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Weather variability and rice-based farmers' adaptation practices in Myinmu Township, Sagaing Region, Myanmar

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ABSTRACT. The negative impacts of weather variability are being felt, especially in developing countries such as Myanmar. Its Central Dry Zone (CDZ) experiences long dry months and uneven annual rainfall distribution. This study sought to understand weather variability as perceived by farmers in Myinmu Township and determine their corresponding adaptation practices. Secondary data from the Department of Agriculture (DOA) and Department of Meteorology and Hydrology (DMH), focus group discussions, and key informant interviews supplemented the survey results conducted among 150 randomly selected farmers. Secondary data revealed that the rainfall pattern in Myinmu Township fluctuated between 1985 and 2019, resulting in an unstable distribution pattern. Survey results show that farmers perceived drier weather as more than half of the respondents reported prolonged dry spells, delayed rainfall, an increase in summer temperature, and a decrease in average rainfall. Drought and flood were identified as the most common weather events and the effects of these events were dominant on crop production. On the other hand, most respondents reported a moderate reduction in crop production and farm income as a result of drought and flood. This moderate effect may be attributed to the farmers' adaptation practices which included crop rotation, modifying planting methods, installing pumps to irrigate farms, and intercropping.

Keywords: climate change, crop production, cropping pattern, farmers' perception, farming system

INTRODUCTION

Agriculture is affected by weather events at uneven proportions (Porter *et al*. 2014), with the poor being the most vulnerable. Developing countries such as Myanmar whose rural communities depend much on agriculture are among the most vulnerable to the impacts of extreme weather events. Myanmar has experienced rainfall scarcity, irregular rainfall, heat stress, drought, flooding, seawater intrusion, land degradation, desertification, deforestation, and other natural disasters (Kywe *et al*. 2015).

Myanmar has several variant climate zones such as the Central Dry Zone (CDZ), coastal, hilly, and delta regions. Annual rainfall varies in different regions, ranging from 4800 to 5800 mm in the coastal area, about 3000 mm in the delta, 1250–2300 mm in the hilly region, and less than 1000 mm in the CDZ area (Ministry of National Planning and Economic Development 2006). Depending on topographical conditions, significant changes in rainfall pattern and rainfall intensity have been observed occasionally in some parts of the country. In some cases, rain intervals were two to three weeks and annual rainfall intensity is far lower than the normal average in Central Myanmar (Climate Change Management 2010 as cited in The N.E.M. 2012). Since 1977, Myanmar has been experiencing late monsoon onset, early monsoon withdrawal, shorter monsoon duration, increased heat and drought indices, as well as decreased annual rainfall (Tin 2012).

The weather variability will greatly affect the livelihood of farmers relying solely on rice production. It is in this light that adaptation to weather variability becomes necessary. The CDZ of Myanmar, a resource-poor area, suffers from below average and uneven rainfall distribution and high temperatures of up to over 40°C during summer. These changes have the potential to negatively affect agricultural production and food security. Rice, a major rice crop of Myanmar is negatively affected by extreme weather and can suffer from more widespread occurrence of diseases such as rice blast, sheath blight, and culm blight (Jaranilla-Sanchez *et al*. 2007).

In agriculture, adaptation requires cost-effective investments in water infrastructure, cropping system development, emergency preparation for and response to extreme weather events, development of resilient crop varieties that tolerate temperature and precipitation stresses, and new or improved land use and management practices. (Howden *et al*. 2007). Fosu-Mensah *et al*. (2010) observed that in the Sekyedumase District of the Ashanti Region in Ghana farmers change crop types, plant short-duration varieties, change planting dates, and practice crop diversification. In Uganda, adaptation is done through income diversification, digging of drainage channels, and the use of drought-tolerant varieties (Okonya *et al*. 2013). In a study in the province of Camarines Sur in the Philippines, Cuesta & Rañola (2009) observed that rice farmers shift to high-yielding and/or early maturing varieties, changing planting dates, diversify crops, and take on non-farm jobs to cope with the effects of rainfall variability and climate extremes. Crop diversification is considered an important adaptation and insurance against weather variability (Bradshaw *et al*. 2004) as cited by Hassan & Nhemachena (2008) and Orindi & Eriksen (2005). In addition, mixed farming, mixed cropping, tree planting, use of different crop varieties, changing planting and harvesting dates, increased use of irrigation, increased use of water and soil conservation techniques, as well as diversifying from farm to non-farm activities have also been reported in Nigeria and South Africa (Apata 2011).

However, Mary & Majule (2009) argue that while climate change is global, adaptation is local and context-specific. It is important to ensure that changes in farming systems and technologies are suited to the specific environmental and socio-economic conditions of farmers without contributing to increasing the risks that beset local communities. Since recent years, there have been several initiatives on the ground in CDZ by different sectors to help cushion the negative impacts of weather variability. Among the strategies employed are distributing new crops or varieties, providing up-to-date weather information, and teaching farmers several adaptation practices. The missing links, however, are studies geared at understanding the impacts of weather variability on crop production of farmers and their adaptation practices to weather variability.

METHODOLOGY

Research sites

A field survey was conducted in Myinmu Township, Sagaing District, Sagaing Region in CDZ of Myanmar. Myinmu Township has a total population of 11,333,925,278 households based on 2017 data. Sample respondents came from 10 purposively selected villages. The general criteria in choosing these villages were the geographical stratification of Myinmu Township (**Figure 1**) and the extent of occurrences of extreme weather events. Occasionally, all 10 villages suffer from drought and flood during the rainy season. Except for Kan Pyar, Kan Taw, and Pe Ku villages, some areas for crop cultivation in the other seven villages are affected by seasonal floods especially when both Mu and Ayeyarwady rivers overflow. This usually happens from June to October while the peak month is in August. On the other hand, some cultivated areas in Kan Pyar, Kan Taw, and Pe Ku are flooded occasionally during the rainy season because of poor engineering designs of embankments, dams, and canals.

Respondents of the study

The total number of households was used as a reference in determining the sample size for this study. The number of sampled households was calculated using Yamane's (1973) formula:

$$n = N/ [1+N (e2)]$$
$$= 25278/ [1+25278(0.1)2] = 100$$

Where: n = Sample size
N = Total number of households
e = Error (0.1)

While the computation suggested 100 respondents, 150 randomly selected respondents were interviewed to get an equal representation of 15 respondents per village.

Data gathering instrument

The field survey was conducted from June to July 2017. Respondents were asked about their perception of weather variability as to whether climate conditions such as temperature or rainfall increased, decreased, or remained essentially the same for a specified time. Respondents were further asked whether crop production and income increased, decreased, or whether there was no change at all as a result of weather variability. Based on the literature review, adaptation practices to weather variability were grouped into five categories: changing cultivated varieties, changing farming systems, rainwater conservation, improving irrigation systems, as well as engaging in non-farm activities and other alternatives. The farmers were then asked which of the specific adaptation farming practices were adopted as a response to weather variability. In addition, key informant interviews (KII) and focus group discussions (FGD) were conducted with the head of the village, the village agricultural extension agents, and staff officers from the Department of Agriculture (DOA) to validate the results of

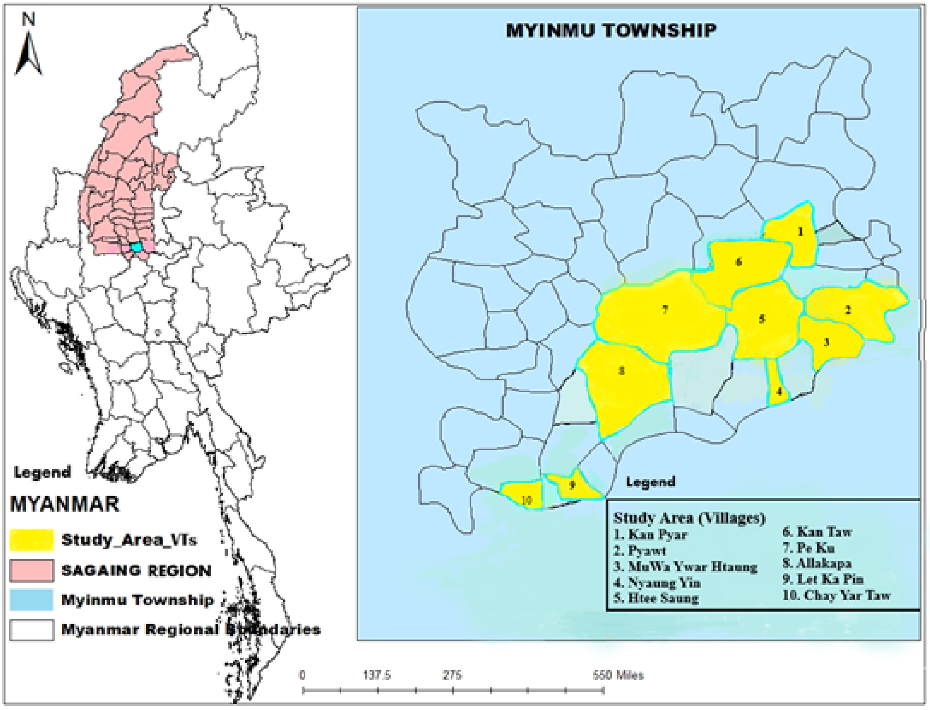

Figure 1. Location of the study area covering Myinmu Township in Myanmar.

the primary data. The questions included awareness and perception of weather variability.

Secondary data was collected from DOA, Department of Meteorology and Hydrology (DMH), and from published and unpublished documents from other government agencies, journals, books, and related references. Climate data in Myinmu Township such as rainfall (mm) from 1985 to 2019 and temperature (°C) from 1988 to 2019 were collected from DMH. These two parameters are the most common climate variables considered by many studies in Myanmar and used to capture weather variability and change.

Statistical analysis

The data collected were coded and analyzed using Microsoft Excel version 16.0 and Statistical Package for Social Sciences (SPSS) version 27.0. SPSS is the most widely used package to code data within both academic and business circles as it is a versatile package that allows many different types of analyses, data transformations, and interpretation of results from a large sample size (Arkkelin 2014). Descriptive statistics such as frequency, percentage, mean, and standard deviation (SD) were used to describe the local patterns of rainfall variability and other variables.

RESULTS AND DISCUSSION

This portion describes the socio-economic and demographic characteristics of rice farmers. Before the interview, the respondents were asked who performs most of the work on the farm. Most (96%) of the respondents are male, within the middle-aged category (54%) with an average age of 53 years old (**Table 1**). According to Teklewold *et al*. (2006), technology adoption may be affected negatively or positively by the age of the farmers depending on the location or technology. Additionally, it can be said that the involvement of farmers within the middle-aged and old categories in farming is higher as the younger ones are more likely to take on non-farming jobs (Thu 2020), in addition to being a rice farmer to support their families. A majority (63%) of the respondents have five to eight family members.

Education is crucial in facilitating the transfer of knowledge on environmental awareness among rice farmers, and in adopting suitable adaptation practices. However, it was found that about 30% and 27% of the respondents completed their primary and middle education, respectively. Four respondents reported they obtained a college degree and 26% finished non-formal education (monastic education). The result implies that most farmers (83%) may have difficulty accessing and accepting new information and technologies from various sources. This can be attributed to their generally low educational attainment that bears on their ability to adopt best farming practices accurately.

As regards farm experience, 33% of the respondents reported having 21–30 years of experience; 19% with longer than 40 years; and 5% with less than 10 years. Farming experience is an important factor that should be considered as those who have stayed long enough in an area can accurately report any significant weather changes. Additionally, the same type of

Table 1. Socio-economic and demographic characteristics of respondents.

Characteristics	Frequency (n= 150)	Percentage
Gender		
Male	144	96
Female	6	4
Age		
Young 18-37)	11	7
Middle-aged (38–57)	81	54
Old (> 57)	58	39
Mean	53.81	
Range	25–75	
SD	10.76	
Household size		
1–4	50	33
5–8	94	63
Above 8	6	4
Mean	5.29	
Range	1–10	
SD	1.68	
Educational attainment		
Monastery	39	26
Primary (Grade 1–4)	45	30
Middle (Grade 5–8)	41	27
High (Grade 9–10)	21	14
College/Institute (Grade11–14)	4	3
Farm experiences		
Below 10	7	5
10–20	29	19
21–30	49	33
31–40	36	24
Above 40	29	19
Mean	30.65	
Range	2–56	
SD	12.07	
Types of rice ecosystems		
Rainfed only	26	17
Irrigated only	10	7
Rainfed+irrigated	114	76
Total cultivated area (ha)		
Below 3	40	26
3-5	46	31
Above 5	64	43
Mean	5.85	
Range	0.4–20.20	
SD	4.15	
Total cultivated area for rice (ha)		
Below 1	46	31
1-3	89	59
Above 3	15	10
Mean	1.68	
Range	0.30–8.10	
SD	1.17	
Gross family income yr^{-1} (Kyats)		
5,000,000 and less	74	49
5,000,001 -10,000,000	50	33
10,000,001 – 15,000,000	17	11
Above 15,000,000	9	6
Mean	6,456,728	

Table 1. Con't.

Characteristics	Frequency (n= 150)	Percentage
Range		420,000–30,340,000
SD		4,995,084 (3,933.14 USD)
Gross annual income from rice production (Kyats)		
1,000,000 and less	70	47
1,000,001–2,000,000	35	23
2,000,001–3,000,000	20	13
Above 3,000,000	25	17
Mean		1,690,620 (1,330.22 USD)
Range		0–9,652,500
SD		1,621,137 (1,275.55 USD)
Credit access		
Yes	149	99
No	1	1

farmers can identify which adaptation practices have already been applied in their community. Hence, they are in a position to assess the effectiveness of any adaptation practice.

This study also found that most farmers (76%) have both rainfed and irrigated farms. This implies that they could grow rice in farmlands even during drought because of access to irrigation. In the study area, 43% of respondents owned more than 5 ha total cultivated area, about 31% with 3–5 ha, and 26% with less than 3 ha. Therefore, the farm holdings of most respondents were relatively larger than the national average where it has been documented that 56% of the total households in the whole country work on a farm holding with less than 2 ha (LIFT 2016). More specifically, the size devoted to rice ranged from 0.30 to 8.10 ha, where a majority (59%) of farmers have 1–3 ha cultivated rice land area while a few (10%) have more than 3 ha, with 76% relying on both rainfed and irrigation for farm water needs.

The annual gross income of respondents varies (**Table 1**). Around 49% of the respondents reported an annual gross family income of around 5,000,000 Kyats (3934.13 USD) while 33% reported income from 5,000,001 to 10,000,000 Kyats (USD 3934.13–7868.25). Among annual gross family income from rice, nearly half (47%) of the respondents reported a gross annual income of around 1,000,000 Kyats (786.83 USD); while 23% reported between 1,000,000 and 2,000,000 Kyats (USD 786.83–1573.65). This study found that the majority of rice farmers (99%) accessed credit from institutions such as the Myanmar Agricultural Development Bank, NGOs/INGOs, cooperative banks, local money lenders, and other agrochemical companies.

Climatic condition in Myinmu Township

Myanmar has three pronounced weather seasons: rainy season (mid-May to October), winter (November to February), and summer (March to mid-May). The annual rainfall pattern in the study area ranged from 400 to 1200 mm and the average monthly maximum and minimum temperatures were 37.28 °C and 19.74°C, respectively. April and May were the hottest months and December and January were the coldest (DMH in Myinmu 2019).

Based on the rainfall data analysis from the DMH in Myinmu Township for three decades, the average rainfall increased, although the overall trend shows the erratic fluctuation of rainfall, especially between the years 2005–2019 where there are sharp peaks and lows. Overall, the rainfall pattern in Myinmu Township fluctuated between 1985 and 2019 resulting in an unstable distribution pattern (**Figure 2**).

It is noted that the average monthly rainfall from 1985 to 2019 is erratic with highs of 1109.98 annual rainfall in 2013 and lows of 406.91 in 2019 (**Figure 3**). On the other hand, the monthly rainfall is lowest from January to March and steadily increases from April to May and drops again by July. Recorded rainfall then increases from July and peaks at September at 166.66 mm. It then significantly goes down, registering the lowest during December. Less rainfall occurred during the winter season (November to February) until March when rainfall starts to increase.

Data on the minimum and maximum temperatures show variations in average temperatures from 1988 to 2019 (**Figure 4**). The average temperatures evolved in serrated increase with maximum temperatures recorded in 1998, 2005, 2009, and 2010; slightly decreased in 2017–2018 but slightly increased in 2019. In 2010, extreme temperature (47.2°C) was recorded in May, which eventually led to El Niño. Farmers shared during the KII that the El Nino during this period negatively affected their sesame production and other sources of livelihood. The minimum temperature trend shows an irregular pattern with slight fluctuations until 1999 and a sharp increase in 2000, with the highest amount of temperature recorded at 25.77°C. Overall, the temperature in Myinmu increased for both maximum and minimum average annual temperature. The maximum annual temperature increased by 0.05°C yr^{-1} but the minimum annual temperature decreased by 0.03°C yr^{-1}.

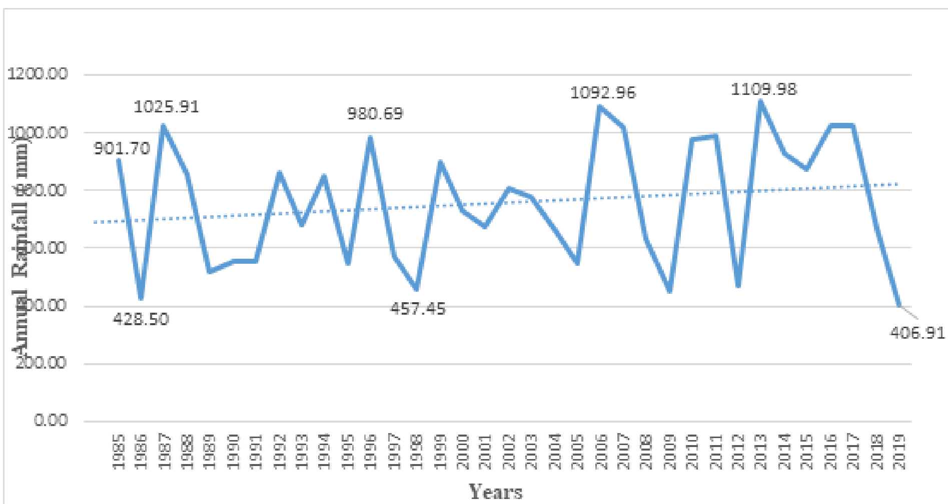

Figure 2. Annual rainfall in Myinmu Township, Sagaing Region, Myanmar (1985–2019).

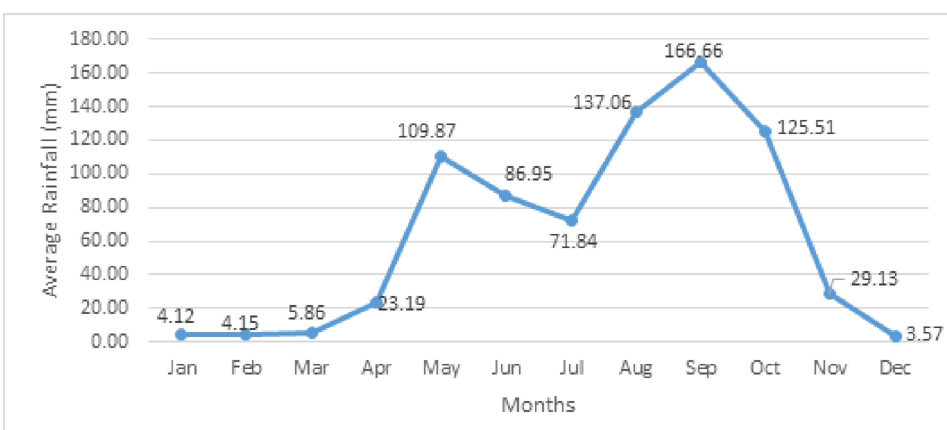

Figure 3. Average monthly rainfall (mm) of Myinmu Township from 1985 to 2019.

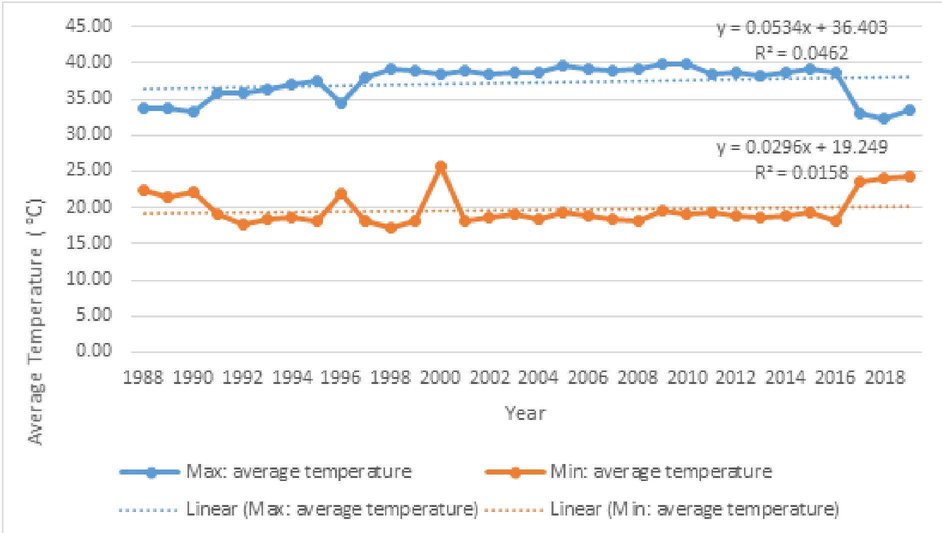

Figure 4. Maximum and minimum temperatures from 1988 to 2019 in Myinmu Township.

Respondents' perception of climate change over the past 30 years

Farmers were asked about their perceptions of climate change over the past 30 years (**Figure 5**). Responses point to the fact that farmers perceived drier weather as more than half of the respondents reported prolonged dry spells, delayed rainfall, increase in summer temperature and decrease in average rainfall. While **Figure 2** shows an increased occurrence of rain from 1985 to 2019, data also show the erratic pattern of rainfall, and the increase in temperatures recorded in **Figure 3** supports the perception that the weather in Myinmu had become even drier. Based on the interviews, a majority (77%) of the farmers decried the delay in monsoon rains which makes it difficult to plan the start of the cropping season. With perceived drier climates and perceived less occurrence of rain, farmers did not see an increase in the occurrence of flooding.

While farmers reported drier climates, they also perceived colder temperatures during the winter season, though almost all of them reported a decrease in the occurrence of frost. This observation is consistent with the secondary data where there was an observed increase in maximum annual temperature and a decrease in minimum annual temperature. For these reasons, 62% of the farmers viewed the weather as unpredictable.

Impacts of weather variability on crop production and income

Based on KII among extension workers, the most common weather disturbances are drought and flood. Thus, farmers were asked about the effect of these events on crop production and income (**Table 2**). Most respondents reported they experienced reduced crop production and farm income as the major effect of drought and flood. For those affected, most said that they were moderately affected. That farmers are affected by drought and flooding in CDZ area are similar to the findings of The (2012). The difference, however, is on the extent of how they were affected as The (2012) reported massive losses in income among farmers from the Pakokku Township in CDZ due to the major impact of weather variability. In this study, more respondents were affected more by drought than by the flood.

Table 2. Impact of weather variability on crop production and income.

Categories	Reduction in crop production		Reduction in farm income	
	F	%	F	%
Effects of drought				
Not affected	32	21	28	19
Affected	118	79	122	81
Very little	15	13	19	16
Little	30	25	31	25
Moderate	43	36	51	42
Strong	26	22	19	16
Very strong	4	3	2	2
Effects of flood				
Not affected	53	35	41	27
Affected	97	65	109	73
Very little	11	11	12	11
Little	28	29	39	36
Moderate	40	41	48	44
Strong	14	15	9	8
Very strong	4	4	1	1

Remark: less than 5 %= Very Little, 5-15% = little, 15-25% = Moderate, 25- 35 %= Strong, Above 35 %= very strong

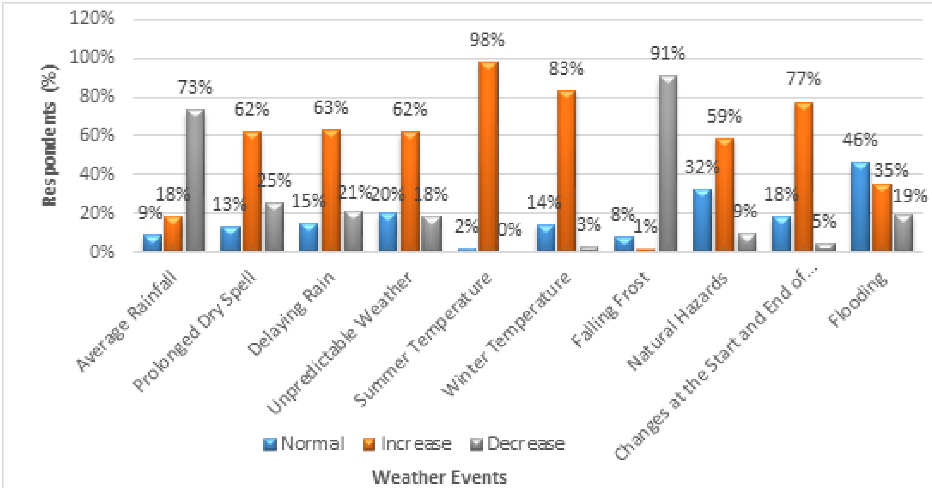

Figure 5. Farmers' perception of climate variability over the past 30 years.

Effect of weather variability on rice production from 2014 to 2016

To determine the possibility of differentiated effects of weather variability on rice production, farmers were asked to rate the effects of weather variability on production from 2014–2016 during monsoon and summer cropping (**Table 3**). It should be noted that farmers planted rice once or twice a year depending on water availability. In a double-crop year, the first cropping was during the pre-monsoon season as summer rice while the second is during the monsoon. Some farmers did not plant rice during the summer season. Based on KII, these farmers said that water supply from irrigation, ponds, and rainwater is not enough to sustain rice crop production during the summer season. During this period, they planted alternate crops such as green gram or chickpea.

Results show that farmers did not attribute changes in rice yield to weather variability either during the monsoon or summer season. KII revealed that the farmers who planted rice during summer were the ones with good access to irrigation and thus, the decrease in rainfall and the reported drier months did not lead to any negative effects on crop yield because the majority of those who were supposedly most affected by drought and less rain did not plant rice during summer.

Table 3. Total perceived effect of weather variability on rice production from 2014 to 2016.

Category	2014 (n=150)		2015 (n=150)		2016 (n=150)	
	Monsoon (%)	Summer (%)	Monsoon (%)	Summer (%)	Monsoon (%)	Summer (%)
Increase	15.3	13.3	21.5	16.7	32.8	21.4
Decrease	27.1	20.0	28.9	22.2	23.8	14.3
No change	57.6	66.7	49.6	61.1	43.4	64.3

Farmers' adaptation practices to weather variability

Changing crops to grow in the previous year (2016), past 5 (2012), and 10 (2007) years

To determine the changes in crops planted, farmers were asked what crops were planted the previous year, 5 yrs ago, and 10 yrs ago. **Figure 6** shows the changes in the crops planted by farmers in 2016 (1 yr ago), 2012 (5 yrs ago), and 2007 (10 yrs ago). While the number of rice farmers had increased in the past 10 yrs, data show a significant increase in farmers growing green gram. Based on FGD results, the increase in green gram production was a result of the inadequate water from the River Water Pumping Station and the increase in high export demand for the crop. Capistrano & Marten (1986) noted that most farmers may change their practices if the move will improve income such as the case when there is a shift in market demand. Moreover, it can be noted that there is an increase in the number of farmers who planted black gram, pigeon pea, chickpea, and peanut in 2016. Based on KII, farmers stressed that these crops require less water, and they also have high export demand.

In 2016, the number of sesame farmers decreased compared to that in 2012 and 2017. FGD participants in Pe Ku said that they opted to stop planting sesame as a pre-monsoon crop owing to the late monsoon onset, lack of monsoon rain, and erratic rainfall. The same decrease is observed among wheat farmers in the past 5 yrs because of unfavorable weather conditions, reduced yield, and low market price.

Data shows that farmers responded to market demands and environmental stresses. The data above prove that farmers planted alternated crops to maximize yield. Thus, while they perceive adverse weather variabilities such as increased temperature coupled with decreased occurrence of rain, or flooding, a majority of those affected also reported only moderate effects only on crop yield and income. This is primarily because they have changed crops to make sure they can maximize opportunities from farming.

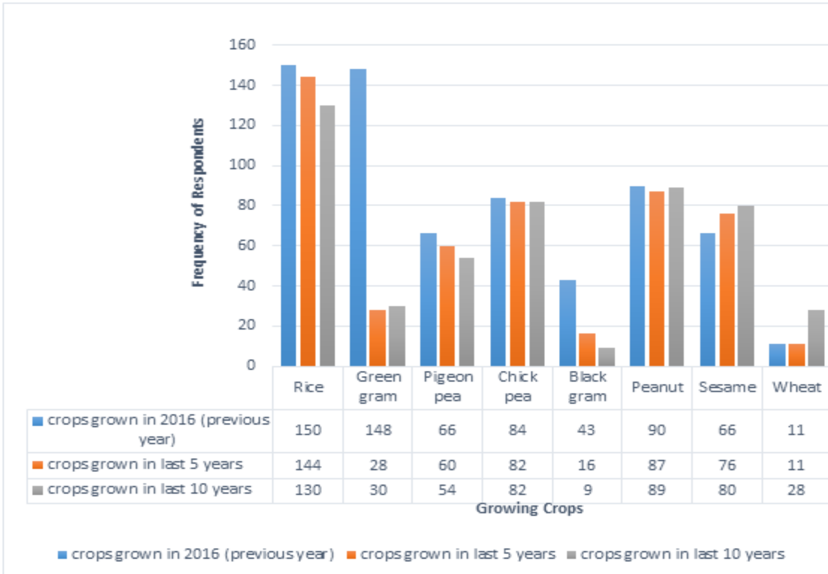

Figure 6. Crops grown by respondents in the previous year (2016), past 5 (2012), and 10 (2007) years.

Changing cropping patterns in rice-based farming systems

As a traditional way of coping with weather variability, farmers used to practice various cropping systems such as mono-cropping, intercropping, and mixed cropping. For rice, there are different rice-based cropping patterns such as mono-, double- and triple-cropping on the same land in a year, depending on water availability (**Table 4**).

Table 4. Changes in cropping patterns for irrigated areas in Myinmu Township.

Current cropping pattern (2016–2017)	Cropping pattern over 5 years	Cropping pattern in the past 10 years
MR-Gg/B- SR	M_ Cp – SR	W
MR- Gg	MR –W	W
MR- SR/ S	MR	MR
MR- Gg	MR- Cp	W
MR – SR/ Gn	MR – SR	MR
MR_ Gg/Cp	MR- Cp	MR- Cp
MR_ Gg/Gn	MR	MR
MR	MR	MR
MR- S	MR- W	MR
MR- O	MR- Cp	MR- Cp

Source: Research Survey Data (Note: MR= Monsoon Rice, SR= Summer Rice, Cp= Chickpea, Gg= Green gram, B= Black gram, W= Wheat, Gn= Ground nut, S= Sesame, O = Onion)

A clear observation is that planting summer rice alone during summer is not a common practice. For those who plant summer rice, a portion of their land is devoted to the green gram, black gram, sesame, and chickpea. Myanmar is an exporter of beans, pulses, and sesame; and these are preferred crops by farmers in CDZ after paddy monsoon (Raitzer *et al*. 2015). In recent years, access to irrigation has been made possible in upland areas which ordinarily depended on rain. However, these farmers planted rice only during the monsoon season and most did not plant rice during the summer season, and the farmers shared that this is because the irrigation supply was not enough. Hence, farmers planted more diverse and popular crops that are more resistant to drought stresses and have high market demand. Overall, there is a more diverse pattern of cropping system with newer crops planted such as green gram and chickpea.

While planting crops other than rice may have helped the farmers maintain income, the preference towards the production of other crops during the summer period has affected total rice production in the area. Depending on the agro-ecological conditions, green gram can also be grown during the monsoon season. For the years 2015–2017, there had been a steady decline in the cultivated area for rice and consequently, in overall rice production. Between the years 2014–2017, cultivated land area in Myinmu decreased by 19% and consequently, production decreased by 24% (DOA 2017). Summer rice was introduced in 1992 but despite irrigation support and strict request by the government to plant summer rice, cultivated area for this has not increased for the past 10–5 years (Raitzer *et al*. 2015). Recent data from DAO showed a decline in rice cultivated areas.

Farm and non-farm adaptation practices

In reducing the adverse impacts of weather variability, it is imperative to better understand the risk associated with this phenomenon and identify potentially useful farmers' practices. **Table 5** shows the different adaptation practices including changing varieties and farming system, conserving rainwater, improving irrigation system, and venturing in non–farm activities employed by the farmer–respondents.

Table 5. Adaptation practices employed by respondents to address weather variability.

Adaptation practices	Adaptation measure							
	Frequently		Sometimes		Rarely		Never	
	F	%	F	%	F	%	F	%
Changing cultivated varieties*								
Drought-tolerant varieties	19	12.7	12	8.0	8	5.3	111	74.0
Short-duration varieties	46	30.7	47	31.3	5	3.3	52	34.7
Changing crops	32	21.3	42	28.0	7	4.7	69	46.0
Changing farming system*								
Changing planting date	36	24.0	44	29.3	5	3.3	65	43.3
Changing planting method	58	38.7	24	16.0	4	2.7	64	42.7
Practicing crop rotation	74	49.3	41	27.3	1	0.7	34	22.7
Practicing intercropping	45	30.0	38	25.3	0	0.0	67	444.7
Practicing crop diversification	11	7.3	14	9.3	2	1.3	123	82.0
Homestead gardening	26	17.3	17	11.3	1	0.7	106	70.7
Vegetable cultivation	10	6.7	13	8.7	1	0.7	126	84.0
Rainwater conservation*								
Digging pond/well	39	26.0	34	22.7	0	0.0	77	51.3
Mulching with crop residue	11	7.0	17	11.3	1	0.7	121	80.7
Improving irrigation system*								
Use of pumps for irrigation	53	35.3	36	24.0	0	0.0	61	40.7
Use of drainage system	21	14.0	12	8.0	2	1.3	115	76.7
Non-farm activities*								
Duck rearing	6	4.0	1	0.7	0	0.0	143	95.3
Engaging in trading	1	0.7	1	0.7	0	0.0	148	98.7
Changing work	27	18.0	4	2.7	1	0.7	118	78.7
Migration	1	0.7	1	0.7	9	6.0	139	92.7

**Multiple responses*

In terms of varietal preference, most preferred to shift to short-duration varieties. Farmers contended that this is because of the delayed monsoon rain which shortens the cropping season. Under farming systems, crop rotation was the most common adaptation practice as farmers explained that this will maintain soil fertility and reduce damage from insect pests and weeds. Due to the delayed onset of monsoon rain and erratic and irregular rainfall pattern, farmers also adjusted their crop planting date and cropping method. Intercropping is also a common practice where farmers planted mango or thanaka, and pulses such as green or black gram were sown as strip crops in-between spaces. These adaptation practices are similar to the findings of Fosu-Mensah *et al*. (2010).

Crop diversification is a recommended adaptation practice. Lin (2011) as cited by Fadina & Barjolle (2018) (P-13) defined crop diversification as “the practice of cultivating more than one variety of a certain crop belonging to the same or different species in a given area in the form of rotations and or intercropping.” The aim is to help build resilience in agricultural systems especially if there are environmental stresses such as weather variability. Ayenan (2017) noted that it is perceived as among the most ecologically feasible, cost-effective, and rational ways of reducing uncertainties in agriculture, especially among smallholder farmers. Most respondents identified their practices more as crop rotation as they plant only one species during a specific season.

It is noted that despite the occurrence of high temperature and drought, the majority, if not most, of farmers still did not practice rainwater conservation practices such as mulching and digging a pond. Farmers explained that shifting to more drought-tolerant crops was the more logical move. This explains why farmers opted to plant green gram or black gram after the monsoon rice crop production. In this way, they can engage in other non-agriculture production-related work such as trike or tractor drivers and some even more to neighboring towns to work as factory workers. For those farmers who engaged in non-agriculture production-related work during the summer season, the farm is left to the other members of the household. For this reason, farmers shared that planting crops such as green or black gram is preferred as it is less laborious and has less water requirement. The engagement in non-farm jobs as an adaptation practice was also noted by Cuesta & Rañola (2009).

CONCLUSION AND RECOMMENDATIONS

Climatic data from DMH show that average rainfall over the past thirty years had been fluctuating and maximum temperature increased while minimum temperature went down. Consistently, most farmers in the study area perceived decreased rainfall, increasing summer temperature, and colder winter months. As extension workers identified drought and flood as common weather disturbances in the central dry zone area, farmers were asked about how these affected their farm production and income. Farmers shared that drought and flood only moderately affected their production and income as they were able to adopt practices that mitigated the impact of these weather disturbances.

A majority of the respondents changed cultivated varieties, cropping patterns, cropping systems, installed water pumps and constructed water ponds in the farm, and used synthetic pesticides to address increased pests in the farm. A major adaptation practice is planting green grams and black grams, chickpea, and sesame during the summer season where before they did not plant anything. As such, a majority of farmers did not see a reduction in income because they were able to derive income from planting crops that are more tolerant to drought stresses and are less labor-intensive.

As farmers moved towards more popular crops such as green gram, black gram, and sesame, it remains important that extension and market support are given to ensure that they do not suffer from low productivity. While irrigation facilities had been provided in some areas, this support had not been enough to encourage farmers to plant rice during summer seasons. This study implies that adaptation practices are rooted in perceived environmental problems, household labor availability, and market opportunities. Farming systems reveal that farmers had not been planting summer rice for the past years because they do not consider it viable. There is therefore a need to study rice production during the summer and monsoon season to ensure that this enterprise remains profitable enough for the farmers to engage in. There is also a need to provide more non-farm income sources which the farmers can engage in to ensure better livelihood opportunities.

Adaptation is a complex process. For farmers to benefit from their choices, the extension service must provide farmers appropriate and timely information relating to future weather variability, production techniques, and market opportunities so that farmers will have a wider portfolio of possibilities.

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