Analysis of Dynamics of Cropping Systems in the Dry Zone, Myanmar

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Abstract

The “Dry Zone” in Myanmar has a tropical semi-arid climate with erratic rainfall, high temperatures, and low-nutrient soils. The majority of residents depend on agriculture and, until recently, practiced traditional upland farming under rainfed conditions. However, since three decades ago, variations in rainfall and fluctuations in crop prices have threatened livelihoods, resulting in a gradual change in farming systems, including the introduction of new cash crops. To determine how the local people have adapted to these changes, four villages in Kani Township and two in Yinmarbin Township, all in the Sagaing Region, were employed in a case study. Interviews with randomly selected households, group interviews, and field observations were carried out. In Kani Township, the existing cropping systems were sufficient for home consumption, adaptable to the environment and adequately supplied an income. Recently, however, the farmers faced a reduction in crop productivity as a result of climate change, and are therefore considering introducing new cash crops. In a riverine village in Yinmarbin Township, easy access to underground water irrigation, its location near the city, and careful farm management have resulted in successful introduction of betel vine. Similarly, in a typical upland crop-producing village in Yinmarbin, villagers have introduced thanakha, a highly prospective cash crop with adaptability to their agro-environment. Although to some extent the conventional cropping systems remain sufficient in providing food and income security, crop diversification with the introduction of new cash crops may have generated more income and contributed to rural development.

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CHAPTER 1

Introduction

The agricultural environment and an overview of Myanmar

According to the World Bank (2014), the total population of Myanmar was recorded as 53.3 million in 2013, an increase of 148% from 21.5 million in 1960. In Myanmar, agriculture plays a major role not only in supporting the population increase, but also the economy, with crop production being the mainstay of the country's economy, accounting for 36% of the GDP (in 2010) and employing some 65% of the total labor force (World Bank, 2013). According to the Department of Agriculture in 2010, 70% of the total population living in rural areas (nearly 63% of the total population) was engaged in agriculture for their livelihood. Myanmar covers a land area of 676,577 km², with approximately 51% covered by forest, 13% by agricultural land, and 14% by cultivable wasteland and fallow land (Settlement and Land Record Department, 2005).

In Myanmar, the southwest monsoon creates a wet season from May to October, providing a large volume of rainfall. Annual rainfall varies, ranging from 4800-5800 mm in the Coastal area, about 3000 mm in the Delta, 1250-2300 mm in the Mountain region, and less than 1000 mm in the Dry Zone area (Ministry of National Planning and Economic Development, MNPED, 2006). Due to variations in agro-ecological conditions, more than 60 different crops are grown in Myanmar, which can be grouped into six categories: cereals, oil seeds, pulses, industrial crops, culinary crops, and fruits and vegetables.

Rice is the staple food crop for subsistence, while pulses are the major commercial crop, used mainly for export. Pulses undergo a process of rapid price adjustment according to the international market. The export of pulses was established after 1990 (Moe *et al.*, 2008) following a major change in Myanmar agriculture that included a closed trade regime and isolation of the domestic from the international market, implemented in 1988 (Favre and Myint, 2004; Soe, 2004; Fujita and Okamoto, 2006). According to the Central Statistical Organization (CSO, 2008, 2011), export of pulses reached 1.04 million tons in 2002, 1.14 in 2008, 1.45 in 2009, 1.14 in 2010, and 0.9 million tons in 2011, indicating large annual fluctuations without any specific trend. The most important export partner for food crops is India, especially with regards pulses. The share of exported food crops to China is lower than that to India, with unstable export values to China between 1988 and 2007 (Aung, 2012). Pulses have become important in the rural economy of Myanmar, not only for their income-earning potential, but also for their dietary contribution and their agronomic contribution within a crop rotation system

where little inorganic fertilizer is available. Seasonal vegetables such as tomato, onion, garlic and chili also play an important role in the Myanmar diet and have high demand within the domestic market (CSO, 2001).

Cropping systems and patterns vary according to agro-climatic conditions within Myanmar. In irrigated areas, double or triple cropping via, for example, paddy-paddy or paddy-pulses-paddy patterns dominate. In the Dry Zone and other upland rainfed areas, mixed cropping or intercropping of pigeon pea with sesame, peanut or other pulses have been practiced (FAO, 2009; Baroang, 2013). In the Socialist era (up to 1988), the Government's agricultural policy was based on self-sufficiency and isolation from the international market. After 1988, however, with the introduction of a market-oriented economy, the various control measures of the preceding period were abandoned. Farmers were allowed freedom of choice in agricultural production and participation of the private sector in commercial production of seasonal and perennial crops was encouraged.

Characteristics of the Dry Zone Region

The Dry Zone, which consists of the southern part of the Sagaing Region, the western and middle parts of the Mandalay Region and most of the Magway Region, is one of the most climate-sensitive areas and is notorious for having poor natural resources. It is situated in the rain shadow of the Yakhaing Mountains, and most of the scarce rainfall therefore comes via the southwest monsoon. It receives bimodal monsoon rains, with some dry spells during July. The average mean temperature is about 27°C, often rising to about 43°C in the summer, and it has an annual rainfall of less than 1016 mm (Department of Meteorology and Hydrology [DMH], 2010). The livelihood of inhabitants of the Dry Zone is based mainly on upland crop production under rainfed conditions, with paddy fields observed only under specific water resource or irrigation conditions. Landless households work as seasonal farm laborers and/or migrate to unban regions or other better farming areas during the off-crop season to find temporary employment. The Dry Zone is the third most densely populated region in Myanmar, with a growth of 26% between 2005 and 2011, a rate of 4.3% annually (CSO, 2005 and 2011).

Sagaing Region within the Dry Zone is organized into nine districts (in 2013) divided into 38 townships, through which the Chindwin River, the third largest river in Myanmar, flows. The largest cities are Monywa, Shwebo, and Sagaing, with Monywa being the major center for trade with India through the border near Tamu and Kalay. According to data from the Department of Agriculture (DOA, 2005), only 12.3% of total agricultural land is under irrigation, with the remaining 87.7% under rainfed conditions. Fifty percent of this total agricultural land is in the upland area.

According to the Land Use Division of the Department of Agriculture, the Sagaing Region is characterized by red-brown soils, dark compact soils, and gravel soils of the savanna. Thus, the soil clearly varies with topography, but all are of low fertility with low organic matter content. Potassium levels are similarly low, as is the soil moisture holding capacity, which along with the high level of evapotranspiration constitutes a major constraint for crop growth during periods of inadequate rainfall (June and July). In line with these agro-ecological conditions, the major cultivated crops in upland areas are cereals (wheat, corn, sorghum, etc.), peas and beans (pigeon pea, chickpea, butter bean, green gram, black gram, lablab bean, etc.), oilseed crops (sesame, groundnut, sunflower, etc.), and other tropical crops (tobacco, cotton, etc.). Sagaing Region is a top producer of wheat, with chickpea constituting its competitor (Oo and Kudo, 2003).

Rationale of the study

Since agriculture is mostly dependent on monsoon rains, it is expected to be seriously affected by climate in rainfed areas of mainland Southeast Asia. As a consequence, changes are expected to severely threaten the livelihoods of people living in rural areas with limited adaptive capacity. Some areas of Southeast Asia, such as the central Dry Zone of Myanmar and northeast Thailand, have a tropical semi-arid climate with low rainfall. Climate changes are exacerbating water shortages in many parts, constraining agricultural production. The International Fund for Agricultural Development (2009) also pointed out that the changing climate is expected to affect agriculture in several ways. For example, irrigation systems will be affected by changes in rainfall and runoff. In particular, scientific studies have documented high sensitivity of major cereal and tree crops to the projected changes in temperature and moisture, with this agricultural impact particularly affecting low-income rural populations that depend on traditional agricultural systems or on marginal lands.

The United Nations Environment Program (UNEP) and DMH stated that over the last six decades (1951-2007), rainfall in Myanmar has increased on average by 29 mm per decade (UNEP and DNH, 2012). Rainfall trends have, however, been variable, with some areas including the Sagaing Region, experiencing a decrease in annual rainfall (UNEP and DMH, 2012; Yi *et al*., 2014). With regular reports of record-breaking rainfall, rainfall patterns in Myanmar have become unpredictable. During the period from 1960 to 2009, a shortened rainfall season combined with erratic and intense rainfall resulted in widespread flooding (Planning Department, 2013).

Small holders, especially those living in marginal environments, who were bypassed by the agricultural modernization, generally do not rely on agrochemicals to sustain production.

Although estimates vary considerably, about 1.9 to 3.3 billion rural people in the developing world remain untouched by modern agricultural technology (Altieri and Nicholls, 2004). Agricultural production systems will change over time depending on the system chosen, which is influenced by factors such as changes in political/economic conditions, household characteristics, and natural resources. Of these, natural resources and political/economic conditions are generally outside the control of the farmer (Aune, 2000).

Climate change is a global phenomenon, while adaptation is largely site-specific (Mary and Majule, 2009). It is important to ensure that changes in farming systems and technologies are therefore suited to the specific environmental and socio-economic conditions of local farmers, without increasing risk or dependence on external input. As the environment becomes more dynamic and challenging, the guarantee of traditional agriculture practices in farmers' livelihoods declines (Pingali and Rosegrant, 1995; Pingal, 2010). Within tropical regions, upland areas are most vulnerable to climate changes (Field *et al.*, 2012). Changes in the nature of farming activities represent one major route for livelihood transformation in such areas. As discussed previously, traditional upland farming is the primary agricultural activity in most rural areas in Sagaing Region and the main source of household income. Therefore, area-specific agricultural systems are needed to secure the livelihoods of rural farm households in those resource poor regions.

Objective of the study

The main objective of this study was to analyze the recent changes in the agro-ecosystem within the Dry Zone and determine how locals are adapting to these changes. The specific objectives were as follows:

1. Clarify the agro-environment, land use and existing farming systems within the survey areas.
2. Analyze the stability and adaptability of traditional farming systems.
3. Determine how Dry Zone farmers operate their agricultural practices even under uncertain conditions.
4. Analyze the changes in farming systems.

Structure of the thesis

Following the general introduction and background information of the surveyed area described in Chapter 1, the three case studies will be discussed in Chapters 2, 3, and 4. In Chapter 2, traditional and recent land use practices and cropping systems in the central Dry Zone, Sagaing Region, are introduced and the agricultural systems practiced in the four surveyed villages in

Kani Township are analyzed in detail. A case study of the introduction of a cash crop in a village in Chindwin River basin, Sagaing Region, where advantageous conditions are available, is discussed in Chapter 3. Chapter 4 analyzes the results of the second case study, conducted in the same study area in Yinmarbin Township, Sagaing Region, but with much more severe natural settings. Here, local people were devoted to seeking ways in which agricultural production could be more stable. Finally, an overall discussion and conclusion are provided in Chapter 5.

CHAPTER 2

Land Use and Farming Systems in Dry Zone, Myanmar: A Case Study in Kani, Sagaing Region

Introduction

Myanmar, the largest country in mainland Southeast Asia is predominantly a monsoon country and seasonal changes in the monsoon wind directions create three seasons: summer, rainy and winter seasons (Sen Roy and Kaur, 2000). Based on its topography and agroecological conditions, Myanmar is generally divided into four different zones, i.e, Coastal region, Delta region, the Dry Zone and Mountain region.

The Dry Zone in central Myanmar covers approximately 8.7 million hectares or about 13% of the country's total land area, and about 14.5 million people, close to one third of the country's population live there (Poe, 2011), and the majority depends on agriculture and allied activities for livelihood. According to the Asian Development Bank (ADB, 2009), Myanmar is one of the countries which are the most vulnerable to climate changes. Drought and water scarcity are the dominant climate-related hazards in the Dry Zone. Kyi (2012) stated that there is a saying in Burmese *"a nyar thar, ta moe loe hnit mawe"*, which means that a dry land people can be poor after just one drought. The dominant features of the Dry Zone regions include erratic rainfall, sandy soils with low fertility and low water-holding capacity, and high temperatures. Since the region chronically receives a low rainfall compared to the other parts of Myanmar, local people meet unstable livelihoods with little prospect of increasing agricultural production.

It is said that most of the small holders have employed practices designed to optimize productivity in the long term rather than to maximize it in the short term (Glissman *et al*., 1981). In order to achieve the optimized sustainable agricultural production, it is indispensable to evaluate the local agricultural resources and past and present farming systems. Therefore, the objectives of the study in this chapter were to analyze the agroecosystems of the Dry Zone and to determine how the Dry Zone farmers adapted themselves to their agro-environment, even under severe conditions, through land use and farming systems. In the present study, the detailed land use and cropping systems in the central Dry Zone, Sagaing region was analyzed as a case study.

Methodology

Field surveys were conducted in Kani Township, Yinmarbin District (officially subdivided from Monywa District in September, 2013), Sagaing Region (Fig.1), in which agriculture is mainly practiced under rainfed conditions, and the area is important in terms of typical field crop production and road-side location on the main route, Monywa-Yagyi-Kalaywa Road, for border trade with China and India. Kani is a small town, located on the western bank of the Chindwin River. The construction of Monywa-Yagyi-Kalaywa Road as a part of the ASEAN highway (AH1, from the border of Thailand to the border of India) project was launched on June 1, 2000, which connected Monywa to the Indian border. It was completed in 2003 and expected to be the shortest link to the border with India and to contribute to the development of border trade and national economy. The road passed through the middle of Kani Township administrative area, from a southeastern to a northwestern direction, 20 km away from Kani Town. The construction of the road from Kani Town to the ASEAN main road was also completed in 2003. The surveyed villages, Chanung Ma (CM), Zee Pin Twin (ZPT), Yet Kan Tine (YKT) and Tha Min Chan (TMC), with a total number of households and population (shown in the parenthesis) of 105 (575), 209 (1041), 172 (946) and 148 (877) at the time of the survey, respectively, were located in the administrative area of Kani Township. Each of the surveyed villages was a part of administrative villages (village tract) with the same names. For example, Chanung Ma (CM) is a small village in the Chanung Ma village tract. The area surveyed was characterized by a generally hilly topography, with undulating slopes and few flat areas. Elevations ranged from 130m in the northeastern parts to about 220m in the southwestern parts of the township territorial area. Crops grown, lack of irrigation systems and accessibility to the nearest town were the factors taken into consideration in the selection of the villages for the study.

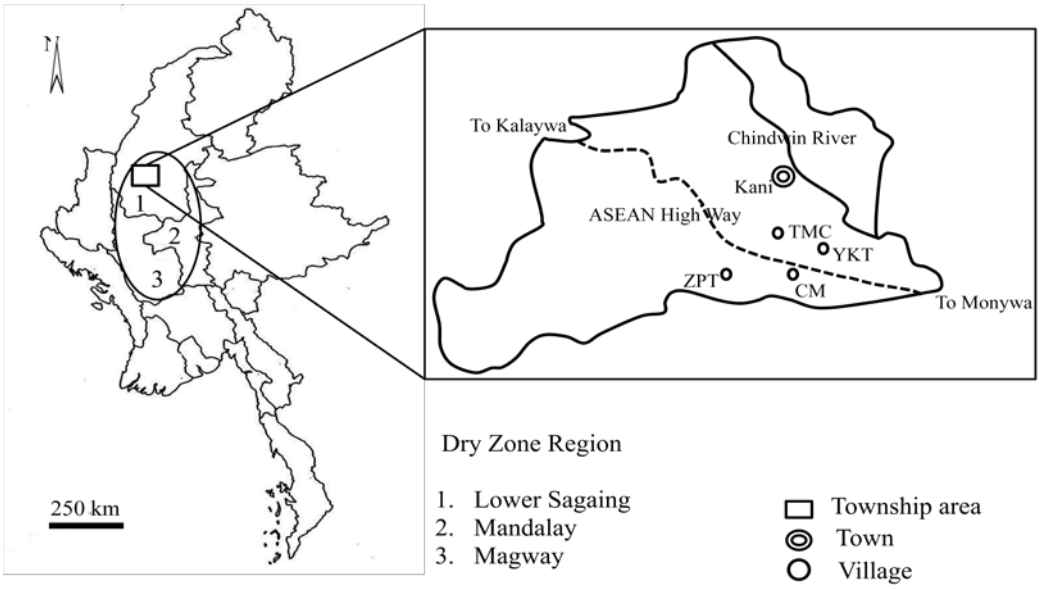

Fig. 1. Map of the study area in the Dry Zone region, Myanmar.
Regarding the abbreviation of the village names, please refer to the text.

The detailed climatic data were obtained from the Department of Meteorology and Hydrology, Kani Township. The statistical data of land use were collected from the annual reports (2011 and 2012) of the Offices of Settlement and Land Records Department, Department of Agriculture, in Yinmarbin and Kani, and the Office of Village General Administration in the surveyed villages. The basic maps showing the landmarks, land-holdings, land types and allocation of land by land parcels in each village were obtained with the assistance of the Settlement and Land Record Department in Kani.

Households were randomly selected for interview surveys related to agricultural activities, land use and farming systems in the present and past. The total number of households (HH) involved in this study was 108 during the periods from December 2011 to March 2012, and from July and to August 2012, namely, 30 HHs from CM, 33 from ZPT, 25 from YKT and 20 from TMC. Further investigations were conducted by informal discussions, and group interviews twice on average in each surveyed village to cover seasonal changes in agricultural activities, land use and farming systems. Field observations were conducted to confirm the location of lowland and upland fields, physical conditions of the soils, household land ownerships, cropping systems and agricultural practices.

Results and Discussion

Land use in Dry Zone area

The Dry Zone Greening Department classified and recorded the land use types of the Dry Zone as follows; agricultural land, forest, water bodies and others (Table 1). Agriculture

was the major land use type accounting for about 57% of the total area of the Dry Zone. About 27%, more than one-fourth of the region was still covered with forests. Water bodies made up only 1.5% of the Dry Zone surface, reflecting the scarcity of water resources. Other land uses included swamp areas, sand areas and settlements. The Settlement and Land Record Department (SLRD, 2011) stated that the net sown acreage of Myanmar in 2010 was 11,965,000 ha. According to Table 1 and the statement of SLRD (2011), 40% of the total agricultural land of the whole country was located in the Dry Zone.

Table.1. Land use types of Dry Zone, Myanmar in 2010.

Land use and ecological type	Area (ha)	% of total
Forest	2,182,007	27
Forest affected by shifting cultivation	986,006	12
Agriculture	4,678,644	57
Other land uses	128,384	2
Water bodies	191,259	2
Total	8,166,300	100

Source: The Dry Zone Greening Department, Ministry of Environmental Conservation and Forestry, Myanmar.

Land use types and characteristics in the study area

Table 2 indicates that in Kani Township, the forest land area occupied nearly half of the total land area of the Township, whereas the cultivated area only one-fourth, similarly to unutilized areas (fallow and meadow). For these regions, forest land referred to the areas with substantially higher levels of canopy closure, up to 60%. Land mostly covered with dense growth of trees and shrubs, from which timber or fuel wood was cut, was designated as wood land.

Table.2. Land use in Kani Township, Sagaing Region, Myanmar in 2011.

Land Use Unit	Area (ha)	% of Total
Agricultural land	76,177	23
Forest	155,979	46
Wood land*	2,429	7
Fallow land	43,134	13
Meadow land	36,643	11
Total land area	336,061	100

*Land mostly covered with dense growth of trees and shrubs, from which timber or fuel wood was cut.
Source: Settlement and Land Record Department Office, Kani.

Land use and distribution in the study area

According to Tables 3 and 4, among the villages in the study, ZPT harbored the largest agricultural and forest lands, while CM the smallest. There was no forest land in the surveyed villages except for ZPT. For cultivated areas in all the villages, there were very few paddy fields and the land area was occupied mostly by upland fields, especially in TMC.

Table.3. Land use of the surveyed villages, Kani Township, Sagaing Region, Myanmar in 2011.

Villages	Land Types					Total area (ha)
	Agricultural land (ha)	Forest (ha)	Wood Land (ha)	Fallow Land (ha)	Meadow Land (ha)	
Chaung Ma	1,268*	0	0	385	580	2,233
Zee Pin Twin	5,733	3,505	4,169	25	2,690	16,122
Yet Kan Tine	1,891*	0	0	378	203	2,472
Tha Min Chan	2,600	0	0	0	192	2,792
	11,492	3,505	4,169	788	3,665	23,619

*Area calculated based on the data provided by the Departments of Agriculture and Land Record.
Source: Annual Report, 2012. General Administrative Department, Kani.
Note: The area of each land type was calculated based on the total area of village tract. (an administrative village). Each of the surveyed villages was a part of administrative villages (village tract) with the same names.

Table.4. Land distribution of the surveyed villages, Kani Township, Sagaing Region, Myanmar in 2011.

Villages	Agricultural Land (ha)			Total area (ha)
	Upland field	Paddy field	Horticultural field	
Chaung Ma	1,227	37	12	1,276*
Zee Pin Twin	4,989	92	652	5,733
Yet Kan Tine	1,814	69	0	1,883*
Tha Min Chan	2,594	6	0	2,600

*Area calculated based on the data provided by the Departments of Agriculture and Land Record in relation to standing crops.
Source: Annual Report, 2012. General Administrative Department, Kani.
Note: The area of each land type was calculated based on the total area of village tract. (an administrative village). Each of the surveyed villages was included in the village tract.

Agricultural environment

Topographically, the average elevation of ZPT was 220m, CM 150 m, YKT 138m and TMC 140m with undulating fields. Mean temperatures ranged from a minimum of about 10º C in December, January and February to a maximum of about 43º C in March, April and May. Fig. 2 shows the mean temperatures in 11 years (2001-2011) with 21-year average monthly rainfall (1991-2011) in Kani Township.

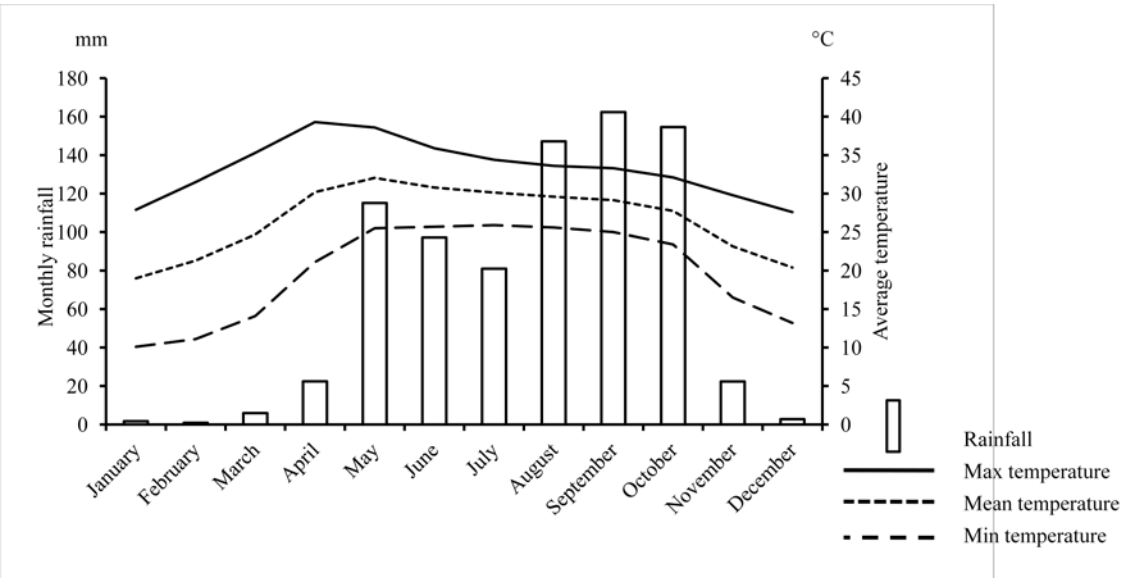

Fig. 2. Monthly average rainfall in 21 years (1991-2011) and maximum, minimum and mean temperatures in 11 years (2001-2011) in Kani Township, Sagaing Region, Myanmar.
Source: Department of Meteorology and Hydrology, Kani (2012).

The area showed a bimodal rainfall distribution pattern influenced strongly by the monsoon, duirng which precipitation was concentrated from May to July and from August to October. According to the villagers, the heaviest intensity of rainfall during 24 hours was generally observed in May and June, whereas September was the month with heaviest monthly rainfall. There were some periods without precipitation. Especially in July, dry spells occurred when dry desiccating winds blew from the south, but the length and frequency of the dry spells were variable.

Based on traditional knowledge, forecasts on the rainfall amount and onset of the rainy season were made by local people for decisions on agriculture. They observed natural phenomena in their environment to predict rainfall. Some examples of rainfall predictions were the observation of animals. The occurrence of bee, wasp and ant swarms indicated the duration of rainy periods. The farmers also predicted the rainfall conditions based on the occurrence of rainfall during the three days of the annual water festival in April. There were some other predictions using e.g. astrological phenomena and characteristics. Although the prediction based on these natural phenomena seems to be non-scientific, the local farmers paid a great attention to them.

According to the soil classification data of the Land Use Department (LUD, 2002), the major soil types found in the area were red brown savanna soils, Luvisol. Local people subdivided and named the soils based on physical properties, i.e sandy soil (*the-mye*), gravel-strewn red soil *(mye- ni–kyauk–sa– yit)*, compact soil *(kyit – mye)* and caliche *(phyut- chay-mye)*. Comprehensive studies have not been conducted on the soils in this area, and very little information was available on the soil properties.

Crop production

The major cultivated crops in the surveyed villages were sesame, pigeon pea, groundnut, rice and jujube (Table 5). According to the interviews of the villagers conducted in 2011 and 2012, all the surveyed households adopted a sesame-pigeon pea intercropping system and produced jujube since they owned upland fields. All of the upland crops were cultivated in the inter-space of jujube trees since there were a number of jujube plants scattered in almost all the upland fields.

Table. 5. Cultivated crops in selected households in the surveyed villages, Kani Township, Sagaing Region, Myanmar in 2011 and 2012.

Villages	Number of households growing					Households
	Sesame	Groundnut	Pigeon pea	Rice	Jujube	
Chaung Ma	30	5	30	12*	30	30
Zee Pin Twin	33	3	33	8	33	33
Yet Kan Tine	25	8	25	14	25	25
Tha Min Chan	20	2	20	2*	20	20

* Decision-making for rice growing depended on the onset and availability of rain. The number of rice-growing households changed year by year unlike that of the households growing other crops.
Source: Household interviews in CM, ZPT, YKT and TMC.

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. After 1988, however, transportation, communication and open market policy were well established under the administration of the State Peace and Development Council (changed to the Government of the Republic of the Union of Myanmar, in 2011). As a result, the farmers were aware of the value of the crop and investigated new and advanced technologies, such as the propagation of improved varieties by grafting to local type jujube trees. The villagers were able to produce marketable jujube fruits; sweet, delicious using small-sized jujube varieties instead of the conventional variety. 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.

Groundnut cultivation without any combined crops except for jujube, was also observed but to small extent. According to the sampled household interviews, the number of groundnut growers had decreased because the yield could not cover the inputs, mainly seed cost, since the price of groundnut seeds at sowing time was very high.

Topography of the survey area was characterized by gently undulating land as previously described. Although in some depressions rainfall accumulated, the amount of water was not sufficient for rice cultivation. In almost all the years, some water which accumulated in lowland both directly from rainfall and by runoff from the upland area, had enabled to cultivate

rice. Among the villages, some households owning paddy fields in YKT and ZPT, were able to produce rice every year, because the water-holding capacity of the soil in YKT and ZPT was higher than that in the other two villages, CM and TMC. The farmers in CM and TMC said that they did not produce rice every year because the soil conditions were unfavorable compared to those in the other two villages. The water-holding capacity of soils that were generally sandy, was too low for paddy production. Rainfall was critically unstable and only in some years, there was sufficient water to grow rice. In dry years, paddy field, especially those located in the two villages, were left idle, based on interviews of the villagers in CM and TMC.

According to the local farmer interviews and statistical data, pigeon pea and jujube were 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.

Agricultural practices and machinery

For crop production, farming practices and machinery were investigated based on interviews of the villagers and the statistical year book of the Village General Administration Office (VGA, 2012). Table 6 shows the extent of mechanization in crop production. Several traditional farm instruments, which were manually handled and/or attached to cattle, had been used for tillage operations. The farmers were still using human and animal power. Only a few farmers in the villages used hand tractors. For farm activities, a few households owned water pumps and threshing machines. All the adult members of the farm households were involved in farm work.

Table. 6. Use of agricultural machinery in the surveyed villages, Kani Township, Sagaing Region, Myanmar.

Villages	Number of agricultural instruments					Total number of households
	Plow & Harrow	Seed Driller	Hand Tractor	Threshing Mill	Water Pump	
Chaung Ma	680	-	-	6	2	105
Zee Pin Twin	1,296	6	-	-	5	209
Yet Kan Tine	855	-	4	11	-	172
Tha Min Chan	787	-	-	5	-	148

Source: Village General Administrative Office in CM, ZPT, YKT and TMC.

Note: The number of plows and harrows was counted for several traditional farm instruments which had been used in the farming process, such as iron bars for breaking hard pan,

harrow teeth, crop seeding markers for sowing, inter-cultivator for weeding, inter-cultivator for pruning/thinning, sickle for manual harvest, etc.

For fertilizer application, at the time of the survey, 100% of the interviewed farm households in the surveyed villages applied manure for all the cultivated crops. The manure, a mixture of cow dung, household waste and crop residues, was piled in the corner of their house and applied to the fields before land preparation. The interviewed households stated that they applied all the manures to their fields, which were produced by daily efforts. Tables 7 and 8 shows how manure and chemical fertilizers were applied, including the application rates for each crop in the study area. In sesame and pigeon pea intercropping, the farmers in CM and ZPT did not apply any fertilizers, while in the other 2 villages they applied a small amount. Households who did not apply chemical fertilizers mentioned that the soil characteristics and moisture conditions were unfavorable for profitable yields steadily and that they restricted investment. Among the villages, YKT used the highest amount of foliar fertilizers for groundnut, while one household did not use any. For rice production, the CM and TMC villagers did not apply chemical fertilizers, unlike ZPT and YKT villagers. However, about 50% of the households applied them twice and the higher amount of fertilizers was used for basal application. The others used them only once with a lower amount for basal application in ZPT and YKT.

For jujube, 100% of the sampled farm households in YKT and TMC applied fertilizers, while the TMC villagers used higher application. Sixty seven percent of the surveyed households in CM and thirty nine percent in ZPT used chemical fertilizers unlike others. Most of the households in CM and ZPT who did not use chemical fertilizers told that without chemicals fertilizers, jujube could produce profit comparable to that of other crops.

Table 7. Number of households using manure and/or chemicals for crop production in the surveyed villages.

Village	Number of households using							
	Sesame-Pigeon pea		Groundnut		Rice		Jujube	
	Manure (M)	Chemicals (C)	M	C	M	C	M	C
CM	30	*	5	3	12	*	*	30
ZPT	33	*	3	3	8	8	*	33
YKT	25	8	8	5	14	14	*	25
TMC	20	5	2	2	2	*	*	20

*No households used respective fertilizer.
Manure was a mixture of cow dung, household wastes and crops residues.
Commonly used chemical fertilizers were urea (N) and compound fertilizer (N:P:K 16:16:8 and 15:15:15).
Commonly used liquid fertilizers were Ca:N:Bo 6:5:1.
Source: Household interviews in CM, ZPT, YKT and TMC.

Cropping systems

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. Fig. 3 shows the crops presently cultivated and the crop calendar of the households based on the type of land-holding and season.

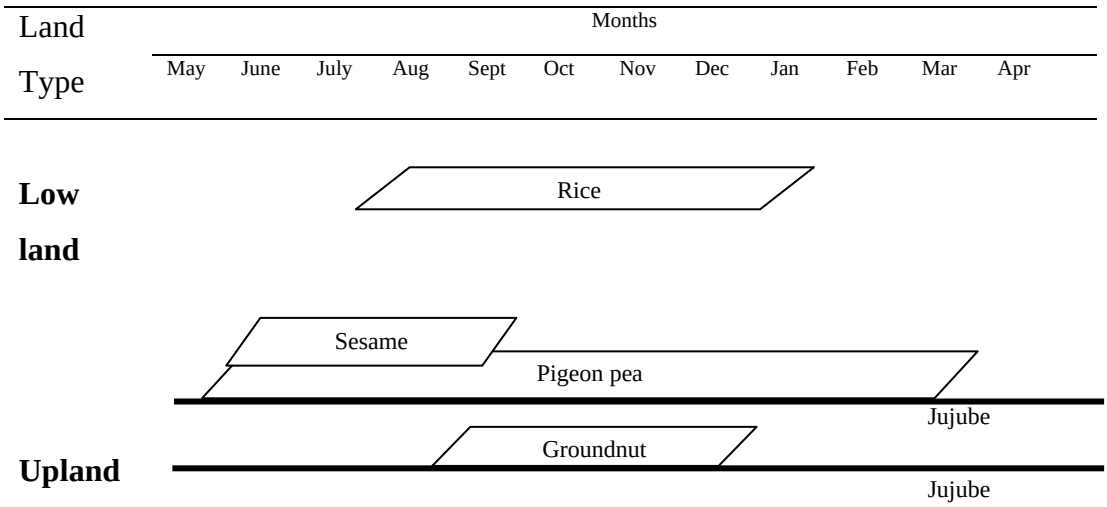

Fig. 3. Crop calendar of the villages studied in Sagaing Region, Myanmar.

In the surveyed villages, a pigeon-pea based cropping pattern was the major traditional cropping system. Under their natural environment, the farmers traditionally planted sesame with pigeon pea in May and harvested sesame at the latest in July or early August. After harvesting of sesame, growth of pigeon pea continued with rain in August and early September. Productivity of pigeon pea was determined by the moisture available at planting time in May and late vegetative and early reproductive growth periods in August according to the farmers. Farmers stated that timely precipitation was essential and they also noted that in some years, insufficient moisture for later growth stages of sesame in July, caused by dry spells, led to lower yield. However, they took this risk because the input for sesame in this cropping pattern was

minimal and negligible compared to the profits from pigeon pea. Groundnut cultivation occurred in August and September. The farmers had planted groundnut during the period from late August to mid-September, during which some amount of rain fell and somewhat stable production was expected. Although groundnut cultivation had decreased year by year recently and its relative importance was not very high, in the past, most of the villagers cultivated it, according to the interviews of the villagers.

According to the household interviews, the choice of crops and cropping system was mainly based on natural setting in their region. For field crop production, supplementary irrigation system managed privately or by the government development project was not available. Water resources such as natural streams were very seasonal since they received water only when rain came. Major soil types in the surveyed villages consisted of sandy and gravel-strewn red soils, with a low water-holding capacity. In this sense, the farmers selected crops which could be produced only under rainfed conditions during the rainy season. The common cropping system, highly evaluated by the interviewed farm households, was sesame-pigeon pea intercropping. Sesame oil is the typical cooking oil for their daily food and it was one of the factors in their consideration. Sesame and pigeon pea were planted in May and sesame was harvested in August. Shading by sesame leaves did not affect the growth of pigeon pea because of the small leaf blades and fall of the lower old leaves. After sesame harvesting, relatively plentiful rainfall was expected in August and September. As a result, the growth of pigeon pea was enhanced, and the moisture received during that period was sufficient for later growth. According to the farming experience and indigenous knowledge, pigeon pea showed a high productivity even in the absence of rain in late October and November. 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. Both pigeon pea and jujube could be exported to India and China, too.

Productivity

Based on the interviews and the data from the statistical year book of 2012 from the Department of Agriculture, the average yield of cultivated crops at the national level and the actual yield in the surveyed area are shown in Table 9. The data clearly indicated that the yield of rice in the research area was significantly lower than national average, whereas that of pigeon pea was similar. Sesame and groundnut yields were also lower than the national average. The villagers stated that crop yields were lower than those in other regions because of the lower soil fertility and available moisture. Especially in rice, the soil type, sandy with a low water-holding capacity, could not give a high yield. Precipitation during the sowing period (May-June) and

growth period (July-October) was also the main factor for determining rice yield. Therefore, investment for rice production was low. For jujube productivity, very little information and few records by the people were available.

Table.9. Average yield in Myanmar and in the surveyed township (Kani , Sagaing Region) in 2012.

Subjects	Yield (kg/ha)			
	Sesame	Groundnut	Pigeon pea	Rice
National	530	1,570	1,250	4,056
Research area	330	993	1,007	750

Source: Department of Agricultural Planning, Ministry of Agriculture and Irrigation, Myanmar and General Administrative Department Office, Kani.

Fig. 4 shows more detailed characteristics of rainfall in the surveyed area during the period from 1991 to 2011. The average annual rainfall of 917mm ranged from 1168mm for the highest year (2006) to 625mm for the lowest year (2001). The value of the coefficient of variation (CV) was 17%, indicating that there were large annual variations during this 21-year period, compared to the other areas of Myanmar. According to Sen Roy and Kaur (2000), CV of annual rainfall during 33 years (1947-1979) was less than 14% in other areas of Myanmar.

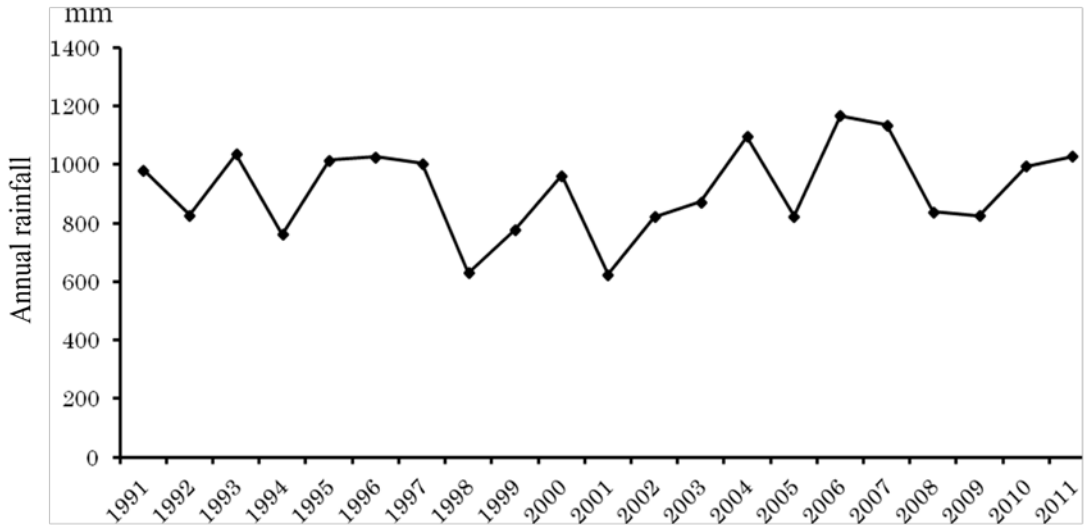

Fig. 4. Changes of annual rainfall during a 21-year period (1991-2011) in Kani Township, Sagaing Region, Myanmar.
Source: Department of Meteorology and Hydrology, Kani (2012).

Fig. 5 indicates the rainfall during crop seasons, which was recorded yearly by the Department of Meteorology and Hydrology, Kani township, i.e. rainfall at planting times of rice, sesame and pigeon pea (May and June) and at the time of the vigorous growth period of pigeon pea or sowing time of groundnut (August and September). During this 21-year period, the average rainfall of the period from May to June was 243 mm and that of the period from August to September was 375 mm. The relatively high values of CV, 46% in the May-June period and 38% in the August-September period, indicated that the yearly variations of the precipitation in these 2 periods were large.

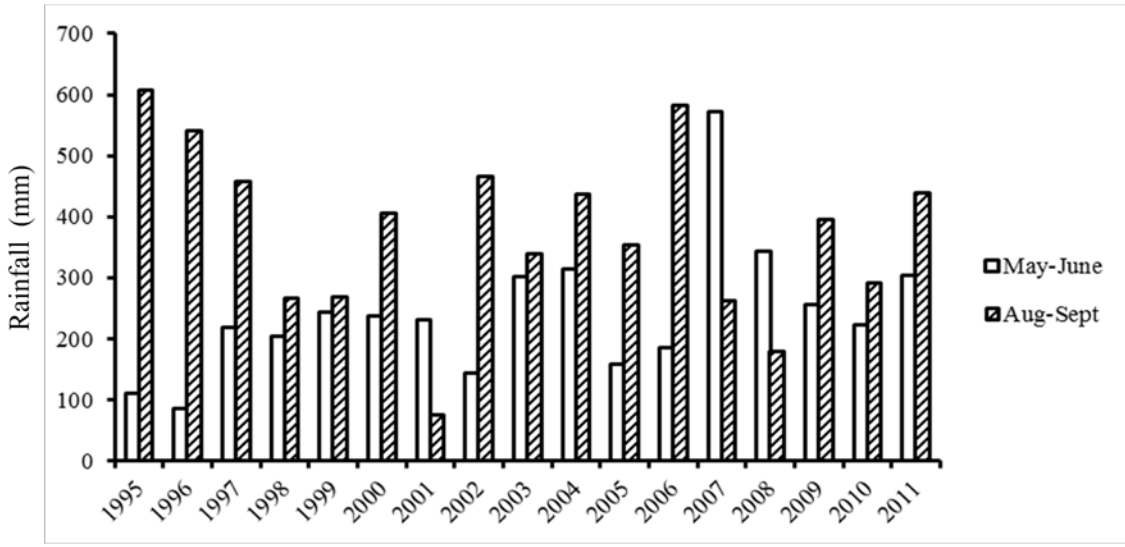

Fig. 5. Rainfall amounts during the periods of May-June and August-September in 1995-2011 in Kani Township, Sagaing Region, Myanmar.

In 1995 and 1996, the lowest amount of rain, less than or about 100mm was recorded in May and June, whereas the highest amount of 500 - 600mm fell in August and September. Therefore, the farmers faced the limitation of soil moisture for planting sesame, pigeon pea and rice, while soil moisture was sufficient for growth of pigeon pea at later stages and groundnut planting. A similar phenomenon was observed in 2002 and 2006. On the other hand, in 2007, rainfall amount during the May-June period was high, while that of the August-September period was low. Hence, soil moisture was suitable for the planting of field crops, but too low for groundnut planting. When the rainfall distribution in 1998, 1999, 2003 and 2010, the rainfall amount during the May-June period and, August-September period did not show a considerable difference. The soil moisture was suitable for planting of sesame and pigeon pea during the May-June period and, also for groundnut planting and growth of pigeon pea during the August-September period. High productivity of all the planted crops could be expected even with the relatively low amount of annual rainfall in these years, suggesting that the cropping systems in

this area were adapted to fluctuation of rainfall distribution within an agricultural season in a year, to ensure successful production from at least one crop, as insurance against the uneven rainfall distribution (Fig. 5).

Although accurate statistical data and records for crop productivity and rainfall were not available, upland crop production had been stable with satisfactory yields several decades ago, according to group discussions with elderly persons in the surveyed villages. They strongly insisted that the rainfall at that time was more stable and evenly distributed. Therefore, the productivity of sesame, pigeon pea and groundnut was significantly high and very reliable for their livelihood. The income from these crops covered household expenditure throughout a year. Starting from the last three decades, however, crop yields had gradually decreased due to uncertain rainfall and insufficient soil moisture.

Natural resources are important and related to all the agroecosystem properties (Subhadhira *et al*., 1987). Among them, soil and water resources determined the productivity of crops here in the Dry Zone. Major upland crops, pigeon pea and jujube could be exported and were the main income source for all the households. Therefore, the farmer selection of cultivated crops in principle was compatible with the adaptability for crops to their agro-environment and natural resources, and also based on the market prices of the crops to some extent, according to the interviews of the farmers. As stated previously, one of the most critical climatic factors affecting agriculture, however, was the large variation of rainfall distribution during an agriculturally important period in a year, rather than the total amount of rainfall (Figs. 4 and 5). Thus, it was essential for the local people to consider crop production in terms of high risk caused by seasonal variation of rainfall.

Crop production in similar natural environment

In Northeast Thailand, in which similar agroecological conditions to those of the Myanmar Dry Zone were observed (Table 10), more than 80% of the agricultural land was used for rainfed farming (Farming System Research Group, 1996), as in the Dry Zone. Like in the Myanmar Dry Zone, farming was performed on a small scale and crop yield was generally low due to the low soil fertility and erratic rainfall in Northeast Thailand (Idhipong, *et al*., 2012). However, the higher annual rainfall in Northeast Thailand may enable paddy rice cultivation on much larger scale than in the Dry Zone of Myanmar. Traditionally, the major agricultural system, rice-based cropping system, had been adopted in association with livestock rearing (Craig and Baker, 1986). Rice is produced for primary subsistence. The focus of rice cultivation is to produce it sufficiently for home consumption and the stability of production is more important than the maximization of yields.

Table. 10. Agroenvironmental data of the Dry Zone of Myanmar and Northeast Thailand.

Characteristics	Dry Zone of Myanmar	Northeast Thailand
Climatic conditions	Semi-arid region	Semi-arid region
Average temperature range	From 15˚C to 32 ˚C	From 19.6 °C to 30.2 °C
Rainfall	From 500 to 1,000 mm rainy season (mid-May to October)	From 900 to 2,500 mm
	cool season (mid-October to mid-February)	rainy season (mid-April to mid-October)
	dry hot season (mid-February to mid-May)	dry season (mid-October to mid-April).
Soil	Mostly sandy soils (including gravel)	Sandy texture
Cultivated crops and cropping systems	Low land (rice-based cropping system)	Low land (rice-based cropping system)
	Upland (pigeon pea-based cropping system, sesame, groundnut, cotton, pulses	Upland (Cassava, Sugarcane)

Source: Food Security Assessment in the Dry Zone of Myanmar.
Natural Resource Management Issues in the Korat Basin of Northeast Thailand, An Overview.

Presently, crops are more diversified than in previous years in Northeast Thailand. Vityakon *et al.* (2004) stated that the expansion of the market economy and increasing commercialization of agriculture arose from socio-political and economic changes at the national and international levels and described the gradual changes from subsistence farming to more commercialized agriculture. About one-fifth of the cultivated area was devoted to upland crops and in the recent decade, cassava and sugarcane have been the two dominant cash crops. Comparison of yields revealed that Northeast Thailand was competing very well with other regions of Thailand for cassava and sugarcane production (Ekasingh *et al*., 2007). Although the Dry Zone of Myanmar and Northeast Thailand shared nearly the same agroecological conditions, Thailand promoted industrialization and open market policy for upland crops. Therefore, farmers in Northeast Thailand were able to adopt a diversified farming system under severe soil and climatic conditions, although the cultivation of flowering herbaceous crops such as maize remained limited.

Cropping systems in the future

Although the present cropping systems seem to be well adapted to the natural conditions, upland crop productivity has gradually decreased due to uncertain rainfall and insufficient soil moisture, according to the villagers. Even though it conspicuous changes in the rainfall tendency could not been found, the local people said that there was distinct rainfall instability, compared to 30 years ago and as a result, crop productivity was also more unstable. As stated previously, since pigeon pea and jujube were crops that could be exported, export market and policy played an important role in the economy of the farm households. Based on these two factors, the villagers were considering for the future.

When the possibility of planting other field crops such as maize was examined, many factors were associated with low yields in Myanmar (Oo and Ekasingh, 2010). The minimum use of improved production technologies was one of the major factors responsible for low yields. The farmers pointed out that maize needed more nutrients, displayed a low drought tolerance and absorbed a large amount of nutrients from the soil. Continuous cultivation of maize might have caused a decline of yield, compounded with the decline of soil fertility and decreased water-holding capacity of soil according to group interviews conducted in 2011and 2012. For the introduction to the Dry Zone of Myanmar of sugarcane and cassava, that are more tolerant crops to environmental stresses and have already been cultivated widely in Northeast Thailand, social investment, such as the construction of processing factories, would be necessary. According to observations of this study, under the high-risk rainfed conditions and soils with a low water-holding capacity and fertility, the farmers tended to limit investment for crop production. The use of chemical fertilizers, which were considered to be useful to enhance the tolerance of crops to various stresses, could not completely compensate for the difficulties of producing profitable yields. Therefore, the current rainfed agriculture may not provide economic growth and food security needed in the near future.

To consider crop production in terms of high risk-rainfed conditions and price fluctuations, one of the Dry Zone products, Thanakha, *Limonia acidissima* (syn. *Hesperethusa crenulata*), a tree plant, whose bark is used for a natural and traditional cosmetic, made by grinding the bark with a small amount of water on a circular stone slab, could be suitable for cultivation. It makes skin smooth and cool, and is considered to remove acne. Joo *et al*. (2004) indicated that UV-absorbent, Marmesin, extracted from the bark of Thanakha could be commercially successful as a UV A-blocking product since Thanakha had long been used as a cosmetic in Myanmar without causing toxicity. Wangthong *et al.* (2010) also stated that the stem bark of Thanakha had been commonly used especially by Myanmar women, for more than a thousand years as a skin care product. The trees that grow in the upland area of the Dry Zone

are more fragrant than those produced in other areas. It is considered that if they were produced in fertile soil, their quality would be low with a thin bark and large trunk. The demand is very high in this region because Thanakha with good quality can be produced only in some specific areas of the Dry Zone. Even the upland farming area under high risk-rainfed conditions, some riverine villages in which better condition for available underground water irrigation, introduced more profitable cash crops in domestic and foreign markets, such as betel vine, hybrid tomato and muskmelon. Betel vine is a non-food, but demand is stable with high consumption, and tomato is indispensible for daily food system. Muskmelon cultivation is expanding in these regions, with the incentive of China market.

Conclusion

The present study on agroecosystems of the Dry Zone based on various data and interviews of the local people about farming practices revealed that they were well adapted to their agro-environmental conditions, since the major land type consisted of upland crop fields, which accounted for 92% of the cultivated area. A vast rainfed upland area led to nearly total dependence on field crops such as sesame, pigeon pea and, groundnut and a fruit tree (jujube). A pigeon pea-based cropping system, i.e. sesame-pigeon pea intercropping has been sustainable in these areas since long time ago. Mechanization and chemical fertilizer application for the improvement of crop productivity were very limited. Edible oil crops, such as groundnut and sesame were produced mainly for home consumption. Pigeon pea, one of the important commercial crops was drought-tolerant and fertilizer requirements were minimal, compared to those of other field crops. Jujube required the least inputs but provided high income if the export market was favorable. Therefore, the existing cropping systems had been adopted long time ago, and enabled to secure home consumption with adaptability to the environment, in addition to providing income to buy staple foods. In this sense, people in the survey area in the Dry Zone were well adapted to their agro-environment even under severe conditions. This conclusion was in agreement with the study of Matsuda (2013), who investigated the changes in crop productivity in a village in the Sagaing Region.

According to Matsuda (2013), maximization of productivity, which tends to reduce stability, would not be appropriate in his surveyed areas. However, the local people were worrying about the future for crop production. Even though the present system, sesame-pigeon cropping was adapted to the local environment to some extent, they were still uneasy about the instability of rainfall and crop market. Therefore, the introduction of new crops, and changes to new systems in this region are likely to take place in the near future.

In this chapter, I clarified the agroenvironment, land use and existing farming systems in the Dry Zone, and analyzed the stability and adaptability of these systems. According to the objectives of this study, in the next two chapters, the recent changes in farming and cropping systems are analyzed and discussed for the local people to adapt themselves to agroecological changes.

CHAPTER 3

Introduction of Cash Crop Production in Dry Zone, Myanmar: A Case Study of the Village in Chindwin River Basin, Sagaing Region

Introduction

In the recent years, there has been increasing interests on the effects of people-plant interactions on the livelihood of people in main land Southeast Asia, including Myanmar, Laos, Thailand, Vietnam and Yunnan Province of China (Ochiai, 2012). People in these regions mainly cultivate rice, staple food crop and other food crops for daily diet, in addition to commercial crops as a source of cash income. Hence, rainfed agricultural systems are major modes of agriculture in the Dry Zone, except in the relatively small irrigated areas, where supplemental irrigation systems can be managed privately or by government development projects.

In most tropical areas, population growth is one of the major factors to induce changes in land use and farming systems, but other factors, such as policies, cultural norms, economies and climate prevailing in a given geographical location also play significant roles (Lambin *et al.*, 2003). In Africa, the small holders were facing insufficient income to buy foods and household needs (Gladwin *et al.*, 2001). They were dedicating most of their land to the production of indigenous food crops, such as cereals, which are allegedly associated with low returns for the farmers. Small holders in the Dry Zone were also facing uncertainty in crop productivity and market as shown in the previous chapter (Aung and Sripruetkiat, 2010, Yee and Nawata 2014). As the population increased, the demand for agricultural products had rapidly increased to buy rice, household needs and social obligations, in addition to costs of the inputs used in crop production. But the production was generally not enough and the local people are required to strengthen agricultural systems that can produce more incomes. This tendency could be also seen in the Magway Region, Dry Zone (Aye and Chamjai, 2009).

Farming systems in Sagaing Region have gradually changed over the last decades caused by various factors, including population growth (CSO, 2005) and resulting insufficient income, although major modes of agriculture have not changed drastically. In these several decades, the local people have been introduced new cash crops in some specific area and modified their cropping systems. The objectives of this study were to analyze how a new cash crop was introduced into an upland farming system and how the new cropping system including a new cash crop was established in a selected village, Sagaing Region.

Methodology

Song Chaung (SC) village, Yinmarbin District, Sagaing Region, was located on the Chindwin River basin (Fig. 6). SC, one of the hamlets in the Song Chaung administrative village (Song Chaung Village Tract), was organized by 4 small sub-hamlets, locally called East, West, South and North SC, whose total number of households was 927 with 5790 people. It was located 16 kilometers northwest of Monywa City and 35 km northeast of Yinmarbin Town, and West SC was selected for the present study. The Chindwin River is the main river of the Division, starting from the northern valley surrounded by highlands of northern Sagaing Region and Kachin State, flowing into the Ayeyarwaddy River near Myingyan Township, Mandalay Region. The river flows through the eastern parts of the Yinmarbin Township and there are two nearby major roads, the Pathein-Monywa Highway, from Monywa City to Pathein City in the Ayeyawaddy region, and the Monywa-Yargyi-Kalaywa Highway, from Monywa city to Kalaywa Town, then leading to the border area with India. Some specific areas in the Sagaing Region, i.e. Sagaing District, Monywa District and Yinmarbin District have been the largest wheat-growing areas with relatively high yields.

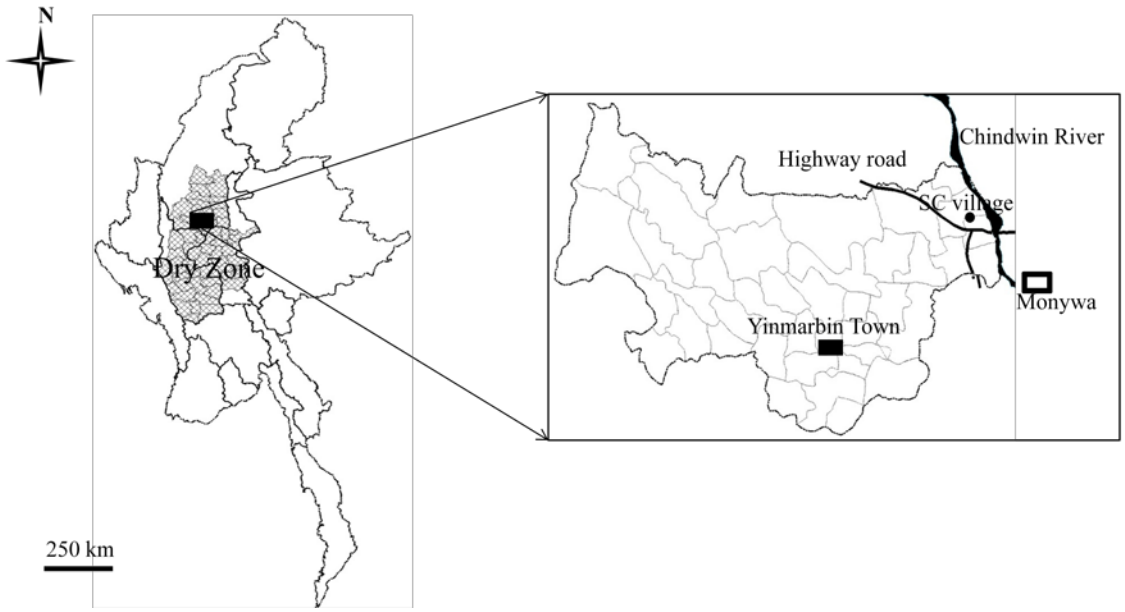

Fig. 6. Map of the study area in the Dry Zone, Myanmar

For this study, firstly, the preliminary survey was carried out to clarify the village natural setting, agroecological conditions, current situation of agriculture and agricultural background by interviewing village headmen and knowledgeable old villagers in 2011. The

survey was further conducted on several occasions in 2012 and 2013. It included interviewing farmers of 52 farm households in the surveyed village with the total number of 160 households and 882 populations at the time of the survey and observing their fields.

Households were randomly selected for interview surveys regarding agricultural activities and farming systems at present and past. Further investigations were conducted by informal discussions and group interviews with villagers. In the discussion on the changes in the cropping patterns, the year of 1988 was used as the base line year for cropping systems because the farmers recalled this year very clearly as the transition point for Myanmar political situations, as a result of large agricultural and economic changes. Field observations were conducted to confirm the topography, soil characteristics, household land ownerships, cropping systems and agricultural practices. Information and relevant statistical data were also obtained from various institutions such as District offices, including the Departments of Agriculture, the Settlement and Land Record, and the Meteorology and Hydrology in Yinmarbin and Monywa Districts.

Results and Discussion

Characteristics of the surveyed village

In the Song Chaung Village Tract, the major livelihood of the local people was agriculture with 1248 hectare of agricultural land. The main cultivated area, 891 hectare was situated in undulating upland and upland near riverine area, whereas 357 hectare in lowland, or back swamp in the riverine fields, including 129 hectare of seasonal alluvial plains, which appeared after flood water receded. Therefore, 71% of total agricultural land was located at undulating upland and upland near the river coast. Riverine lowland in this village was flat and included depression areas, where the water was retained in the rainy season.

Based on the data from the statistical year book in 2013 of the Village Administrative Office, the numbers of household and their land holdings were categorized in Table 11. The data clearly showed that nearly half of the households possessed less than 1 hectare of land and large holders were limited. The farmers in the Song Chaung Village, therefore, were regarded as small holders, based on the definition of small holder farming by FAO (2010). According to the statistical year book of Village Administrative Office, population in the surveyed village increased 31 percent in a 13 years period (2000-2013) or at a rate of 2.4 percent annually.

Table 11. Land ownership of agricultural households in Song Chaung (SC) Administrative Village, Yinmarbin Township, Yinmarbin District, Sagaing Region in 2013.

Land area (ha)	Households	% of total
<1	378	43
1-2	212	24
2-4	154	18
4-6	108	12
6-8	25	3
	877	100

Source: The Village General Administrative Office, Song ChaungVillage

The major livelihood of the surveyed village was agriculture and almost all the people were farmers. In the surveyed village, several upland and horticultural crops, such as pigeon pea, wheat, groundnut, chickpea and garlic were produced under rainfed and/or irrigated conditions with privately managed irrigation systems, but there was no land for rice cultivation. The landless households also depended on agriculture to earn incomes from farm activities. In most cases, farm works were done using family labor, but hired labor was common during peak seasons like planting and harvesting of the crops. The agricultural products were sold to local markets at the Monywa City. The road connecting the village with the Monywa City was developed in 2003. Before that, the river was used for transportation.

Agricultural environment, topography, land types and soils

Fig. 7 showed the mean air temperatures in 13 years (2001-2013) with average monthly rainfall for 43 years (1971-2013) in Yinmarbin Township. The mean air temperatures were high during the period from May to October, and the average monthly air temperatures during this period were above 25ºC with the maximum air temperatures of about 43ºC in March, April and May. In other months, they seldom exceeded 25ºC. From December to February, it was cold with frequent foggy days and the minimum air temperatures were sometimes lower than 10ºC according to the data from the Department of Agriculture. The area was characterized by a bimodal rainfall distribution pattern influenced strongly by monsoon. The rainfall was concentrated during the period from May to October with the heaviest rainfall in September. In July, dry spells occurred but the length and frequency of the dry spells were unstable.

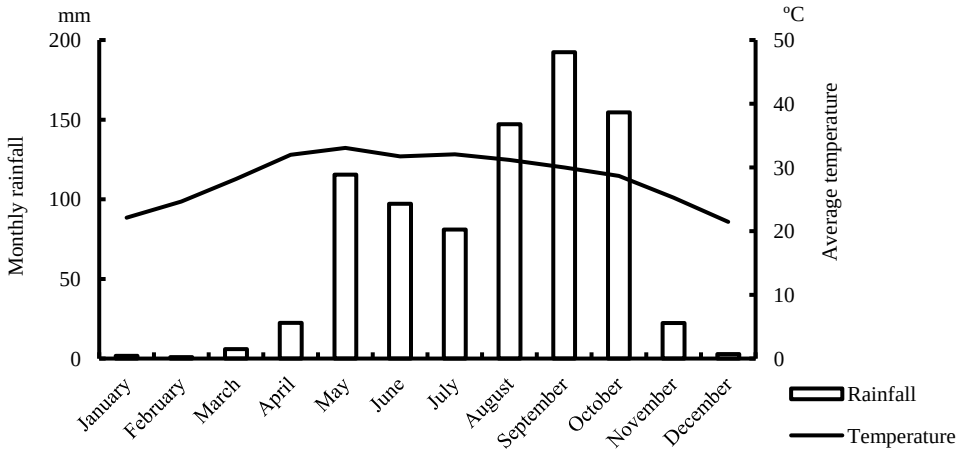

Fig. 7. Monthly average rainfall in 43 years (1971-2013) and mean air temperatures in 13 years (2001-2013) inYinmarbin Township, Sagaing Region, Myanmar.
Source: The Department of Agriculture, Yinmarbin District (2014)

The surveyed village consisted of flat or gently undulating plains, located at the average elevation of 77 m. Local farmers classified and named their lands according to land and soil properties, *Kone*, *Kyune* and *Inne* respectively. Undulating upland area *(Kone)* were characterized by the elevation of 77-81m and scattered in the whole village territory. The eastern edge of the surveyed village was riverine natural levee *(Kyune)* with the height of 71-73m. The village residential area was surrounded by riverine lowland, or back swamp (*Inne*), the lowest region of the village with the elevation of 60-70m. Based on physical properties and appearances, local people subdivided the soil into 3 types, i.e. gravel strewn red soil (*mye- ni–kyauk–sa– yit*), sandy loam (*the non-mye*) and dark compact soil (*ta- ne mye*). According to the analysis by the Soil Science Division, the Department of Agricultural Research, properties of the respective soils in different land types were shown in Table 12. The soil in the back swamp area was clayish with the highest organic matter contents, whereas undulating upland areas had the smallest organic matter contents and soils in the natural levee were characterized by the highest percentage of silt.

Table 12.Properties of different soil types in Song Chaung (SC) village, Yinmarbin Township, Sagaing Region.

Land	Soils (local name)	pH	N (mg/kg)	P (mg/kg)	K (mg/kg)	Organic Matter (%)	Soil Texture (%)			Soil Texture
							Sand	Silt	Clay	
undulating upland	*mye- ni–kyauk–sa– yit*	8.51	80	8	145	0.76	78.8	8.8	12.4	Sandy loam
Natural levee	*the non-mye*	8.18	65	5	78	1.25	53.6	35.5	10.9	Sandy loam
Back swamp	*ta- ne mye*	7.50	114	18	135	1.30	60.6	14.9	24.5	Sandy clay loam

Source: Soil Science Division, TheDepartment of Agricultural Research, Yezin, Myanmar

Crop production in the past (up to Socialist period, ~1988)

The village had no land for paddy production as previously described, and the major cultivated crops were upland crops such as wheat, groundnut and chickpea since long time ago. According to the interviews with key informants and knowledgeable elder persons, there was a market for staple crops in Monywa for domestic consumption and the household economy was supported mainly by the income from selling wheat, chickpea and pigeon pea. The villagers said that, in the Socialist Era, they were in good communication and sharing knowledge with neighborhood, and supported by the governmental institutions. The institutions supplied new varieties and provided agricultural technology for the application of chemical fertilizers and insecticides, etc. Crop productivity in that period was remarkably stable and able to assure home consumption because some portion of chickpea and pigeon pea was consumed at home, in addition to gaining income to buy rice and supplementing household income. Fig. 8 indicated basic cropping systems in different land types that the villagers practiced, up to the end of the Socialist Era (1988). In rainy season, pigeon pea was planted in the undulating upland fields. In upland fields with better soil characteristic, the villagers cultivated wheat and chickpea in early dry season. During the dry season, in the natural levee and the back swamp area, wheat, chickpea, groundnut and garlic were grown.

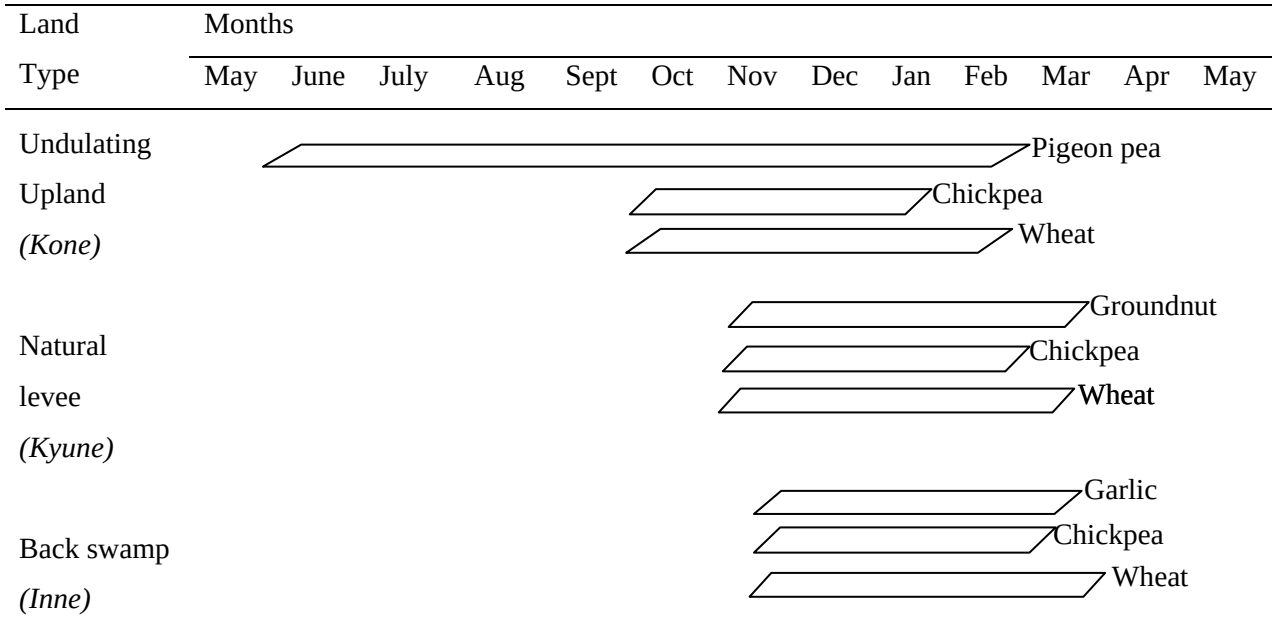

Fig.8.Crop calendar of the surveyed villagein the past, up to the end of the Socialist period (~1988)

Source: Villagers' interviews, group discussions in 2012, 2013

Introduction of a new cash crop

In the neighborhood of the surveyed village, 16 km away from the village, there was a village called “Twin”, in Budalin Township, Monywa District, near the natural lake area, Twintaung, in which Spilulina, one kind of algae, was produced. The villagers in this village started betel vine production since 1980, according to the interviews with the local people in 2011. The village had been very famous for betel vine production and village economy was also much improved. The quality and productivity of betel vine in that village were highly evaluated in the Monywa betel vine market, according to the interviews with brokers in the Monywa betel vine sale center. One of Song Chaung villagers, working in that the Spirulina production factory, noticed the successful betel vine production there and learned the cultivation technology. Then, he transferred the technology of betel vine cultivation to villagers in his native village. He cultivated betel vine in one of his farms and shared the knowledge to the villagers. The trial period for the betel vine cultivation in SC was in 1988 and 1989, and betel vine was widely grown in 1990, according to the interviews with the villagers. In contrast with field crop production under rainfed conditions, betel vine farms needed regular irrigation. The villagers started to construct ground water irrigation systems in their farms with a tube well and water pump. Because of the proximity to the Chin Dwin River, groundwater was available to use for irrigation.

When 52 households were interviewed in 2012 and 2013, the villagers explained the process of the introduction after confirming the adaptability and profitability of betel vine in their village. As stated previously, all surveyed households cultivated pigeon pea, wheat and chickpea in their upland fields up to 1987 (Fig. 9.a). Among 52 interviewed households, 15 households who owned relatively large farm land started the cultivation of just only 100-200 betel vine plants in 1988 (Fig. 9.b). A limited number of betel vine were planted in a small part of their upland fields, and after confirming the profitability of the betel vine production, they extended the betel vine farm in 1990. Among 37 remaining households, 30 small holder households followed the betel vine cultivation after observing others’ success. The last 7 households, landless at that time, gained land tenure for betel vine growing by the local agreement among the villagers (Fig. 9.c). According to the villagers’ interviews and field observations, the introduction of the new cash crop occurred only in upland, and back swamp and natural levee were fixed with existing dry season crops.

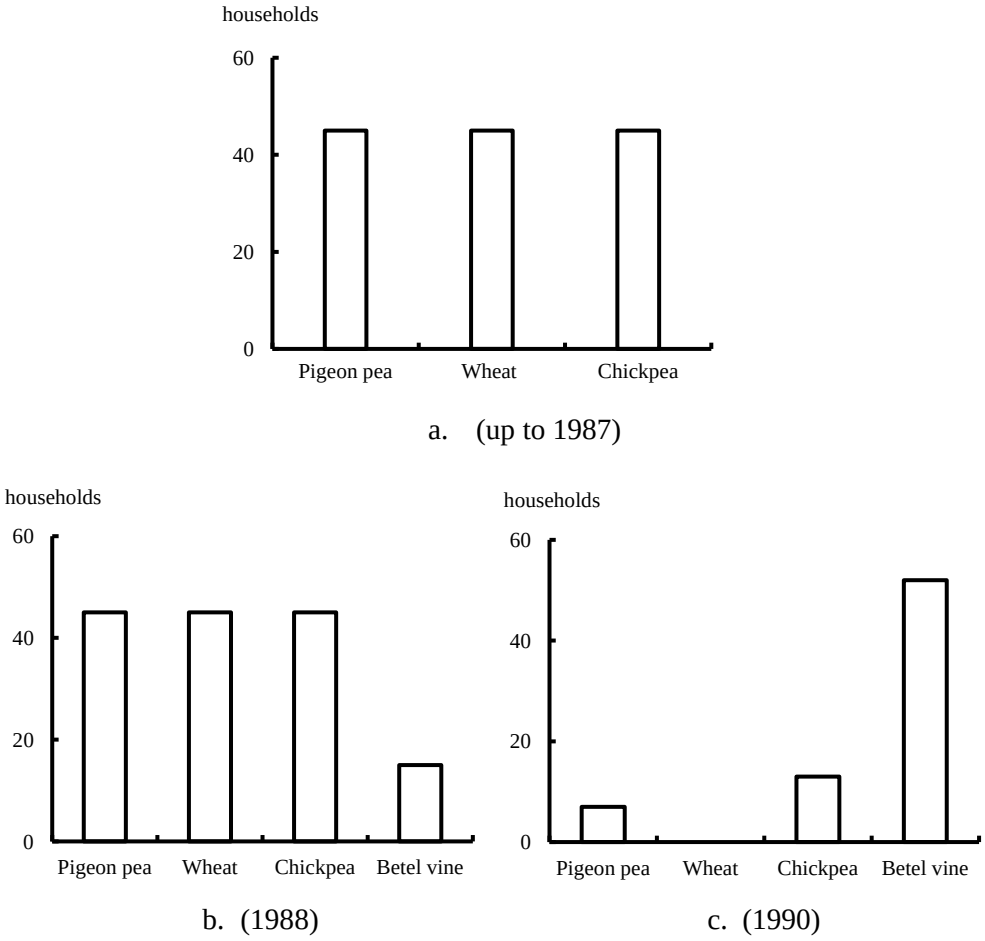

Fig. 9. Selected households and expansion of betel vine cultivation in upland before 1987, 1988 and 1990.
Source: Household interviews in 2012 and 2013, and Village General Administrative Office

Betel vine in Myanmar

The betel vine (*Piper betel* Linn), belonging to Piperaceae, has deep green heart shaped leaves. According to the old histories, Myanmar people were accustomed to the betel chewing since the ancient time. Basically, a betel quid (*Kone Yar)* was composed of betel vine leaf, betel nut, slaked lime, tobacco and catechu or cutch (extracts containing tannin, obtained from the heartwood of an Indian acacia tree, used for tanning and dyeing), according to Myanmar tradition. It is used in a number of traditional medicines, and in many cultural and social activities in Myanmar. Kyaing *et al* (2012) reviewed that, betel vine consumption was the highest in Myanmar, compared to the other neighboring countries.

Betel vine production system in the study village

According to the interviews with villagers and field observations, the betel vine production system was as follows.

The farmers cultivated the betel vine in their lower upland fields with irrigation, since the betel vine was not able to adapt themselves to lowland at back swamp because of waterlogging damages and to higher upland for water shortage. Land preparation was done in the rainy season, mostly in June and July. They prepared the planting rows with 1m spacing and plant spacing was 0.5 m. Organic substance, a mixture of cow dung, crop residues and household wastes was applied to the spacing lines as basal manure and irrigated the field to enhance decomposition before planting. At this time, a simple greenhouse was constructed for shading to protect newly planted shoots from sunburn.

For new planting, multiplied betel vine shoots had to be prepared at least 28-30 days prior to the desired planting date and well managed. After introducing a betel vine production system from Twin village, the farmers established a betel vine propagation system in their own farms by cutting and layering. To be the qualified shoots for propagation, 1 year old betel vine plant was the best for further growth and successful harvests. For their new farms, the villagers paid a great attention in selection of betel vine shoots for planting. When they bought shoots for planting from other farms, they carefully observed them and checked the history of that farm, whether this farm was free from the diseases in the past.

Cultivation was started in August or September or October, but it was considered to be the best in September. Shading was especially important for a new farm, and therefore, roofing the simple greenhouse with branches and leaves of coconut, neem and other trees or shrubs (Fig. 10. a), or plastic nets (Fig. 10. b) had to be done prior to the planting date. The young shoots were planted to the spaced lines and irrigated. Two weeks later, small woody poles were set attached to each plant, to support the climbing vines. Topping was done by hand when new shoots were 1 month old, to enhance the development of new lateral branches and shoots. One of the important factors for betel vine cultivation was to keep shading the whole farm to provide proper amount of sunlight. The common diseases, infecting betel vine plants, were bacterial leaf spot, stem rot and foot rot. Weeding, fertilizer application, irrigation and drainage, plant protection and soil management were operated in appropriate times.

(a)

(b)

Fig. 10 a. A simple greenhouse with branches and leaves roofing
b. A simple greenhouse with plastic net roofing

A newly planted betel vine farm started to be harvested and to produce income 5-6 months after planting and after that harvest was carried out twice a month. Although it depended on the management, inputs used and plant protection, the lifespan of a betel vine farm producing profits was generally about 3 years after planting. Fig. 11 showed monthly yields and selling prices of the betel vine in 2013 in this village. In this figure, the calculation of betel vine production was based on 500 plants. The farm size with 500 plants was the basis for the management, according to the discussion and group interview with the farmers. The minimum productivity was found in December and January with low temperatures. In August and September, higher yields were observed probably because of plenty of rains. The low productivity caused higher prices in December and January, whereas high productivity lowered prices in August and September.

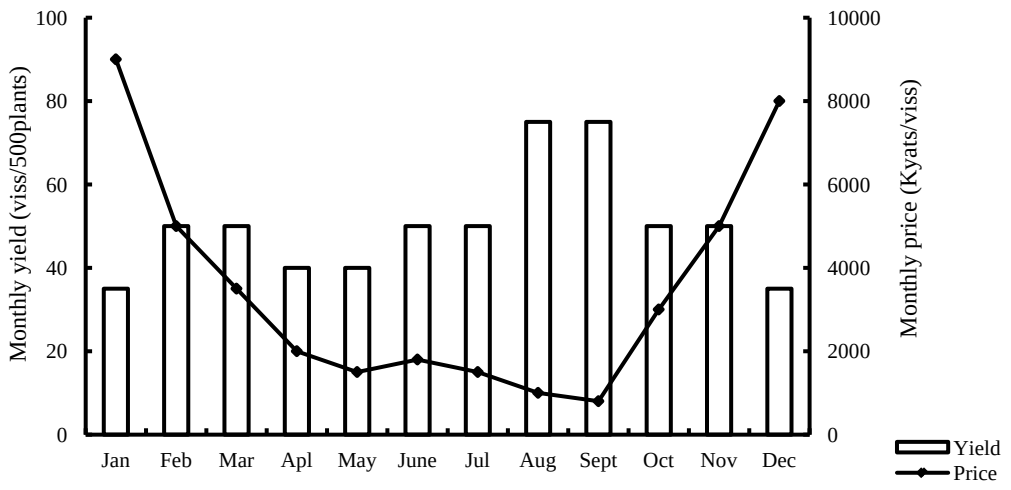

Fig. 11. Changes in yield and selling price of betel vine in a year
Source: Farmers and local broker interviews in 2013

The productivity and crop price in 2013 were described in Table 13. The yields and crop prices were calculated from the data obtained from the interviews with farmers, local brokers, wholesale merchants and officers at the Crop Market Section of the Department of Agriculture in Monywa. The results showed that the annual income from betel vine at unit area basis was 10 times larger than that of pigeon pea, wheat and chickpea. In addition, the income was gained in short duration, twice a month, because harvest was done twice a month, and this formed one of the incentives of producing betel vine. Although the income from betel vine was much higher than field crops, the farmers limited the production scale because of high investment such as the costs of new young shoots for planting, construction of simple greenhouses, roofing, and labor and management, according to the villagers interview and field observation.

Table 13.Average yield and price of crops in upland area of SC village (Yinmarbin Township,Sagaing Region) in 2013.

Crops	Price (Kyat/basket, Kyat/viss)*	Productivity (basket/acre, viss/500 plants)**	Income/year (Kyat)
Pigeon pea	24,000	7	168,000
Wheat	12,000	12	144,000
Chickpea	20,000	8	160,000
Betel vine	800-9,000 ***	600	1,860,000

Source: 1. Farmers and local brokers' interviews, in 2013

2. The wholesale centers and crops market section, The Department of Agriculture, Monywa

*Kyat/basket for field crops and Kyat/viss for betel vine.

**Basket/acre for field crops and Viss/500 plants for betel vine. Total productivity was calculated in a year. Five hundred plants were the basis for the management of betel vine and the upland crop yield per unit area was shown based on local measurement.

***Viss was a Myanmar measurement for weight (One vissis ca. 1.65 kg.).

Note: Income/year of betel vine was calculated based on the average and common price in this region. Nine hundred and fifty Kyats is ca. 1USD (in 2013).

Present cropping system

Cultivated crops and cropping patterns of the past and present were significantly changed by the introduction of betel vine in upland fields, but in riverine natural levee and back swamp were remained unchanged, according to the interviews with the villagers and field observation.

At the time of the survey, 100% of the interviewed farm households cultivated the betel vine in their farms. Thirty five percent of the interviewed farm households in the surveyed village owned only upland, and 23% of households had both upland and lowland, whereas 29% of them possessed upland, lowland and land at natural levee. The other 13 % owned land tenure only for betel vine cultivation. According to field surveys and interviewed data, although the villagers have not abandoned field crop production in upland area, their main concern was for betel vine cultivation. Fig. 12 indicated the present cultivated crops and crop calendar of the households based on the type of their land holding and season. In the undulating upland fields, betel vine farms were major components. Although it depended on the crop price, chickpea was grown to some extent because betel vine cultivation was rotated with chickpea cultivation or fallow. Wheat and pigeon pea production was very rare in this land category with low productivity.

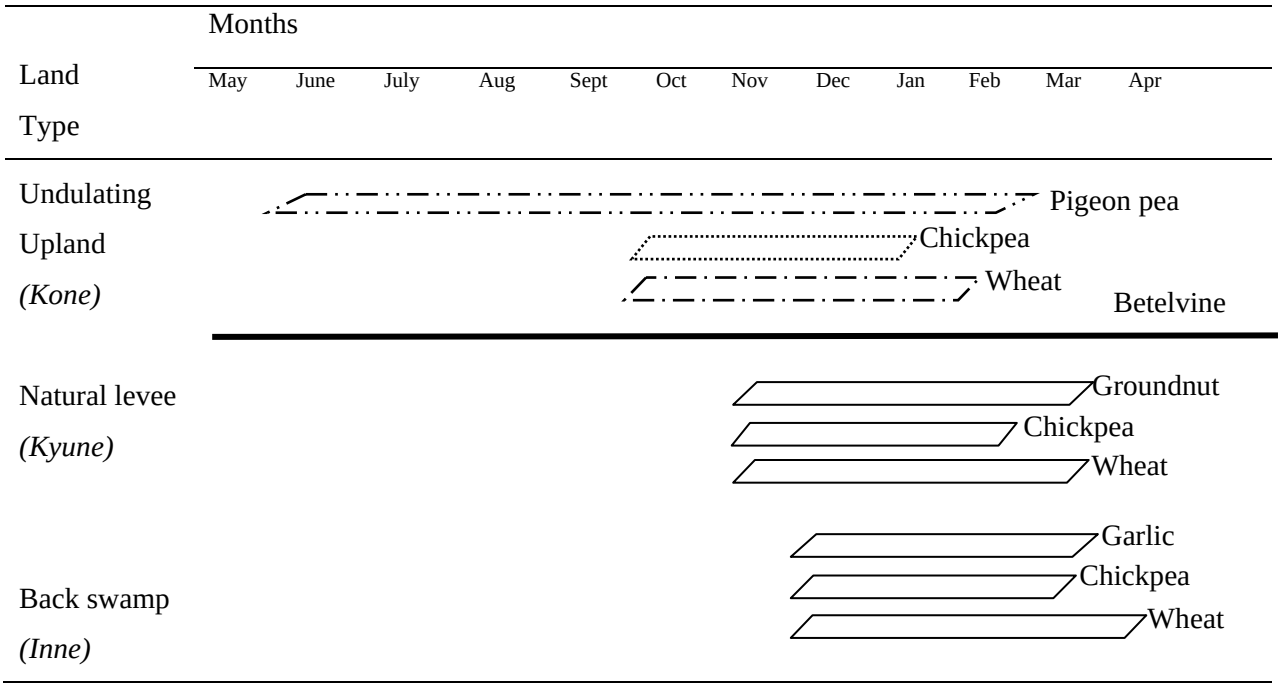

Fig.12.Crop calendar of the surveyed village in the recent years
Source: Farm household interviews and field surveys in 2012, 2013
Note: The thick line shows the betel vine production throughout the year.
The broken lines show very rare production in wheat and pigeon pea.
The chain line shows the production of chickpea to some extent (rotate with betel vine cultivation or fallow)

It is considered that factors to enable successful production of betel vine in this village are several conditions for cultivation, such as availability of irrigation by underground water (Kaleeswari and Sridhar, 2013) and soils with good drainage (Sengupta, 2014). Usually the depth of the groundwater table is small near permanent bodies of surface water such as a stream, lake and river (Winter *et al*., 1998). This village is located near the Chindwin River and rich riverine groundwater can be used for irrigation throughout the year, according to field observation. When a possibility is considered to introduce this crop to other upland crop producing areas in the Dry Zone, available water resources can be the limiting factor in most of the areas. The moisture requirement for betel vine is much larger than upland crops.

The next important factor was the improvement of infrastructure. The relatively low level of infrastructure and resulting long transportation time lead to high transaction costs for purchases and sales of agricultural inputs and outputs that limit agricultural productivity and growth (Tunde and Adeniyi, 2012). By the changes of the transportation measures from waterways to the Monywa-Yagyi-Kalaywa Road, perishable commodities like betel vine could reach from the surveyed village to the main trading centre, Monywa City with less time consumption. The previous study had suggested that road improvement not only reduced

transportation costs and increased producers' prices, but increased the area where the good could be sold (Minten and Kyle, 1999). For Song Chaung village, the location of nearby major roads also provided better chances to reduce cost, to produce higher income and to enlarge market. These conditions in the surveyed village, i.e. groundwater availability and distance to the markets, were site-specific and more favourable for betel vine cultivation than other areas in the Dry Zone. In other villages with quite similar topographical conditions, transportation conditions such as good infrastructure and the proximity to the markets are also the significant factors.

According to the interviews with local people, the betel vine farms in this village were found to be infected by some diseases in the past. The villagers had well controlled these diseases by several management practices, such as use of healthy young shoots, and crop rotation with appropriate fallow periods. The farmers practised the betel vine cultivation on a limited scale and as a consequence, they managed to do rotation cropping of betel vine with other field crops and fallow the betel vine farm for 2-3 years. Moreover, soil addition was a good management procedure for successful betel vine cultivation in this village. When the plant was 1 year old, the villagers added and piled the sandy clay loam soil from the back swamp area (*Inne*) to each plant lines and covered the foot of the betel vine plants. According to their experience, this soil addition accelerated the vigorous growth and assured the long-term successful betel vine cultivation. Soil addition was done once a year during the betel vine cultivation. As Jane *et al.* (2014) stated, betel vine cultivation was affected by some of serious diseases, such as bacterial leaf spot and stem rot, which occurred very virulently and if not controlled, the cultivation resulted in the total destruction of the entire farm. With their good and careful management during the long-term cultivation period, such as the selection of disease free juvenile plants, proper irrigation and drainage, appropriate fertilizers application and plant protection, and soil additions, the local people were keeping the successful betel vine cultivation without severe disease damages, according to the field observation and interviews.

As profitable new cash crop, betel vine had been successfully introduced in the surveyed village with high profit. The villagers paid a great attention to invest for the production of betel vine, which could produce net profits with a high frequency, in comparison with field crops. In general, the profitability of horticultural and industrial crops was high (Fujita and Okamoto, 2006) and the introduction of betel vine had contributed substantially to the improvement of the rural economy of this village. Although there were several villages along the Chindwin River, these villages were unfavorable to produce betel vine, because their land holding was mainly located at back swamp areas. Therefore, water-logging was a big problem for betel vine cultivation.

Conclusion

Intensive surveys, including field observations, interviews with the local people for their farming practices and the collection of various data, revealed that the introduction of a new cash crop, betel vine was successfully done in the surveyed village. The village was located near the Chindwin River and the groundwater irrigation could be used throughout the year. Improvement of the transportation and short distance to the market were also favourable for successful introduction of betel vine cultivation in this village. By using these advantages, the introduction of the new cash crop, betel vine was done 25 years ago and cultivation has been successfully carried out. Since careful process of the introduction, the villagers have accumulated experiences on betel vine cultivation and have improved management systems. The selection of disease free plants, proper irrigation and drainage, plant protection systems and soil additions during the long-term cultivation period may have resulted in successful betel vine cultivation at present.

The present study in the surveyed village provides a good example for the successful introduction of a new cash crop using the advantageous conditions. Without the special situations, such as the availability of water resources, village location securing transportation and villagers' efforts, the introduction of betel vine cultivation in other area may be difficult.

CHAPTER 4

Introduction of New Cash Crop, Thanakha and Diversified Farming System: A Case Study in Yinmarbin Township, Sagaing Region, Dry Zone, Myanmar

Introduction

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, for example, the introduction of sugarcane in Northeast Thailand (Ekasingh *et al*., 2007) and that of vegetables in Red River Delta, Vietnam (Yanagisawa *et al*., 1999) at village levels.

As stated in the previous chapters, small holders in Sagaing Region had been facing uncertainty in crop productivity in terms of yield and market price fluctuation since several decades ago (Hoseop and Gilhaeng, 2003, Yee and Nawata, 2014). In this sense, local people have introduced more stable new cash crops and practiced diversified cropping systems to provide higher economic viability than those in the traditional cropping systems. The study in this chapter aimed to analyze the process of the introduction of a new cash crop into their existing upland cropping systems and how the farmers operated diversified agriculture in the selected village.

Methodology

The surveyed village in this study, Kyauk Pyoke (KP), Yinmarbin District, Sagaing Region, was located in the undulating plains, about 15 km north of Yinmarbin Town (Fig. 13), at the average elevation of about 130 m above sea level. The capital of Sagaing Region, Monywa was 34 km southeast of this village, and for trading agricultural products and social needs, the villagers frequently went to Monywa city. Monywa-Yagyi-Kalaywa Road, which connected

Monywa to the Indian border, passed through the eastern regions of Yinmarbin Township administrative area, about 5 km away from the surveyed village.

This village was selected for our study after preliminary surveys in 2011 in whole Yinmarbin Township administrative area, because it was notorious in scarcity of water among the neighboring regions, lack of irrigation systems and dependence on upland crop production. The surveyed village consisted of 185 households with the population of 1037, at the time of the survey in 2014. Among 185 households in the village, 110 households were the farmers and the other 75 households did not own their land for practicing agricultural activities. Thirty-four farm households among 110 agricultural households were randomly selected for interviewing them and observing their fields in 2012, 2013 and 2014. The interviews covered land use, crops and cropping calendar, cultivation, and farming and cropping systems at present and past. For further investigations such as village history, changes in crop productivity, and weather conditions in the past, group interviews and informal discussions with knowledgeable elder persons and villagers were implemented. Observations and field visits were conducted to confirm the topography, physical conditions of the soils, household land ownership and agricultural practices. Information and statistical data were also obtained from the various institutions such as District Offices, including the Department of Agriculture, the Meteorological Department in Monywa and Yinmarbin Districts, and the Village General Administrative Office.

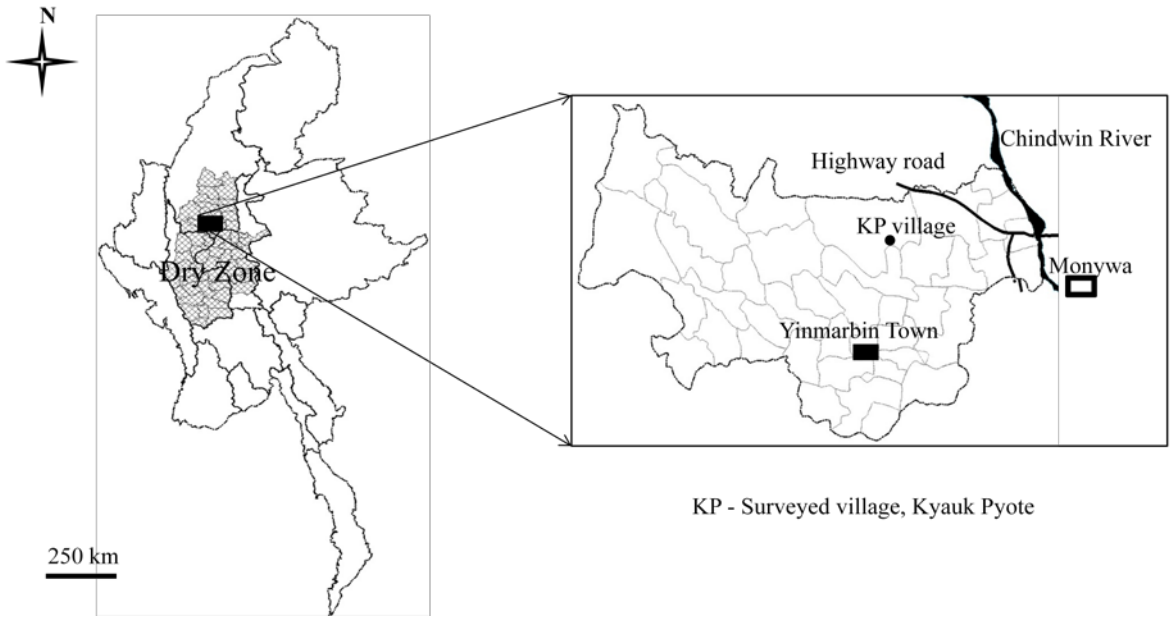

Fig. 13. Map of the study area in the Dry Zone region, Myanmar

Results and Discussion

Agricultural land holding of the surveyed village

According to the farm household interviews and statistical data, the total land holding of the village was 1059 ha, in which 98% of the total land area, 1034 ha was used for upland crops cultivation, and only 2%, 25 ha was low land area for rice cultivation. All of the farm households (110) owned upland fields, and among them 35 households had paddy fields, too. Forty households owned over 5 ha of agricultural field, 60 households 3-5 ha and 10 households 2.5 ha. A little more than 50% of farm households possessed average farm size (approximately 4 ha) ranging between 3-5 ha (Table 14). For paddy production, only 3 households possessed 2 ha of paddy fields, 10 households less than 0.5 ha and 22 households 0.5 to 1ha.

Table. 14. Number of farm households owning different types of land in Kyauk Pyote village, Yinmarbin District, Sagaing Region, Myanmar in 2014.

Upland field		Lowland	
Area (ha)	Number of households	Area (ha)	Number of households
>5	40	2	3
3-5	60	0.5-1	22
2	10	< 0.5	10
	110		35

Source: The Village General Administrative Office in Kyauk Pyote

Topography and soil

The village territorial area consisted of a flat to undulating planes, and the elevation ranged from about 100 m to 153 m. Based on physical properties and appearances, local people classified the soils into 3 categories, i.e. gravel strewn red soil (*mye- ni-kyauk-sa-yit*), caliche *(phyut- chay- mye*) and compact soil (*kyit-mye*). Soil properties in this area were characterized by relatively low organic matter content (0.53%), and strong alkalinity (pH 8.01), with sandy clay and/or clayey texture, based on the analysis by the Soil Science Division, Department of Agricultural Research.

Precipitation

The area had a bimodal rainfall distribution and the precipitation occurred from May to October with high variability, strongly affected by the monsoon, as shown in our previous study (Yee and Nawata, 2014). The heavy rains were received in August or September, and dry spells usually occurred in July. Fig. 14 shows the average monthly rainfall in the two periods, 4 decades ago (1971-1982) and the recent 12 years (2001-2012) in Yinmarbin Township. The average

annual rainfall during the previous period (1971-1982) was 903 mm and decreased to 835 mm in the recent period (2001-2012). In the previous period, rainfall amount of June, July, August and November was higher than that of the recent period, and that of May and October was low. September was the month with the heaviest rains and did not show a considerable difference between these two periods.

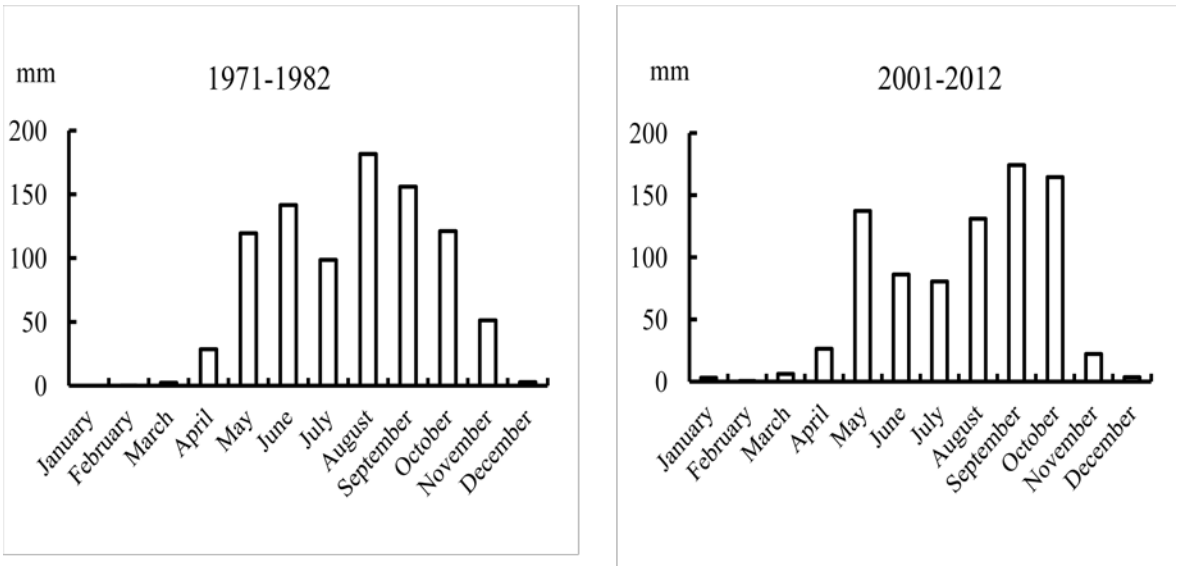

Fig. 14. Monthly average rainfall in the previous period (1971-1982) and recent period (2001-2012), Yinmarbin Township, Sagaing Region, Myanmar
Source: The Department of Agriculture, Yinmarbin District (2014)

Cultivated crops, cropping patterns and markets

According to field observations and statistical data, sesame, pigeon pea, tomato and naturally grown or intentionally planted jujube were widely observed in the upland fields and rice production was only observed in limited lowland area. All interviewed farm households (34 hhs) cultivated pigeon pea and tomato, 88% (30 hhs) sesame, 29% (10 hhs) jujube and 18% (6 hhs) rice (Source: farm household interviews in 2012, 2013, and 2014).

According to the farmers, the most common cropping pattern was sesame-pigeon pea intercropping system, like other areas in the Dry Zone (Yee and Nawata, 2014). The crop productivity had been stable with satisfactory yields until recently. This cropping system had been sustained for a long period to secure home consumption and to provide income to buy staple foods, in addition to cover household expenditures throughout a year. Since three decades ago, the local people had faced the irregular and sporadic rainfall in sowing time, and scarce rains during plant growing periods or heavy rains at harvest time. As a consequence, villagers had not always produced enough yields of sesame and pigeon pea for their livelihood. Early rainy season

sesame did not yield well in several years and it was remarkable that they got no yield in 1999 and 2000, according to the interviews with villagers and group discussion with elder persons.

Due to instability of rainfall, the sesame-pigeon pea intercropping system was no longer carried out recently in this village, and therefore, sole cropping of sesame and pigeon pea in different times of the rainy season, i.e. pigeon pea during the period from May/June to February/March, and sesame during the period from August/September to November/December in different land parcels, had been adopted for the recent years. The villagers paid great attentions to pigeon pea, shown by their efforts, such as the adoption of line sowing instead of broadcasting, and application of fertilizers if they could. Tomato, pigeon pea and jujube were major crops as described previously. Among them, pigeon pea and jujube were cash crops, mainly exported to India and China. The prices of these crops were fluctuated by influences of domestic and foreign markets as previously shown (Yee and Nawata, 2014).

Introduction of a new cash crop

As stated previously, the traditional upland crop production had been carried out for a long period, but the annual income from these crops was often unable to cover household needs. One of the villagers in the surveyed village, who owned large upland fields, started to cultivate thanakha, one of the Dry Zone tree crops, in his farm using local knowledge from neighbouring area in 1996, according to the records from the village headman and group discussion with the villagers. He intended to demonstrate that thanakha was adaptable to their agro environment even under poor soil and scarce rainfall conditions because thanakha had been commercially produced since long time ago in Wartan, Kanphyu, Kanpaw and Wayaung villages in Ayardaw Township and Kyaukka village in Monywa Township, which had similar agroecological conditions to this village. After confirming profits from thanakha plantation in his field, the local people gradually introduced thanakha cultivation into their cropping systems. Table 15 shows thanakha growing households in 2014. All of the interviewed households already planted thanakha in their upland fields. All of them had at least 2 ha of thanakha farm land and the largest one owned 6 ha. The percentage of thanakha farms occupied in their agricultural land ranged from 50% (3 ha in 6 ha of total agricultural field, largest) to 10% (0.2 ha in 2 ha, smallest) in the surveyed households. Among them, 4 households owned 6 year old thanakha farm and their field had just started to harvest the product. Households who owned the smallest thanakha farm had just started thanakha cultivation 1 year ago (Table 15). This was because they considered the scale of their land holding and examined the reliability of thanakha introduction and the profits from other crops.

Table. 15. Thanakha plantation in the upland fields in Kyauk Pyote village, Yinmarbin District, Sagaing Region, Myanmar in 2014.

Planted year	Number of thanakha cultivation households categorized by the total land ownership					Number of Total households
	6 ha	5ha	4 ha	3 ha	2 ha	
6	2	1	1	-	-	4
5	5	2	-	-	-	7
4	2	2	-	-	-	4
3	-	-	2	1	-	3
2	-	-	5	-	-	5
1	-	-	3	5	3	11

Source: Farmers' interview and Village General Administrative Office, Kyauk Pyote village in 2012, 2013 and 2014

Thanakha in Myanmar

Thanakha, *Limoniaacidissima* (syn. *Hesperethusacrenulata*), is a common tropical plant species in the Indian subcontinent and Southeast Asia (Wangthong*et al.*, 2010, Amornnopparattanakul*et al*., 2012). Thanakha trees were grown in the area between the central part of Myanmar, Shwebo District, Sagaing Region and the southern part of Pyay District, Bago Region. It is very adaptable to the Dry Zone agro-environments, i.e. gravel-strewn red soil, or sandy soil mixed with small stones, or compact soils with scarce rainfall (Davis, 1960, Myanmar Encyclopedia, 1972, Hla, 1974, Tun, 2014).

Thanakha is a wild or cultivated tree plant, whose bark is used for a natural and traditional cosmetic, made by grinding the bark with a small amount of water on a circular stone slab. The stem bark of thanakha has been commonly used by Myanmar women and children as a skin care cosmetic for more than a thousand years (Davis, 1960, Myanmar Encyclopedia, 1972, Lwin, 1995). According to the Forest Department in Myanmar, thanakha is included in non-timber forest products for trade purposes (Lwin, 1995), but thanakha have been cultivated in the Dry Zone since long time ago as described previously. For trading, the document to permit the transportation, authorized by local Forest Department is necessary (Myanmar Encyclopedia, 1972).

According to Davis (1960), Myanmar Encyclopedia (1972), and Tun (2014), thanakha was naturally grown long time ago in some specific area of the Dry Zone, including Yinmarbin Township. In some areas, thanakha was cultivated in home gardens and horticultural gardens since several decades ago. In Ayawdaw Township, thanakha home gardening was started by two farmers in Kanphyu and Kanpaw villages in 1928 (Hla, 1974). According to local people, home gardening in those areas was expanded in 1960, and the commercial production started in 1980 and increased rapidly.

The trees grow in upland areas of the Dry Zone were found to be more fragrant than those produced in other areas. It was also found that if produced in fertile soils, the tree gave large trunk but with poor quality caused by thin barks, according to the interviews with the local people and growers. The demand for the products in this area was very large because thanakha with good quality is able to be produced only in some specific areas of the Dry Zone, where several thanakha markets are managed. Although thanakha is planted widely in the Dry Zone, the two most popular marketable thanakha are produced in Shwebo Township, Sagaing Region (Shwebothanaka) and in Pakokku and Yaesakyo Townships, Magway Region (known as Shinmadaung thanaka).

Commercial thanakha cultivation

The local people knew thanakha was highly tolerant to drought and water deficit. As previously stated, thanakha in gravel strewn red soil (*mye- ni–kyauk–sa– yit*) in upland fields gave good quality. The villagers selected the seeds from the farm, which was well known for good germination and quality. The seedlings were grown in the rainy season. When the seedlings were 3 month old, they were transplanted with the spacing of 1.4 m between plants and 3 m between rows. The moisture requirement was minimal, and ample moisture was necessary only for sowing time. The growth continued with seasonal rains.

Careful managements, including cutting branches at appropriate times, were important for growing thanakha with quality and raising income because a hard, compact, straight and thick-bark thanakha was highly evaluated for its quality and offered a satisfactory price. To avoid narrow spacing and dense plant populations was also important for quality controls. Generally, the plant could be harvested in 6-7 years after transplanting, but the older plant had better quality and provided higher price. After the first harvest, the base of the plant was cut, and several new sprouts appeared from the basal part of the trunk, which resulted in the second generation, but farmers used only 1-2 sprouts for good quality. Thus, they need not practice new plantings. Possibility to use the third or fourth generations depended on the management and the quality of the plant, according to the local growers.

Present cropping system

Fig. 15 shows the recent crop calendar in the surveyed village. As explained previously, all the surveyed households introduced thanakha but they still cultivated pigeon pea, tomato and sesame. For sesame, 4 households were worrying unstable rainfall distribution these days and quitted to grow, at the time of survey in 2014. Since thanakha was a tree crop with wide spacing, other seasonal field crops such as sesame, green gram, cow pea and maize, could be cultivated

between the rows for the first 3 to 4 years (Fig. 16. a, b), before thanakha trees were fully grown. Thus many villagers in the surveyed village adopted these cropping systems.

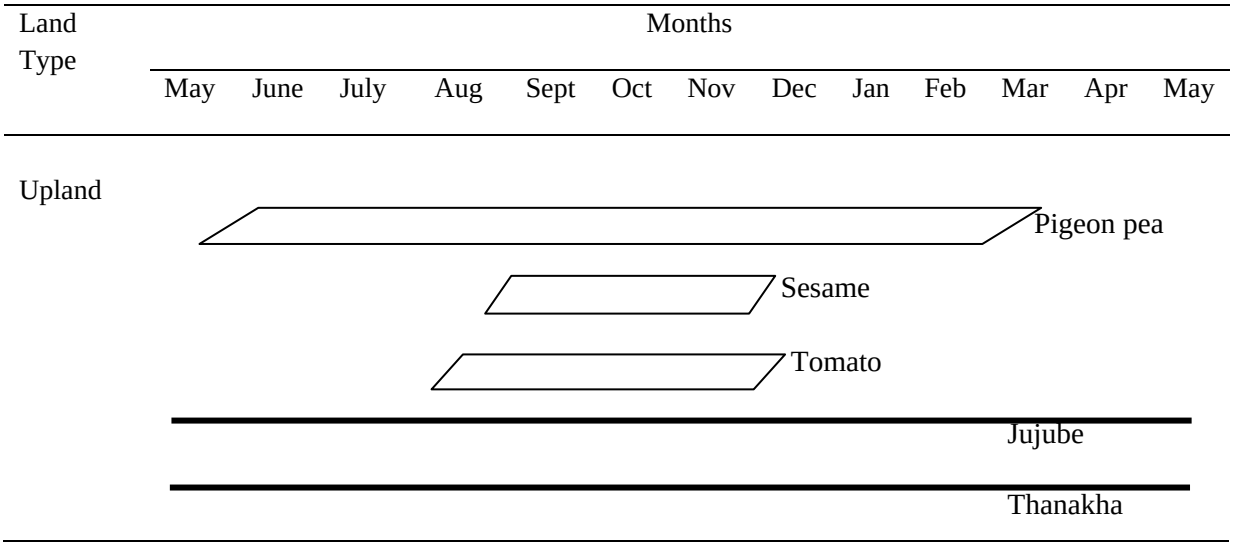

Fig. 15. Crop calendar of the Kyauk Pyote vilage, Yinmarbin District, Sagaing Region, Myanmar
Source: Farm household interviews in 2012, 2013 and 2014

(a) (b)

Fig. 16.a. Cropping maize between thanakha rows at Kyauk Pyote village, Yinmarbin District, Sagaing Region, Myanmar
b. After harvesting sesame grown between thanakha rows at the above village

By the climatic risk and crop price fluctuation, without productivity improvements and better adaptation to the local environment, the agricultural sectors suffer from significant losses

(ADB, 2009). According to the field observations and farmers interviews, thanakha introduction seemed to be successfully done in this village. Keeping the traditional upland crops and jujube was important for fulfilling the home consumption and raising income to buy rice, farm inputs, etc. The villagers considered that the income from thanakha was mainly for additional purpose and safety for their living. They intended to use the profits from thanakha in special occasions, such as sending the children to universities, donations for religious or other purposes, to buy land or a new house, cow, motorbike, etc., and urgent necessities, which were not covered from income from the other crops. In some years, if the traditional upland crop production failed and income did not cover the daily food and household needs, income from thanakha also could be used for it. Farming should be taken up with the motive of profit making rather than just making a subsistence living (Ramakrishna and Rao, 2008).

Crop diversification is an important mechanism 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). 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 (Abro, 2012). 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. In addition, the domestic demands of thanakha have not been decreased and the foreign markets such as Thailand, Philippine, Malaysia and Singapore were well established. Although thanakha was adapted to the upland 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.

As stated previously, Monywa-Yargyi-Kalaywa Road was completed in 2003. Before that, transportation of the agricultural products was very limited and difficult. Local people only produced thanakha as a home garden crop for their own consumption or as a commercial crop cultivated in their agricultural fields to some extent for local markets. After 2003, agricultural products were directly brought to Monywa City by themselves or the dealers from Monywa and Mandalay Cities visited the production sites. When the dealers found good quality thanakha in this area, they directly visited the production fields. Depending on the demand and quality,

sometime the grower earned profits than expected, according to the interviews with the villagers and field surveys in several villages in Yinmarbin and Kani Townships.

According to the Myanmar Agriculture Policy by the Ministry of Agriculture and Irrigation (MOAI), the local people are permitted to produce only the principle crops which are recommended by the Ministry of Agriculture and Irrigation, for example, rice in irrigated area, and cotton and pulses in upland rainfed area. Thanakha is categorized as a non-food crop by the Department of Agriculture, and is not allowed to cultivate commercially in the agricultural land, except in home gardens. However, to facilitate the development of agricultural sector, the government lightened the system to control farmers, and the MOAI changed the policies to some extent (DAP, 2003 and Fujita and Okamoto, 2006). Under the release of policy constraints, the local people introduced thanakha in their upland fields.

There are some areas with the same agricultural settings as those of the surveyed village, but thanakha is a perennial plant with wider spacing and, therefore, small landholders cannot always cultivate them as stated previously. Good transportation and communication with the city is one of the factors necessary for commercial thanakha plantation. In addition, local people are worrying for the above agricultural regulation by MOAI. As discussed previously, thanakha is a non-food crop, and commercial thanakha plantation in all agricultural land may be a risk in those regions, where the local authority is still strict. Therefore, although the incentive of thanakha cultivation is high, the commercial cultivation of thanakha in agricultural land is still limiting in the Dry Zone.

Conclusion

To consider agricultural production in terms of high risk rainfed conditions and price fluctuations, thanakha has a high possibility. The local people in the surveyed village introduced a more prospective new cash crop, thanakha, to provide higher economic profits than those produced in the traditional cropping systems. Sesame, pigeon pea and tomato were still cultivated for their daily foods and basic household needs. The income from thanakha was intended mainly for the more comfortable life and safety. Therefore, the local people have carried out the diversified farming system by introducing thanakha to the existing cropping systems for food and income security. Crop diversification with the introduction of new cash crops in the Dry Zone might have generated more income and resulted in rural development. At present, however, the introduction of thanakha is one kind of trial by the farmers in this village and the profits do not come, yet.

Thanakha had long been used as a traditional cosmetic by Myanmar people and recently found ways to foreign market. Therefore, thanakha was highly prospective as a cash crop with

adaptability to agro-environment in the Dry Zone. However, although our study found out that thanakha farms and plantation had been expanded in the surveyed area, the local people should carefully think about the supply and demand of thanakha in future. An incentive to thanakha cultivation is strong, but commercial cultivation of thanakha in the agricultural land in other areas under similar natural settings may be restricted by land holding, transportation conditions and government policy.

CHAPTER 5

Discussion

The Agricultural environment and farming systems

The study area within the Dry Zone, Myanmar, was found to receive the least amount of annual rainfall compared to other regions. Surveyed areas were characterized by clay, sandy loam and sandy soils that included gravel. The undulating land and scarce water resources, low-fertility soils poor in organic matter, and high temperatures were found to be natural limiting factors for agricultural production, occasionally leading to food insecurities and severe environmental degradation. In the surveyed villages, 70-90% of the agricultural land was upland, with upland farming and limited paddy production being the major mode of agriculture.

Traditional agriculture was found to be still in practice with livestock and minimum use of chemical fertilizers and pesticides. 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. After 1988, in the surveyed villages in Kani Township, a local variety jujube was improved to make it more marketable, with pigeon pea and jujube becoming the main source of income through export to India and China. Song Chaung village, located in a riverine area in Yinmarbin Township, had produced wheat and chickpea in upland fields under better soil characteristics and moisture conditions compared to other parts of the Dry Zone. In Kyauk Pyote village, the productivity of sesame and pigeon pea used to be high and stable, covering food and household needs throughout the year. In addition, tomato was grown as a cash crop, with stable demand in the domestic market within the village.

Factors affecting existing farming systems

Since precipitation is the most important climatic element affecting agricultural development under rainfed conditions, seasonal variation was found to have a remarkable impact on the sustainability of upland farming in the surveyed areas. In Kani, large variations in annual rainfall during the past 21 years were revealed (1991-2011), in addition to yearly variations in rainfall during crop seasons. Moreover, recent annual rainfall has decreased

compared to that of several decades ago, as shown in the rainfall trend in Yinmarbin. As a consequence, crop yield has gradually decreased, and crop failures occurred in some years.

Myanmar has recently embarked on a path of unprecedented political and economic transition (Rao *et al*., 2013), and pulses, a major foreign exchange earner, have consequently increased in importance with regards the national economy, serving as stable income generators for farmers in the Dry Zone. According to Shwe (2011), about 74% of pulses exported from Myanmar are exported to India, which stands as a regular customer. Accordingly, export of Myanmar's pulses relies solely on the import relationship with India. However, India also imports various types of pulses from Canada and Australia, and as a result, changes in the market price of pulses may reflect export prices in Myanmar. In addition, the pulses market fluctuates annually based on weather conditions of both the importing and exporting countries (Oo and Kudo, 2003). Villagers in the surveyed areas therefore face crop price fluctuations caused by foreign markets.

Changes in farming systems

Capistrano and Marten (1986) pointed out that most farmers are willing to change their practices if it will improve income, changing crops in response to changing market opportunities. If it was not what they expected, it would be difficult to change traditional technologies that had endured and served them well over the centuries. 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 thanakha, which would result in changes to their conventional systems.

Farmers commonly follow adaptive strategies to reduce or totally avoid climate change-related risks. For example, farmers in the northern Philippines have shifted from irrigated rice with limited irrigation water to tobacco and other drought-tolerant vegetable crops, while in the semi-arid region of Brazil, farmers have altered their crop calendars, planting different crops in succession (Lasco *et al*., 2011). In Song Chaung village, Yinmarbin Township, the available groundwater irrigation favored the introduction of the more profitable cash crop betel vine, which showed high demand in Monywa City. In addition, the location of the village near the city improved transportation conditions, with villagers eager to cultivate this new crop. These factors seem to have contributed to the successful introduction of betel vine cultivation.

In many cases, farmers have had to diversify their agricultural system in order to survive, not because they particularly wanted to (Donagh and Bahiigwa, 2002). Villagers in Kyauk Pyote village, Yinmarbin Township, have done so by introducing the new cash crop, thanakha, into their upland fields. However, they continued to maintain traditional crops to

enhance their seasonal and annual incomes. That is, diversified farming was introduced through the introduction of new crops into the existing cropping systems, giving food and income security. At present, seasonal and annual crops provide sufficient income for the household needs. Based on the present situation, villagers in the study areas claim that they would rather diversify their farming practices than boost existing farming activities under the uncertain rainfall and crop market conditions.

Conclusion

The main objective of this study was to present the recent changes in the agro-ecosystem of the Sagaing Region, the Dry Zone, Myanmar, and determine how local people were attempting to adapt to these changes. The three case studies across four villages in Kani Township, and one riverine village and one typical upland crop-producing village in Yinmarbin Township, were conducted in 2011, 2012, 2013, and 2014.

This study evaluated a pigeon pea-based traditional upland cropping system, the introduction of new cash crops and diversified agricultural practices employed to overcome the constraints caused by unstable rainfall, crop productivity and cash crop markets. The results demonstrate that traditional farming systems have been adaptable due to the local knowledge of the farmers. The selection of cultivated crops, cropping patterns, and agricultural practices has adapted to the natural environment, and so far, has shown long-term sustainability.

This study confirms that climate change is having an impact on this region, as shown by variations in rainfall distribution and water shortages, resulting in unstable agricultural production. As a result, the crop market is unstable and crop prices fluctuate according to international markets and national policies. The livelihoods of the villagers are therefore also at risk; however, farmers have overcome these difficulties by optimizing their farming systems and introducing new crops through the implementation of diversified farming practices, thus providing security and necessary income.

In some villages such as Song Chaung, new cash crops have been successfully introduced thanks to favorable conditions. In other villages in undulating upland areas, villagers have maintained their traditional systems with some modifications and also efforts to introduce new cash crops. As a result, some villages have successfully introduced the new cash crop thanakha, which is highly adaptable to drought-prone and nutrient-poor soil conditions. However, the cash crops that have been introduced into these areas are non-food crops. Villagers should therefore think carefully about the effects of, for example, further expansion of betel vine cultivation on food crop production in the area. Although thanakha is a cash crop with high demand, wide expansion may influence the balance of supply and demand. Among the

surveyed areas, only Song Chaung village was found to have good communication with local governmental institutions, and subsequently, adequate support. The remaining two areas are isolated and generally lack governmental support, although they carry out successful knowledge sharing within the neighborhood. In those resource poor regions, good relationships with governmental institutions and/or NGOs are a prerequisite for assistance.

This study points out that not only instable rainfall but also various other factors are associated with low and instable crop productivity in the surveyed areas. Poor soil conditions, limited irrigation facilities, and minimal use of improved production technologies are some of the major factors responsible for low yield, although locals were found to have adapted to these adverse conditions to some extent. In conclusion, agricultural as well as rural development should be the basis for economic development of the country, with strategic implementation of various practices to help improve agricultural productivity and income. Although there remains considerable uncertainty regarding future climatic change and market dynamics, assessment of the impacts of these practices on agricultural production systems and evaluation of the alternatives should be carried out on both scientific and policy bases.

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