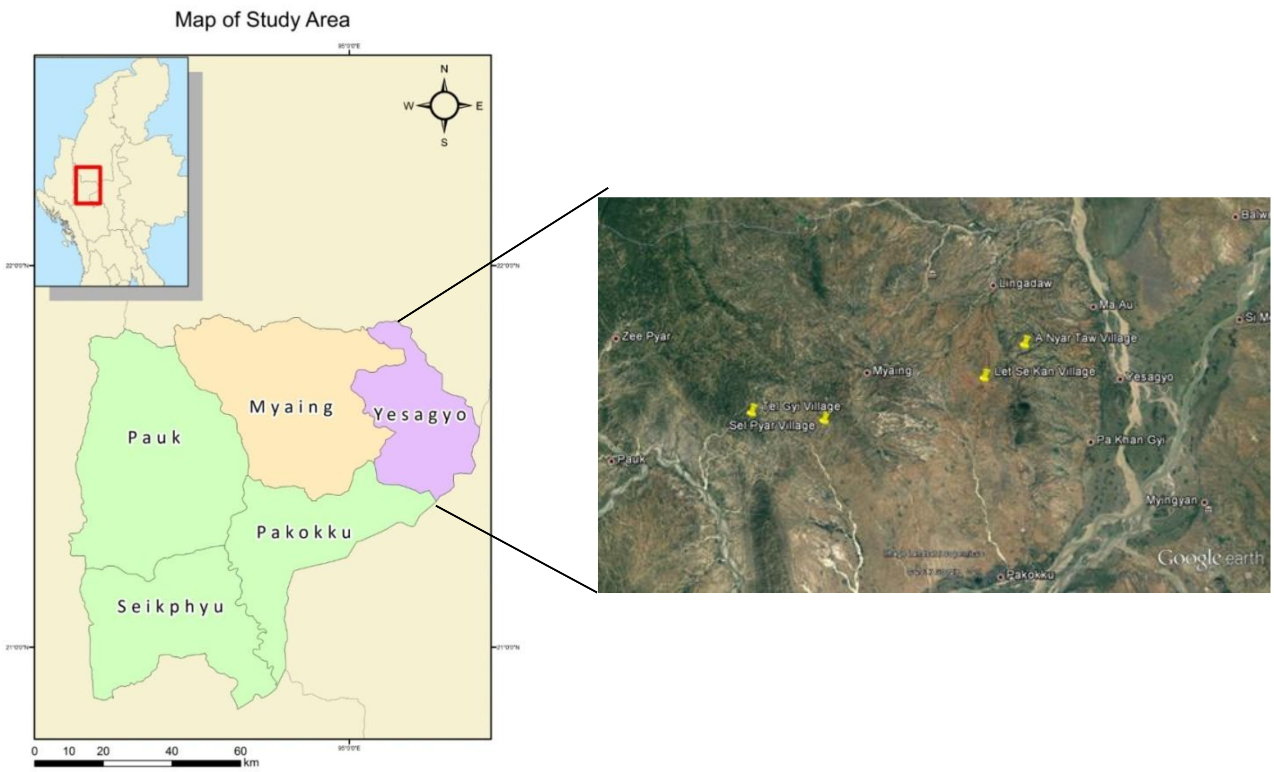


Figure 1: Location of Pakokku District showing the Study Area

Although Pakokku District is made up of five townships, only two townships, Myaing and Yesagyo townships, were selected because these townships were closely located and had similar general conditions (homogeneity of population); thus were considered as one case study while conducting the analysis. In each township, two villages were selected and within each village, 25 to 30 households were identified by purposive sampling because of the rule of thumb that a minimum sample size of 25-30 households from each village is appropriate for a village that ranges in size from 100 to 500 families (Alain Atangana et al., 2014). Totally, 108 households were interviewed with questionnaires. The present study referred to three criteria when selecting the study areas: 1) the villages that have at least 100 households; 2) rural livelihoods mainly depend on agriculture and livestock; and 3) prominent effects of climate change on productivity of crop and agriculture. Village profiles are described in ***Table 1***.

Table 1: Selected Villages in Myaing and Yesagyo townships

No.	District	Township	Village Tract	Village	Population	Households	Sample Households
1	Pakokku	Myaing	Ywar Tan She	Sel Pyar	527	101	27
2	Pakokku	Myaing	Sin Sein	Te Gyi	1500	250	30
3	Pakokku	Yesagyo	Let Se Kan	Let Se Kan	2250	450	25
4	Pakokku	Yesagyo	Sar Lin Gyi	A Nyar Taw	1897	367	26

4.2 Climate Data of the Study Area (2007 – 2016)

As the Pakokku district falls within the dry zone, it is very hot in the summer and is relatively cold in winter. The average temperature of April, which is the hottest month of the year, is 31.45˚C. The average temperature of January, which is the coolest month of the year, is 20.45˚C. The annual average distribution of rainfall is 671.03 mm a year in that area (2007 - 2016).

Based on the climatic data of the reference period of 2007 - 2016, the monthly aridity index after DE MARTONNE is calculated with the use of the following expression (Lungu et al., 2011).

$$A_j = \frac{P(mm)}{T_j + 10} \ (Yearly)$$

$$A_m = \frac{12p}{T_m + 10} \ (Monthly)$$

Where,

A_j = yearly aridity index

A_m = monthly aridity index (Am below 20 means dry month)

P (mm) = total annual precipitation in millimeters

p = mean monthly rainfall in millimeters

T_j = mean annual temperature in °C

T_m = mean monthly temperature in °C

The aridity index is a useful indicator to identify the dry period of a year. The month possessing the aridity index (Am) of less than 20 is defined as a dry month (Lungu et al., 2011). The aridity index of the study area showed that dry season started from November to April and from June to July while the rests are humid periods. The monthly climatic characteristics of the study area are shown in ***Table 2.***

Table 2: Monthly mean precipitation, temperature and aridity index in Pakokku Township, Myanmar (2007 -2016)

Months	Temperature (°C)	Rainfall (mm)	Aridity Index
January	20.45	3.09	1.21
February	22.59	0.71	0.26
March	26.37	1.62	0.53
April	31.45	10.13	2.93
May	31.44	93.68	27.12
June	30.38	54.53	16.20
July	29.43	32	9.74
August	28.92	133.48	41.16
September	28.67	119.66	37.13
October	26.99	195.71	63.49
November	25.29	23.5	7.99
December	21.28	2.92	1.12
Year	26.93833333	671.03	17.41

Source: Pakokku Weather Station, Pakokku Township, Pakokku District

The climatogram of Pakokku is shown in ***Figure 2*** which was drawn from the representation model of the Walter and Lieth (1967).

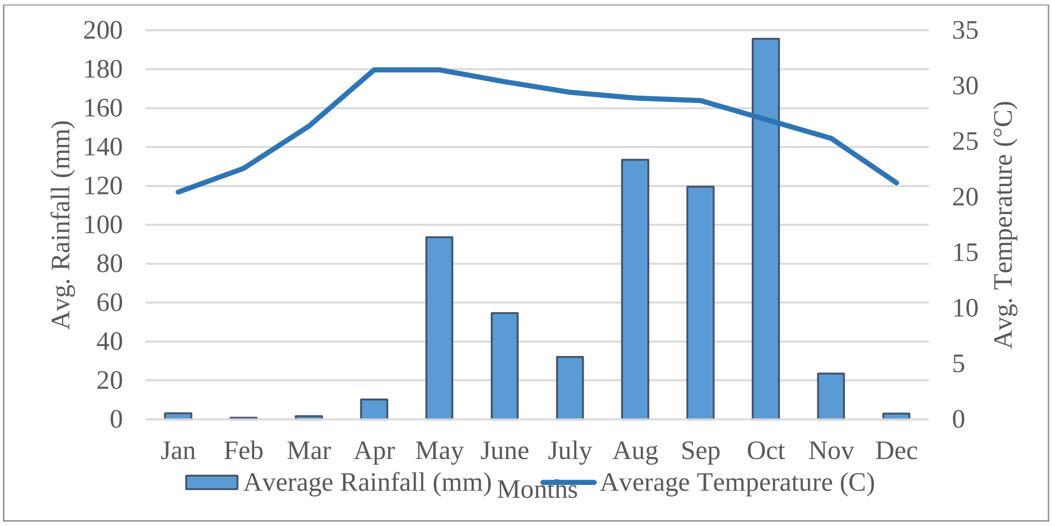


Figure 2: Climate diagram for Pakokku weather station, Pakokku Township, Myanmar

4.3 Methods of Data Collection

The research employs a case study approach and combines both qualitative and quantitative methods for an effective assessment. The study employed a combination of methods including ‘Participatory Action Research (PAR) tools’. These were:

i. Reconnaissance Survey
ii. Household Survey
iii. Focus Group Discussion
iv. Direct Field Observation
v. Secondary Data

Primary data was gathered using 'Household Survey' with semi-structured questionnaires to fulfill the objectives of the study during May 2017. Socioeconomic survey performed on the selected farmers whose primary source of income is agriculture and adopting diversified farming including both crops and trees on their farm land. To obtain information, a number of questions having socio-demographic characteristics like gender, family size, level of education, landholding and economic characteristics like main occupation and income were included in questionnaire.

'Focused Group Discussions' was also used to investigate seasonal activities and cultivation patterns, climate change impacts and coping strategies and what factors or drivers influenced promoting agroforestry. Four group meetings were done in study area, each with 5-8 members, including farmers, village head, both men and women.

'Field Observation' was carried out to observe the farm behavior, landscape, practices, to analyze the actual practices in the natural settings and to triangulate the data obtained from other methods. Secondary data were collected from the various sources and records like- reports published by related project. Maps, journals, publications, reports of other line agencies, published or unpublished and relevant literature were also consulted in the library and the relevant websites to make better understanding, interpretation and analysis of the research.

4.4 Methods of Data Analysis

The data were coded, categorized and fed in computer and analyzed using computer software packages MS Excel and SPSS (Statistical Package for Social Science) 20 versions. Quantitative data were analyzed by simple statistical tools such as frequency, mean, percentage, standard deviation and range. The results are presented through text, tables and figures with interpretation accordingly.

5 Findings

5.1 Major Economic Activities in the Study Areas

Farming is the major economic activity for all of the respondents. All households were involved in rain-fed agriculture as their main source of livelihood. Livestock keeping is the secondary livelihood activity in these areas. Production of palm sugar is one of the main economic activities in all villages and other minor economic activities included migrant worker, joss stick making, etc. Rain-fed agriculture depends on the patterns of rainfall and its reliability. The high participation in crop production suggests that when such activity is impacted by climate change, it may have serious consequences on household food security and rural livelihoods.

Table 3: Major Economic Activities in the Study Areas

Major Economic Activities	Household Involvement (%)			
	Sel Pyar (n=27)	Tel Gyi (n=30)	Let Sel Kan (n=25)	A Nyar Taw (n=26)
Farming	96.3	100	100	100
Livestock Keeping	7.4	100	8	3.8
Production of Palm sugar	7.4	3.3	16	42.3
Migrant Worker	40.7	3.3	4	0
Joss Stick Making	0	0	100	57.7

5.2 Cropping Systems

The most frequent method of growing trees was through deliberate retention and management of naturally regenerating tree seedlings. Another important feature in this system was the existence of jujube, cultivated with sesame and pigeon pea. This crop is drought-tolerant and inputs used by the farmers were minimal compared to those for other field crops and both pigeon pea and jujube could be exported to neighbor countries such as India and China. Based on the interviews of the villagers, although the number of groundnut growers had decreased and the importance of jujube in home economy had increased, cultivated crops and cropping patterns of the past and present did not change significantly since the farming was practiced, and the constraints associated with natural conditions did not permit the growers to change the system.

In the study area, agroforestry practices involved

i. Agrosilviculture (growing trees with crops)
ii. Agrosilvopastoral (growing trees with pastures), and
iii. Parklands (scattered trees on agricultural farms).

(A) **(B)**

Figure 3: (A) Agrosilviculture (growing trees with crops) and (B) Agrosilvopastoral (growing trees with pastures)

Figure 4: Parklands (scattered trees on agricultural farms)

In the surveyed villages, a pigeon-pea based cropping pattern was the major traditional cropping system. A pigeon pea-based cropping system established a long time ago and adaptable to the natural environment was also found to be in use, with sesame-pigeon pea intercropping being the most common system; the sesame oil fulfilling home consumption and the pigeon pea being used mainly for export. Pigeon pea is drought-tolerant and its initial slow growth reduces competition for light, water and soil nutrients when intercropped (Dalal, 1974), thereby minimizing any negative impacts on the companion crop.

5.3 Crops Grown as Source of Livelihoods in the Study Area

The major cultivated crops in the surveyed villages were groundnut, sesame, pigeon pea, maize and green gram ***Table 4***. According to the interviews of the villagers conducted in 2017, all the surveyed households adopted a Thanakha-pigeon pea intercropping system on their farms. All of the crops were cultivated in the inter-space of jujube trees since there were a number of jujube plants scattered in almost all the fields.

According to the local farmer interviews and statistical data, pigeon pea was cultivated in all the sample households, mainly for commercial use, for gaining income to buy staple foods and other household needs. Other crops, sesame, groundnut and rice were mainly grown for home consumption. Maize was mainly cultivated for animal fodder.

Table 4: Crop Sown in the Study Area

Crops	Sel Pyar Village (n=27)		Te Gyi Village (n=30)		Let Se Kan Village (n=25)		A Nyar Taw Village (n=26)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Groundnut	24	88.9	26	86.7	21	84	5	19.2
Seasame	3	11.1	0	0	25	100	17	65.4
Pigeon pea	17	63	29	96.7	22	88	20	76.9
Maize	17	63	13	43.3	10	40	10	38.5
Chickpea	1	3.7	9	30	0	0	2	7.7
Greengram	14	51.9	5	16.7	15	60	5	19.2

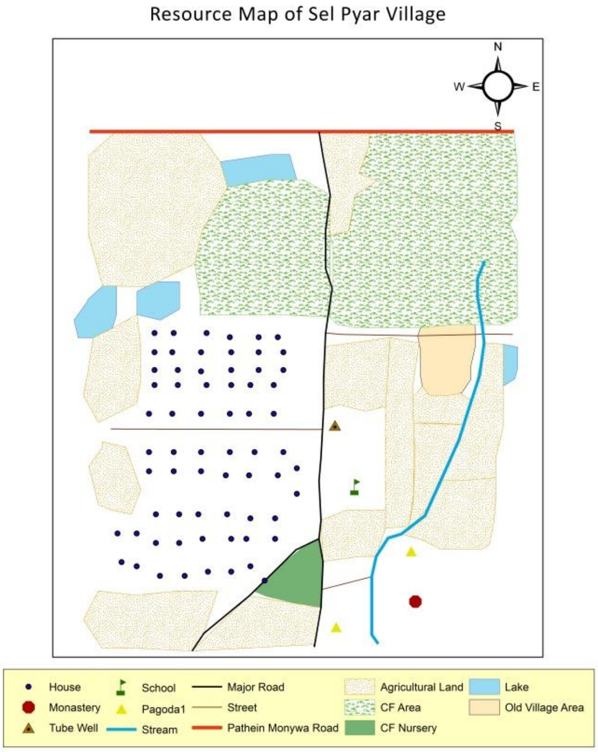
5.4 Livestock Reared in the Study Area

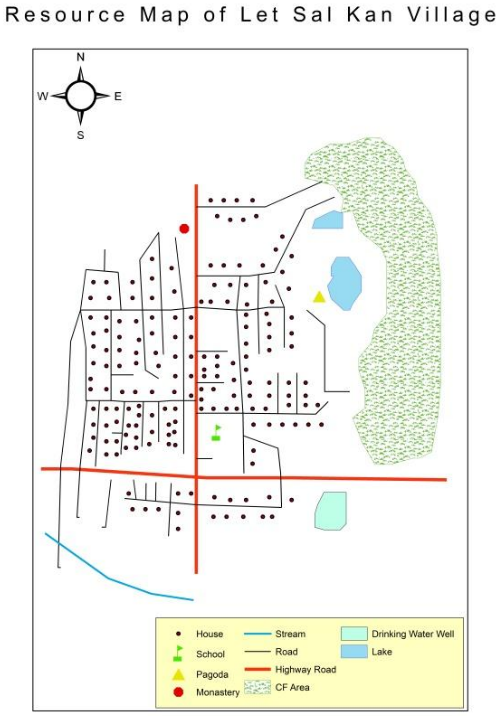
The household surveys revealed that 89% of households were involved in livestock keeping. Among the animals frequently kept included cattle, pig, goats and chicken. Cattle were reported to be preferred by 71.29% only for farming activities and also chicken by 39.8% for home consumption. Goats are also preferred because of their drought endurance, but some respondents argued that browsing behaviour of goats can disturb the cultivation of crops and trees. Some respondent reported that pigs are kept as emergency solution in case they faced climate stresses such as crop failure as well as insufficient income or need money urgently. In this case, the study revealed that most of the animals are reared in these area are for farm activities, home consumption and investment, and not for commercial use.

Table 5: Livestock Reared in the Study Area

Major Livestock	Frequency	Percent
Cattle	77	71.29
Pig	12	11.11
Goat	9	8.33
Poultry	16	14.81

5.5 Resource Maps of the Villages





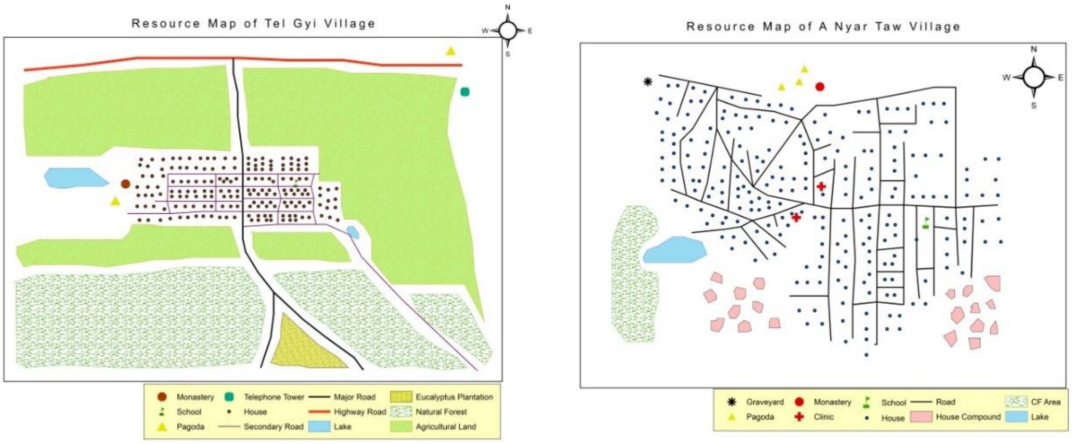


Figure 5: Resource Mapping of Villages

5.6 Challenges Caused by Climate Change on Agricultural Cultivation

Based on household surveys in four villages, it is apparent that climate change related factors are the most important constraints to crop production ***Figure 6***. Almost all of 108 respondents answered "yes," when asked if they were experiencing impacts of climate change. Majority (97%) noted the negative effects of climate change.

Ranked in the order of their importance are:

i. Irregular/ unpredictable rainfall (unclear onset and ending of rains) (83.3%)
ii. Increasing disease and pest incidences linked to warming (68.5%)
iii. Water availability for crop cultivation (67.6%)
iv. Drought (57.4%) and
v. Declining crop production (46.3%) associated with drought and low soil fertility

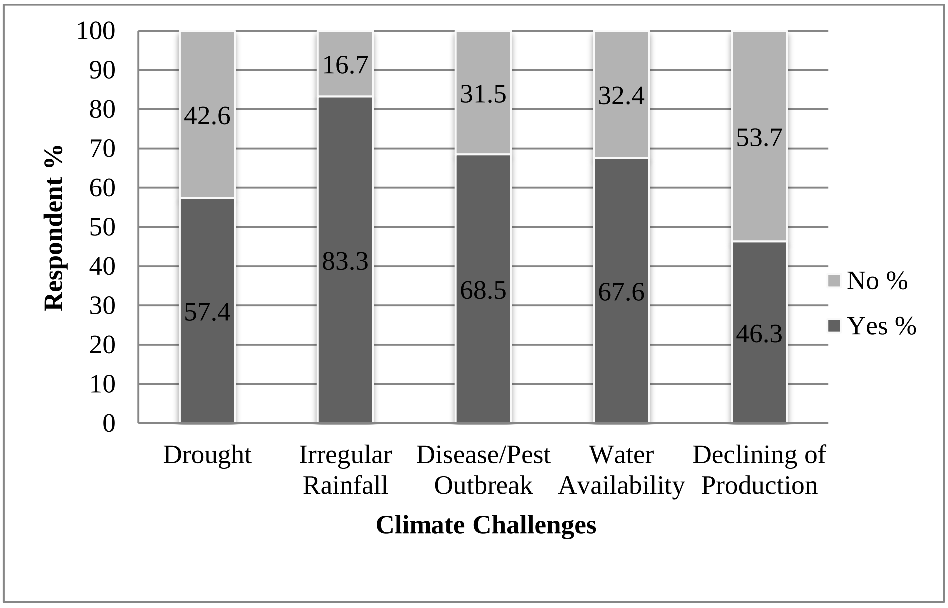


Figure 6: Climate Challenges in Study Area

i. Irregular/ Unpredictable rainfall (Unclear Onset and Ending of rains)

Respondents reported that delayed raining days and sometimes receiving rainfall earlier than normal lead to poor germination of seeds and they often undergo crop failure. Climatic fluctuations in the dry zone have become more intense, with droughts becoming more frequent and with rainfall patterns changing in recent decades. Even though farmers know that it is very risky for their crop cultivation, they have tended to grow their crops under this uncertain climatic condition, because their main sources of income mainly depend on agriculture. If the first crop suffers from lack of rain and dies, especially in the early cropping season, they need to grow again to ensure a final harvest. But, the net yield from their crops is generally unsatisfactory because of the accumulated amount of investment needed during the cropping season.

Crops grown at rain-fed cultivation need the rhythm of rain and sunshine. If the rain comes in flowering period, flowers fall down and produce lower crop productivity. If the rain falls near harvesting period, the seeds are affected by diseases and could not produce the quality seeds which directly affect its price. As all of the agricultural works have to be done by labor forces, farmers who have insufficient labors frequently face the crop damage because of the irregular rain during harvesting period. Thus, rain-fed cultivators suffer from these very high risks for their successful crop production under the irregular rainfall.

ii. Increasing Disease and Pest Incidences Linked to Warming

Pest interference is also the significant factor of climate change impacts, which has become serious over the last five or six years. The two most important climatic elements determining the occurrence and localization of pests and diseases appear to be moisture and temperature. FAO (2007) reported that changing temperatures and rainfall in drought-prone areas are likely to shift populations of insect pests and other vectors and change the incidence of existing vector-borne diseases in both human and crops. Most of the respondent perceived that there has been an increase in disease and pests due to warming. When raining occurs during the dry season, rainfall can facilitate the spread of crop diseases. When rain fails and the weather is cloudy for three days, pests occur in Thanakha trees and crops and as a consequences, it leads to damage of trees and crops and threatens livelihoods of local people.

iii. Water Availability for Crop Cultivation

Water availability is a major problem in the study area due to low and irregular rainfall and poor soil water retention. Rising temperature and changes in rainfall pattern have direct effects on crop yields as well as indirect effects on water availability. Meanwhile, increase in occurrence and severity of drought will decrease water availability and water quality. As a consequence, crop productivity is low and livelihoods of farmers are mainly affected.

iv. Drought and Declining Crop Production Associated with Drought and Low Soil Fertility

Also more frequently, farmers reported prolonged drought leads to low yield or total crop failure. Linked to climate change, drought might have contributed to low soil productivity as it tends to reduce water in the soil consequently affecting nutrient mineralization and their availability to crops. Rains can be delayed by several weeks or stop during critical germination periods, leading to short- and long-term droughts with crop failures, food shortages and famines.

5.7 Local Coping Strategies of Climate Change in the Study Area

Farmers were interviewed to identify their coping strategies ***Figure 7***. Results revealed that the first strategy involved was selling Thanakha trees, jujube and tamarind on their farmlands as reported by 81.48% of the respondents in order to meet their basic needs, 71.3% of the respondents reported to depend on diversification of crop varieties and 28.7% of the respondents reported to change time of sowing. Another coping strategy was seasonal migration to other regions as reported by 11.11%. Some of the respondents burned crop residues to ease cultivation and to control crop pests. There was small proportion of farmers who allowed livestock to graze on farmlands after harvesting crops.

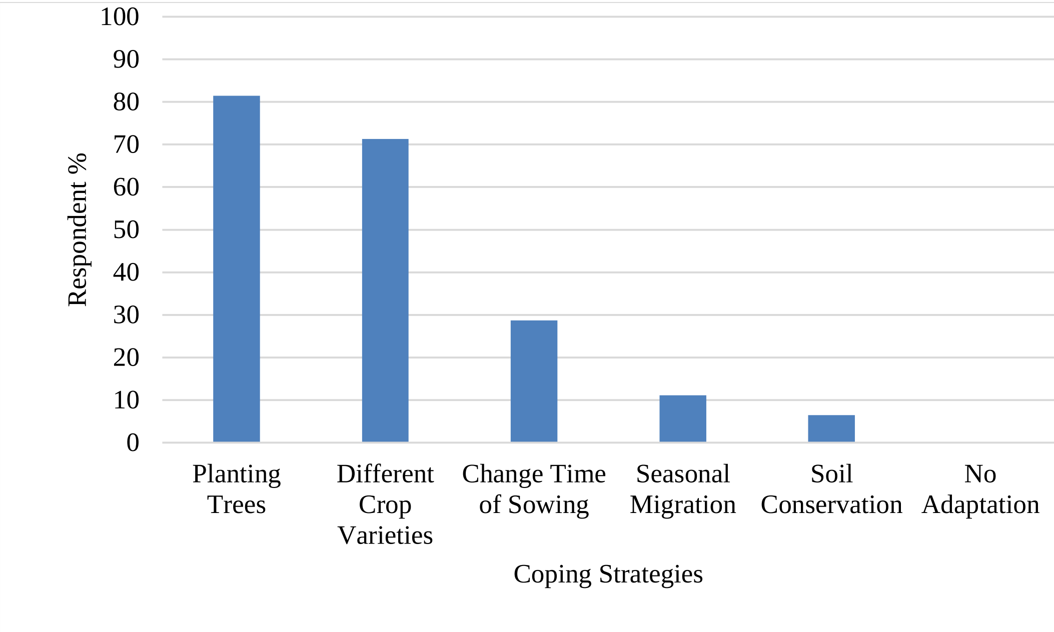


Figure 7: Local Coping Strategies of Climate Change in the Study Area

(1) Tree Planting

And, planting trees on farm boundary could help in addressing economic risk in the face of climate stresses by getting additional cash income. Mixed cropping which involves growing two or more crops in proximity in the same field is another adaptation strategy. The system is commonly practiced in all surveyed villages where maize, groundnut, pigeon pea and Thanakha are grown together. From discussions with farmers, it was noted that they have wide field knowledge on advantages of mixed cropping with varying attribute in terms of maturity period, drought tolerance, input requirements and end uses of product. Tree planting has become another adaptation strategy for farmers. When interviewing how trees were an adaptation strategy, respondents said that they use trees to integrate them with crops in their farms. Farmers said that fruit trees (tamarind, mango, palm) on their farms provided fruits for consumption, cash income, helped in controlling soil erosion (by providing ground cover with their canopy and leaves) and improve soil fertility through falling leaves.

(2) Use of Different Crops Varieties or Crop Diversification on Farmlands

Growing different crop varieties on the same plot or on different plots reduces the risk of complete crop failure as different crops are affected differently by climate events, and this in turn gives some minimum assured returns for livelihood security. In addition, some farmers from study areas diversified crops in order to counteract the effects of climate change. The study revealed that crop diversification can serve as insurance against rainfall variability.

(3) Changing Planting Dates

Climate change adversely affects crop production through long-term alterations in rainfall resulting in changes in cropping pattern and calendar of operations. Shifts in planting dates include early and late planting options as a strategy to adapt to the changing climate. This strategy helps to protect sensitive growth stages by managing the crops to ensure that these critical stages do not coincide with very harsh climatic conditions such as mid-season droughts.

(4) Seasonal Migration

About 10% of sampled households migrate to other townships for job opportunities and seasonal migration provides as a livelihood source in the study areas. Temporary migration as an adaptive response to climate stress is already apparent in these areas. People most vulnerable to climate change are not necessarily the ones most likely to migrate. The region has suffered a prolonged drought for much and one way that households have adapted is by sending their young men and women in search of wage labour after each harvest.

(5) Soil Conservation

Soil conservation practices and technologies that enhance vegetative soil coverage and control soil erosion are crucial to ensuring greater resilience of production systems to increased rainfall events, extended intervals between rainfall events, and to potential soil loss from extreme climate events. Adaptation to impacts of climate change and variability in farming systems requires resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). FAO (2007) concluded that a key element in response to both problems is to improve soil organic matter. Soil organic matter stabilizes the soil structure so that the soil absorb higher amounts of water without causing surface run-off and it also improves the water absorption capacity of the soil during extended drought.

5.8 Contribution of Farm Trees for Farmer's Income

It was found from the research that farmers of the area mostly obtained their income generated from three major activities: (i) agriculture (509,259 Kyats), (ii) farm trees (484,613 Kyats), and (iii) livestock (37,962 Kyats). The farmer's total annual average cash income in the study area was (572,834 Kyats). However, the results show that, the agriculture was the first most important contributor to farmer's annual total cash income (49%), followed by farm trees products (47%), and livestock (4%) ***Table 6***.

Table 6: Distribution of Household's Income from Different Economic Activities in Study Area (n=108)

Activity	Annual Total Income (Kyats)	Annual Average Income (Kyats)	% of Contribution to Total Income
Agriculture	55,000,000	509,259	49
Farm Trees	52,338,300	484,613	47
Livestock	4,100,000	37,962	4
Total	111,438,300	572,834	100

These findings revealed that forest trees make significant contribution to total income of farmer in the study area. Although, trees on farms were not the main livelihood activity for the farmers, the income received from it was used for expected and unexpected expenditures including: income generation, domestic subsistence, safety net and livelihood security. In the study area, income from farm trees is the second most important source of farmer's annual income when compared with livestock as main activities in the study area.

5.9 Tree Species Uses and Functions that Enhance Vulnerability to Climate Change

The respondents were able to speculate about types of tree species that are resilient to climate variability ***Table 7***. The results also revealed that most of the trees regenerated naturally. For example, *Ziziphus jujuba* Lam., *Borassus flabellifer* L., *Acacia catechu* Wild., *Tectona hamiltonia* Wall..

Table 7: Tree species that enhance farmer`s resilient to climate variability

Local Name	Scientific Name	Uses
Thanakha	*Hesperethusa crenulata* (Roxb) Roem.	Cash
Zi (Jujube)	*Ziziphus jujuba* Lam.	Fuelwood, Fodder, Food
Htan(Palm)	*Borassus flabellifer* L.	Timber, Fuelwood, Fodder, Food, Cash
Magyi (Tamarind)	*Tamarindus indica* L.	Timber, Fuelwood, Fodder, Food, Cash
Thayet (Mango)	*Mangifera indica* L.	Food, Cash
Shawphyu	*Sterculia versicolor* Wall.	Gum Extraction, Cash
Sha	*Acacia catechu* Wild.	Timber, Fuelwood

Dahat	*Tectona hamiltonia* Wall.	Fuelwood, Fodder

Originally, there were many jujube trees in upland farms, owned by former generations. These trees were naturally grown as the natural conditions in the region were favorable. It was a local variety developed from wild types and at first the farmers were not interested in this type of jujube for cultivation. They allowed these trees to grow in the fields mainly for the protection of their crops from damages by cattle and possibly thefts from their neighbors, since thorny branches could be used as a hedge. Since the jujube plants were naturally spread out in their fields, the villagers produced marketable jujube grafted on existing local type plants without increasing the plant population or area extension. This study revealed that most of the trees in AF were used for cash income, fuel wood and timber. Other tree products and functions included, fodder, shade. Acacia species was reported to be a source of fodder for livestock.

6 Discussion

Tree planting and crop diversification are important mechanisms to increase the resilience of subsistence farming to rainfall instability (Gilbert and Holbrook, 2011). In addition, it is one of the coping mechanisms of food security, production instability and market risks (Rehima et al., 2013). Converting monocultures to more diversified agricultural production systems will help farmers to cope with changing climatic conditions. Monocultures are more vulnerable to climate change, pests, and diseases. The basic objectives of agricultural diversification in this area seemed to be the stable supply of household food and income security, considering crop production under high risk rainfed conditions with frequent price fluctuation of the products. The introduction of a more stable new cash crop and diversification of farming systems with the existing cropping systems, seem to be a contribution to the agricultural development in the Dry Zone. In recent years, Thanakha farms appeared and the production have been increasing rapidly in this area. Although Thanakha was adapted to the farming conditions in the Dry Zone and successfully produced, there were some limiting factors for cultivation. To produce good quality thankha commercially, specific conditions such as appropriate soils (gravel strewn red soils) are needed, even in the Dry Zone. It is a perennial plant with wide spacing, and the farmers should wait at least 6 years after planting them to gain profits. Small holders have less chance for that kind of long time investment without regular seasonal incomes. At the time of the survey, villagers in the study area were considering introducing more profitable cash crops, adaptable to their agro-environment, such as Shaw Phyu, which would result in changes to their conventional systems. Farmers commonly follow adaptive strategies to reduce or totally avoid climate change related risks.

Furthermore, there are positive links between agroforestry and adaptation to climate variability, which means agroforestry option may provide a means for diversifying production, increasing resilience of subsistence farmers and buffering against production risk associated with climate. Agroforestry has been proposed as potential strategy for helping subsistence farmers reduce their vulnerability to climate change through the intention use of tree in cropping systems to increase productivity, diversify income sources and improve environmental services.

7 Conclusion

Trees help to buffer subsistence farmers against environmental extremes by modifying temperatures, providing shade and shelter and acting as alternative sources of feed for livestock during the period of drought. Traditional resource management adaptations, such as agroforestry systems, may potentially provide options for improving farmer adapting to climate change through simultaneous production of food, fodder and firewood as well as mitigation of the impact of climate change. Tree-based systems are more profitable and less risky than other agricultural options because of the variety of products. The study argues that livelihood diversification strategies including tree planting, integration of livestock, crop production and non-farm activities are crucial to enhance adaptive capacity of the local community in the study area and other parts of the country with similar agro-ecological conditions. Such local adaptation strategies need to be supported by relevant policies that enhance climate change adaptation at various levels.

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