

Article

Do Farmers Perceive the Trends of Local Climate Variability Accurately? An Analysis of Farmers' Perceptions and Meteorological Data in Myanmar

Yarzar Hein ^{1,2,*} , Kampanat Vijitsrikamol ³, Witsanu Attavanich ⁴ and Penporn Janekarnkij ³

¹ Philosophy Program in Agricultural and Resource Economics (International Program), Graduate School, Kasetsart University, Bangkok 10900, Thailand

² Department of Agricultural Economics, Yezin Agricultural University, NayPyiTaw 15013, Myanmar

³ Department of Agricultural and Resource Economics, Kasetsart University, Bangkok 10900, Thailand; fecoknv@ku.ac.th (K.V.); penpornj@gmail.com (P.J.)

⁴ Department of Economics, Kasetsart University, Bangkok 10900, Thailand; attavanich.witsanu@gmail.com

* Correspondence: yarzarhein@yau.edu.mm

Received: 1 April 2019; Accepted: 3 May 2019; Published: 5 May 2019



Abstract: With the existing state of issues related to global climate change, the accuracy of farmers' perceptions of climate is critically important if they plan to implement appropriate adaptation measures in their farming. This article evaluated if farmers perceive the trends of local climate variability accurately, and was verified by the historical meteorological data analysis. Ordered probit perception models were applied in this study to determine the factors influencing the accuracy of farmer perception. It was observed that farmers' perceptions of the rainfall amount during the early, mid, and late monsoon periods were highly accurate, and they also accurately perceived summer temperature change, but less accuracy of perception was observed of the temperate changes of the winter and monsoon seasons. Access to weekly weather information, participation in agricultural trainings, farming experience, and education level of the farmer were the major factors determining the accuracy of perception in this study. Based on the empirical results, this study suggested policy implications for (a) the locally specified weather information distribution, and (b) integration of weather information into agricultural training programs, which are available to the farming community to enhance the government implantation of the Myanmar Climate Smart Agriculture Strategy and Myanmar Climate Change Master Plan 2018–2030.

Keywords: accuracy of perception; climate trend; climate variability; Myanmar; ordered probit

1. Introduction

Climate change poses a serious threat to livelihood security, as well as enhancing risk in climate sensitive sectors such as agriculture and forestry. Due to the increased frequency and intensity of extreme weather events and climate variability, declining crop yields and associated economic losses create vulnerability within the farming community. To reduce climate vulnerability and adapt to the world of changing climate, awareness and understanding of current climate trends is one of the indispensable capacities of an agricultural farming community.

As per the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), the observed climate trends, variability, and extreme events in South-East Asian (SEA) countries are specified as 0.1 to 0.3 °C temperature increase per decade between 1951 to 2000, a decreasing trend of precipitation and number of rainy days between 1961 and 1998, and droughts normally associated with El Niño Southern Oscillation (ENSO) years occurring in Myanmar, Laos, the Philippines, Indonesia, and Vietnam. Moreover, the frequency of monsoon depressions and cyclone formation in the Bay of

Bengal has declined since 1970, but the intensity is increasing and causing severe floods in terms of damage to life and property [1].

Based on the last six decades (1951–2015), the rainfall in Myanmar has increased on average by 29 mm per decade. Changes in rainfall have also influenced the duration of the monsoon season. The southwest monsoon onset has become later in the year, and withdrawal occurs earlier in the year [2]. According to the climate projections for 2021–2050 by the Regional Integrated Multi-Hazard Early Warning System (RIME) and Department of Meteorology and Hydrology of Myanmar, the temperature scenario shows warming (1.2–1.8 °C) during June to November, across the whole country. It remains warm, with the same magnitude, in other months in lower Myanmar, the deltaic region, and the southern part of the country, but not in the rest. Warming increases by 2.5–3.0 °C from December to May elsewhere in the country. The scenario of precipitation shows most of the country will receive about a 10% increase during March to November. In the northern, the eastern, and the central regions, there will be deficient rain by up to 80% during the cool months of December to February [3].

The key features of probable climate trends at the country level for Myanmar are (i) a general increase in temperature, with more extremely hot days and more extreme rainfall, resulting in more droughts and floods, (ii) an increased risk of flooding as a result of higher average rainfall intensity in monsoon events, and (iii) more variable rainfall in the rainy season, with an increase across the country from March to November and a decrease between December and February [4].

With the changing climate conditions, Myanmar farmers have to adjust their farming activities through adaptation strategies to those changes. Faced with climate change, adaptation and mitigation strategies are vital in agriculture. Adaptation strategies are difficult to implement, however, without an accurate perception of climate change. Theoretically, a higher perception of climate change enhances the use of proper adaptation strategies, and builds more adaptive capacity. However, the ways that individuals perceive climate change are highly personal, place-based, and influenced by several factors. Therefore, the precision of perception has become an issue to be examined academically.

While the accuracy of farmers' perceptions is critically important if farmers plan to implement appropriate adaptation measures, to our knowledge there are very few research studies examining the extent to which farmers' perception of climate change tracks with observed changes, and no previous study of this kind has been done in Myanmar. For this reason, "do farmers perceive the trends of local climate variability accurately?" becomes the primary research question in this study. Based on the research question, there are two main research objectives; (i) to evaluate the accuracy of farmers' perceptions of climate variability and (ii) to assess the factors influencing farmers' perceptions of climate change. To evaluate the accuracy of farmers' perceptions, this study also explored the pattern and trend of climate variability in the study area, using historical meteorological data analysis.

As per the recent literature, Abid, Scheffran [5] explored farmers' understanding of climate change and the role of the accuracy of perceptions in the use of adaptation process, through two important hypotheses: (1) more accurate perceptions lead to stronger adaptation intentions, and (2) underestimated perceptions lead to weaker adaptation. Their study found that most of the perceptions of an increase in summer and winter temperatures correspond with historical climatic trends for both summer and winter temperatures, and confirmed that farmers accurately perceive mean temperature changes. However, they also reported there was a discrepancy between farmer perceptions of rainfall changes and local climate records in their study; the accuracy of the response rate was below 30%.

Niles and Mueller [6] also measured the accuracy of farmers' perceptions of climate change by comparing farmers' perceptions with the historical trends of temperature and precipitation. Their study pointed out that farmers' perceptions were influenced by a variety of personal and environmental factors, including infrastructure and local knowledge. A total of 45% of farmer perceived a decreased summer temperature trend over time, and 42% thought the temperature had stayed the same, even though there was a positive summer temperature trend. Only 13% believed the summer temperature had increased. Similarly, while historical data showed a positive trend of winter temperatures, 42% of farmers perceived that winter temperatures had stayed the same, and 19% felt they had decreased. In

the case of the negative trend of annual precipitation, 51% of farmers perceived annual rainfall had increased, 42% felt it had stayed the same, and 7% felt it had decreased. Consequently, the accuracy of their perceptions was questionable, as they were inconsistent.

The studies of Brulle, Carmichael [7] and Hamilton and Stampone [8] revealed that people's concern or perceptions relating to climate change may not always reflect reality, and climatic events or trends may be misinterpreted or wrongly remembered for a variety of reasons. However, Aymone Gbetibouo [9] compared farmers' perceptions of temperature and precipitation with the actual trends of meteorological data, and observed that the majority of farmers' perceptions were in line with the actual climate data trends. Likewise, in other studies [10–13], farmers' perceptions of the changes in temperature and precipitation were also verified by the historical meteorological data. In terms of the level of accuracy of farmers' perceptions, Ayanlade and Radeny [10] revealed that 67% of the sampled farmers had the correct perception of changes in climate, and those farmers' perceptions of climate change were exactly the same as the results of meteorological analysis. A recent study by Patrick, Edilegnaw [12] also proved that 68% of the interviewed farmers recognized the actual changes in local climatic patterns.

As per study of Menapace, Colson and Raffaelli (2014) [14], the farmers' perceptions to climate change were vital to their farm management, especially in risk perception, as they observed that the farmers who perceived climate change were aware of the negative impact of climate change and could predict long term agricultural risk associated with climate change. Moreover, Tun Oo, Van Huylenbroeck and Speelman (2017) also mentioned the role of farmers' perception to climate change in the farming adaptation practices. Their study measured the farmers' perception of climate change by a five-point liker scale and found that 60.8% of famers perceived the climate change. Based on the farmers' perceptions of climate change, the adjustment of sowing time and crop diversification were the major adaptation options in the dry zone of Myanmar [15].

2. Research Methodology

2.1. Data Collection

In this study, both secondary data and primary data were utilized. For the analysis of local climate trends, the time series data of precipitation (rainy days, amount of rainfall), and temperature (maximum and minimum temperatures during 1987 to 2017, collected from the Department of Hydrology and Meteorology and Department of Agriculture in the study area).

The primary data, including the socioeconomic characteristics of the farming households, farmers' perceptions and awareness of climate change, the climatic stresses experienced by the farming households, and their adaptation strategies to existing climatic stress and unfavorable climate changes, were collected by the farm household survey. The study was carried out in two townships of the dry zone of Myanmar; ShweBo, and KyautSe (Figure 1). Based on the extent of rice growing area, purposive sampling was employed for the selection of village tracts from townships, and three village tracts from a rainfed ecosystem and another three village tracts from an irrigated ecosystem were selected in each township. In the selection of sample farm households, the stratified random sampling method was used. According to the farmer population lists of the Department of Agriculture and General Administrative Department, 20% of rice farming households in the selected villages were randomly chosen in three farm categories, including small, medium, and large-scale farms. Although 300 farm households were selected, only 289 samples were retained for data analysis: 96 farm households from ShweBo and 87 farm households from KyautSe represented irrigated agriculture, and 50 farms in ShweBo and 56 farms in KyautSe were operated under rainfed conditions. This sample ratio was almost the same as the percentage of irrigated and rainfed-farm households in each township.

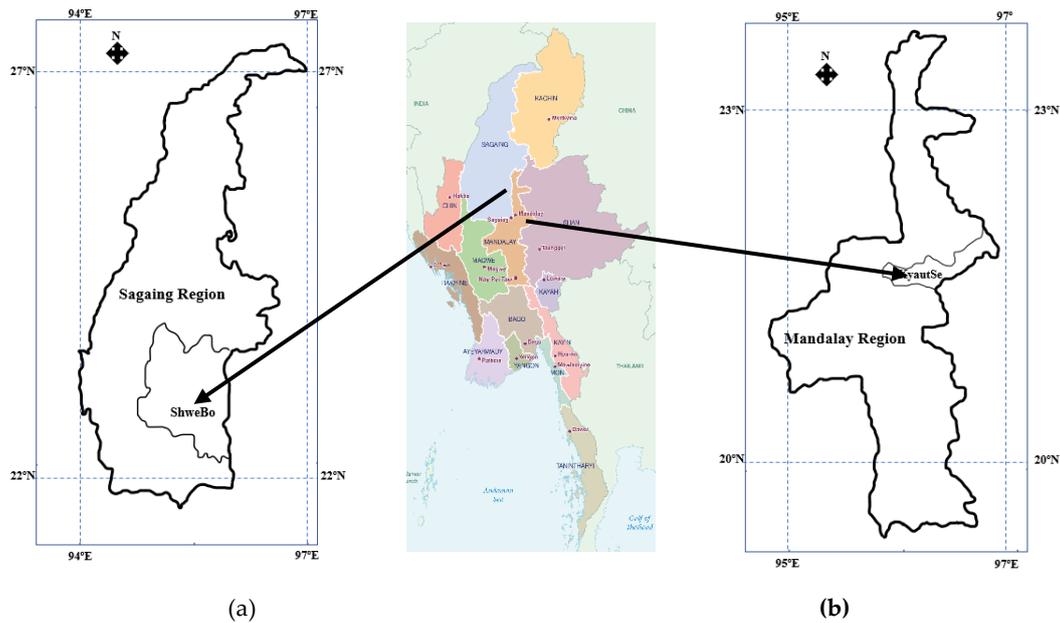


Figure 1. Study area map: (a) ShweBo Township in Sagaing region and (b) KyautSe Township in Mandalay region, Myanmar.

2.2. Theoretical Models and Empirical Tools

2.2.1. Analysis on the Pattern and Trend of Climate Variability

With the aim of exploring the local climate trends in the study area, the empirical analysis on the pattern and trend of climate variability was undertaken using the anomaly index and cumulative departure index.

Anomaly Index: The anomaly indices were used to study the annual variability of rainfall and temperature in the study area from 1987 to 2017. The rainfall and temperature anomaly indices were calculated by the following equations:

$$RAI = +2 \left(\frac{R - M_R}{M_{H10} - M_R} \right) \quad (1)$$

where RAI is the rain anomaly index, R is the actual rainfall (mm/year), M_R is the mean rainfall (mm/year), and M_{H10} is the mean of the 10 highest values of rainfall (mm/year).

$$TAI = +2 \left(\frac{T - M_T}{M_{H10} - M_T} \right) \quad (2)$$

where TAI is the temperature anomaly index, T is the annual average temperature in a specific year ($^{\circ}\text{C}$), M_T is the 30-year mean of the annual average temperature ($^{\circ}\text{C}$), and M_{H10} is the mean of the 10 highest values of annual average temperature ($^{\circ}\text{C}$).

Cumulative Departure Index (CDI): The cumulative departure index was used to assess the trend of rainfall during the early growing season (EGS) and late growing season (LGS), showing within-season variability of rainfall [10]. The cumulative departure index for seasonal rainfall variability was calculated using the following equation:

$$CDI = \frac{R_a - R_m}{SD} \quad (3)$$

where CDI is the cumulative departure index, R_a is the actual rainfall for the growing season months (developed from the daily rainfall data, mm/season), R_m is the mean rainfall (mm/season), and SD is the standard deviation of the total length of the period of study.

This method was also applied in the analysis of temperature change (average day and night temperatures within the season in degrees Celsius).

$$CDI = \frac{T_a - T_m}{SD} \tag{4}$$

where T = the temperature.

2.2.2. Farmer Perception Score and Level

In examining farmers’ perceptions of specific climate variability, five options were given to each respondent (Increase Trend, Unchanged, Decrease Trend, Irregular Trend, or No response, within the time frame of the last five years). There were nine questions about local climate variability; rainfall amount changes in the early-monsoon/mid-monsoon/late-monsoon, changes in rainy days in early-monsoon/mid-monsoon/late-monsoon, and temperature changes in summer/monsoon/winter, resulting in nine responses for each farmer’s perception of climate change.

Precipitation in the early days of monsoon season is very important for the farmer to decide the planning time. Based on their perception, the farmer can manage effective and timely land preparation. Precipitation in mid-monsoon make the farmers to decide where additional water is needed or not to their plantation. Precipitation in late monsoon season is a challenge to farmers if there is heavy rain in the harvest period. Based on their perception of monsoon precipitation, the planting time should be adjusted to avoid heavy rain in harvest time, or the farmer should have a strategy to address such an event. For the perception to temperature, variation within a season is not much different in the study area as it is in tropical zone, however, it is different between the three seasons (summer, winter and monsoon). Concerned with technical aspects, high temperatures during a growing season, (i.e., monsoon temperature for the rainfed rice growing season or summer temperature for the irrigated rice growing season) are very important for the productivity and crop failure that occurred in some years due to the high temperatures and drought. If the farmer is aware of high temperature trends in a rice growing season, they may change the stress tolerant rice varieties or may change some other crops rather than rice. Thus, the farmers’ perceptions to rainfall amount and rainy days, and perception of temperature trends in the summer, monsoon and winter seasons, were examined in this study.

Following the concepts of farmers’ perceptions and meteorological comparison [9–13], the accuracy of farmers’ perceptions was justified by the actual local climate trends from meteorology data records. If the perception was the same as the actual trend of rainfall changes in the early-monsoon, the score was 1, and 0 otherwise. In Table 1, PRA_i captures farmers’ perceptions of changes in rainfall amount. PRD_i captures farmers’ perceptions of changes in rainfall duration, and PT_i captures farmers’ perceptions of changes in temperature.

Table 1. Scoring method on farmer’s perception.

Perception Indicators	Perception Period		
	Early Monsoon	Mid-Monsoon	Late Monsoon
Rainfall Amount	$PRA_{EM} (0/1)$	$PRA_{MM} (0/1)$	$PRA_{LM} (0/1)$
Rainy Day	$PRD_{EM} (0/1)$	$PRD_{MM} (0/1)$	$PRD_{LM} (0/1)$
	Summer	Monsoon	Winter
Temperature	$PT_S (0/1)$	$PT_M (0/1)$	$PT_W (0/1)$

Note: EM, MM, and LM are abbreviations for Early Monsoon, Mid-Monsoon and Late Monsoon, respectively. Also, S, M, and W are abbreviations for Summer, Monsoon and Winter, respectively.

As there were nine indicators for perception of climate variability, the total score a farmer obtained to indicate accuracy of perception of climate variability consistent with the meteorological data record was between 0–9. As these “0–9” scores were derived from the comparison of farmers’ perception to specific climate variable with the respective trends of meteorological data recorded, it was noted as the consistency of farmer perception to the climate trends of meteorological data. Then, these scores were categorized into three levels: low consistency of famers’ perception, medium consistency of famers’ perception, and high consistency of famers’ perception to the recorded climate trends.

2.2.3. Ordered Probit Perception Model

The ordered probit model is widely used as an approach to estimate models of ordered types. The ordered probit model is built around a latent regression in the same manner as the binomial probit mode $Y_{ij} = \alpha X_{ij} + \varepsilon_{ij}$, in which Y_{ij} is the latent unobservable variable and normally distributed with a zero mean, X_{ij} is the vector of farmer i ’s socioeconomic characteristics, α is the unknown parameter to be estimated, and ε_{ij} is the random term of the latent regression [16].

In this study, three levels of farmer’s perception consistency (0 = low consistency of farmers’ perception, 1 = medium consistency of farmers’ perception, and 2 = high consistency of farmers’ perception) were ordinal in nature and discrete variables, then it was specified as:

$$Y = \begin{cases} 0, & \text{if } 0 < Y_{ij} < \mu_1 \\ 1, & \text{if } \mu_1 < Y_{ij} < \mu_2 \\ 2, & \text{if } \mu_2 < Y_{ij} < \mu_3 \end{cases} \quad (5)$$

where μ_1 , μ_2 and μ_3 are the classifying threshold values. Like the models for binary data, the probabilities for each of the observed ordinal perceptions were given as:

$$\begin{aligned} Prob(Y = 1|X) &= F(\mu_1 - \alpha X_1) - F(-\alpha X_1) \\ Prob(Y = 2|X) &= F(\mu_2 - \alpha X_1) - F(\mu_1 - \alpha X_1) \\ Prob(Y = 3|X) &= F(\mu_3 - \alpha X_1) - F(\mu_2 - \alpha X_1) \end{aligned} \quad (6)$$

where $F(\cdot)$ is the cumulative standard normal distribution function, X is the vector of independent variables that affects the farmer’s perception level, and α is the unknown parameter to be estimated. The ordered probit model is a non-linear regression, and its coefficients cannot represent the marginal changes in the dependent variable as the independent variables change. In that case, the marginal effects were computed as follows:

$$\begin{aligned} \frac{\partial P(Y=1|X)}{\partial X_j} &= f(\mu_1 - \alpha X_j)\alpha_j \\ \frac{\partial P(Y=2|X)}{\partial X_j} &= f(\mu_1 - \alpha X_j)\alpha_j - f(\mu_2 - \alpha X_j)\alpha_j \\ \frac{\partial P(Y=3|X)}{\partial X_j} &= f(\mu_2 - \alpha X_j)\alpha_j - f(\mu_3 - \alpha X_j)\alpha_j \end{aligned} \quad (7)$$

The hypothesized model for the determinants of local farmers’ perceptions of climate variability is shown in Equation (8), and the definition of variables is provided in Table 2.

$$FPL = \alpha_0 + \alpha_1 FEX + \alpha_2 EDL + \alpha_3 GEN + \alpha_4 POF + \alpha_5 MCF + \alpha_6 RAW + \alpha_7 AAE + \alpha_8 ALO + \alpha_9 ISL + \alpha_{10} FIS + \alpha_{11} ATP + \alpha_{12} EDS + \alpha_{13} EUR + \alpha_{14} EFE + \alpha_{15} HAF + \alpha_{16} LDA + \varepsilon \quad (8)$$

Table 2. Definition of variables of farmer perception model.

Variables	Description
FPL	Farmer's perception levels (low, medium, high)
FEX	Farming experience (years)
EDL	Education level of farmer (schooling years)
GEN	Gender of farmer (0 = female, 1 = male)
POF	Primary occupation (1 = farming, 0 = other) of farmer
MCF	Major crop of farm (0 = non-cash crop, 1 = cash crop)
RAW	Regular access of weather information weekly (0 = no, 1 = yes)
AAE	Previous agricultural extension contacts (frequency within last season)
ALO	Agricultural land operated (ha)
ISL	Irrigation status of agricultural land (% of total farm land under irrigation schedule)
FIS	Farm-income share (% of total income)
ATP	Agricultural training participation (frequency)
EDS	Experience on dry-spell period in a growing season (frequency within last five year)
EUR	Experience on unexpected rain in critical crop growth (frequency within last five year)
EFE	Experience on flood event in growing season (frequency within last five year)
HAF	Holistic affect: How the farmer feels about CC ((1 = Climate change impact is better for farming, 2 = no effect on farming and 3 = worse in farming)
LDA	Location Dummy (0 = KyautSe, 1 = ShweBo)

3. Results and Discussion

In this section, the findings are reported in three main parts, including: (1) Climate variability and its trend; (2) farmers' perceptions of climate variability; and (3) factors influencing farmers' perceptions on climate.

3.1. Climate Variability and its Trend

In this subsection, we report on the variability and trends of precipitation, temperature, and local climate stress.

3.1.1. Precipitation Variability and its Trend

The distribution and density of precipitation were analyzed by the rainfall anomaly index (RAI) and cumulative departure index (CDI). Figure 2 shows the rainfall anomaly index (RAI) with five year moving averages for annual precipitation density (annual rainfall amount) in the ShweBo and KyautSe townships.

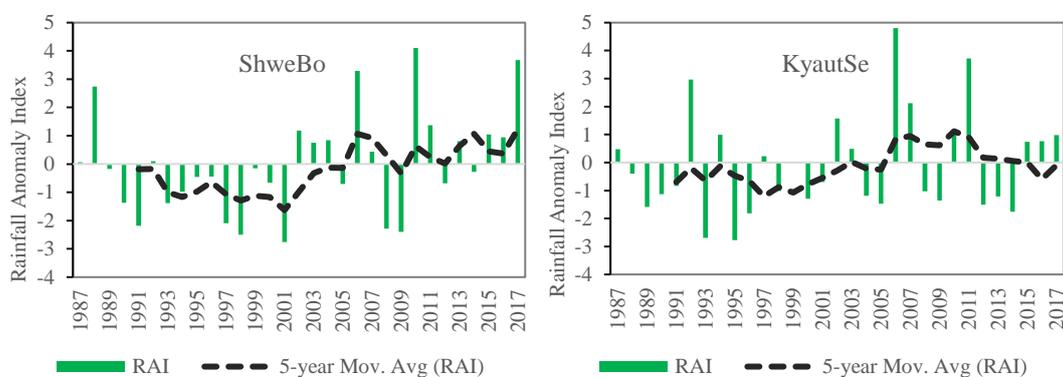


Figure 2. Rainfall anomaly index (RAI) and five-year moving average for ShweBo and KyautSe from 1987 and 2017.

In accordance with the rainfall anomaly index, there were noticeable variabilities of annual precipitation in both ShweBo and KyautSe. The positive variabilities were observed in the year 1988,

2006, 2010, and 2017 in ShweBo, and 1992, 2006, and 2011 in KyautSe. Moreover, it was observed that those years were recorded as flood years in the study area. The five-point moving average of annual rainfall showed that approximately two-thirds of the years from 1987 to 2017 were below the 30-year average annual precipitation, in both cases. Specifically, the annual rainfalls before 2006 were lower than the 30-year average, then after 2006 it fluctuated, but with increasing trends.

Figure 3 explains the pattern and distribution of rainfall in the ShweBo and KyautSe areas. The rainfall distributions of these areas were observed as a bimodal pattern, indicating two important durations for agriculture: early monsoon (April, May, June) and late monsoon (August, September, October). The dry spell or drought normally occurred in July in the study area and is called the “July Drought” by the local people. However, during the years 2013 to 2017, drought was observed earlier than July in both the ShweBo and KyautSe areas. In terms of the duration of rain during the most recent five-year period of 2013–2017, it is observed that there were less rainy days in the early monsoon and more rainy days in the late monsoon season than the 30 year average (1987–2017).

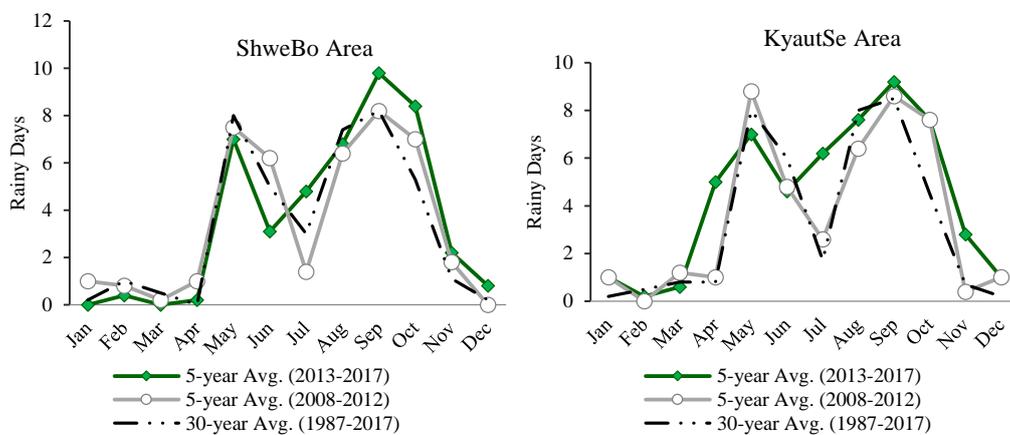


Figure 3. Distribution and pattern of average monthly rainy days in ShweBo and KyautSe.

Figure 4 presents the trends of rainfall within a growing season by the cumulative departure index. The cumulative departure index of ShweBo revealed that the early growing season rainfalls (EGS CDI) were above the normal in the earlier period of 1987 to 1999, then fluctuated in the late period during 2000 to 2017, and overall had a decreasing trend.

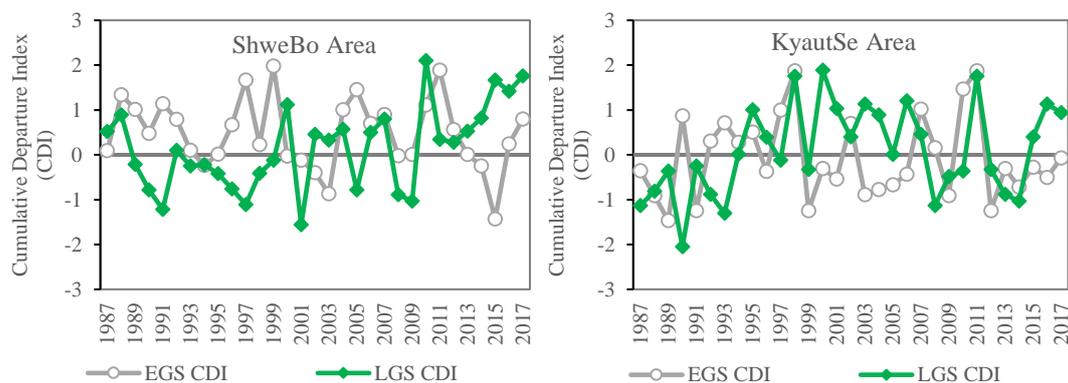


Figure 4. Growing season fluctuation of rainfall based on cumulative departure index between 1987 and 2017 (EGS: early growing season, LGS: late growing season).

There was a decreasing trend of rainfall in the early growing season of ShweBo. However, observation of the trend of rainfall in the late growing season (LGS CDI) showed the opposite. Most of the seasonal precipitation in earlier years (1989–1999) was below the normal level, fluctuated during 2000–2010, then was above the normal from the year 2011 to 2017. Generally, it was concluded that there

was an increasing trend of the late growing season rainfall in ShweBo. In the case of KyautSe, although the precipitation in both the early growing season and late growing season fluctuated throughout the study period, the negative values of EGS CDI indicated that the rainfall during the early growing season was reduced, and the positive values of LGS CD indicated the rainfall in the late growing season was increased. It was also observed that there was an increasing trend of late growing season rainfall, and a slightly decreasing trend of early growing season rainfall.

3.1.2. Temperature Variability and its Trend

Figure 5 shows the temperature anomaly index (TAI) with five year moving averages in the study area. The TAI index indicated the noticeable temperature variabilities throughout the 30 year period (1987–2017). The five-year moving average line revealed that the temperatures were above normal generally, although temperature in some years were below the normal line. It was found that the temperatures within the last five years (2013–2017) were obviously above normal.

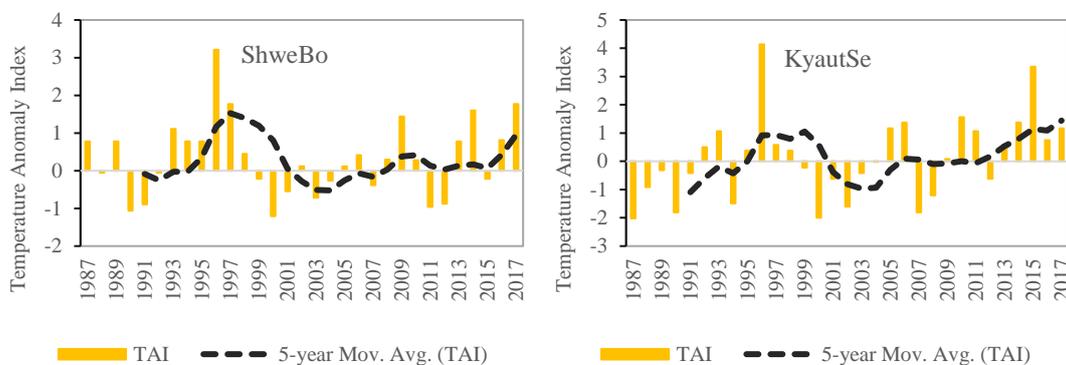


Figure 5. Temperature anomaly index (TAI) and five-year moving average for ShweBo and KyautSe, from 1987 and 2017.

In particular, it was also observed that the seasonal temperatures within the last five years (2013–2017) were higher than the 30-year average temperature and five-year average of 2008–2012, as shown in in Figure 6. It stated that the 2013–2017’s temperatures of summer, monsoon and winter periods of ShweBo and KyautSe had an were higher than the previous five years. Figure 7 describes the season temperature fluctuation by the cumulative departure index (CDI) during 1987 to 2017. It was observed that the summer temperature trends (Summer CDI) of ShweBo and KyautSe were above the normal; the monsoon temperature trends (Monsoon CDI) fluctuated throughout the 30-year period; and the winter temperature trends (Winter CDI) were nearly normal in both ShweBo and KyautSe. Generally, the summer and monsoon temperature had visible increasing trends, but slightly increasing trend for winter temperature was also observed.

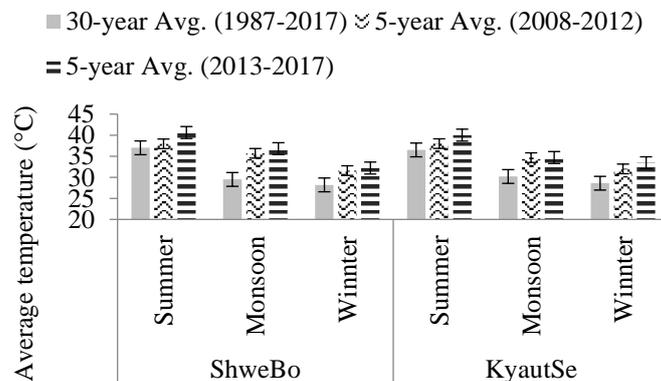


Figure 6. Five-year average seasonal temperature (°C) for 2013–2017 and 2008–2012.

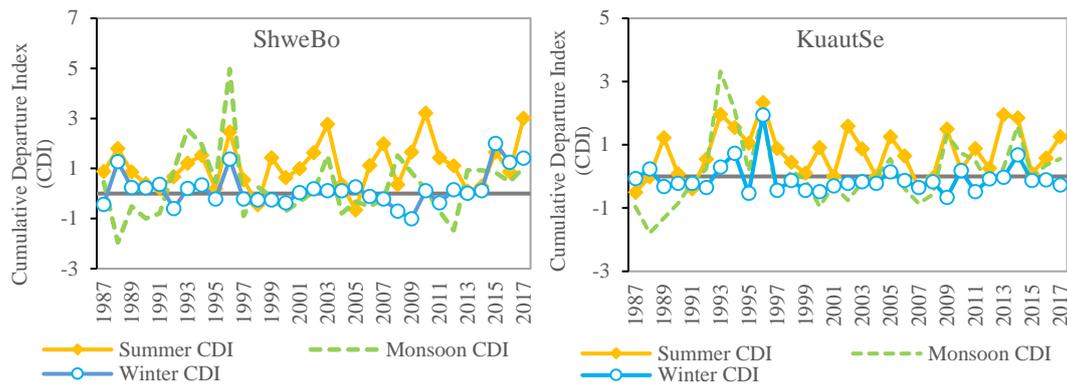


Figure 7. Season temperature fluctuation based on cumulative departure index (CDI) between 1987 and 2017.

3.1.3. Local Climate Stress in Agriculture

There were three types of climate stress observed in the farming system: (a) dry spell periods during the crop growing season, which 91% of the rainfed farming and 27% of the irrigated farming areas reported that they suffered within last five years, (b) unexpected rain during critical crop growth stages, happening to 95% of rainfed farms and 85% of irrigated farms, and (c) serious flood during crop season, suffering by 86% of rainfed farms and 46% of irrigated farms (Figure 8). Specifically, these three climate stresses were detailed by the different levels of occurrence within the last five years in the study area.

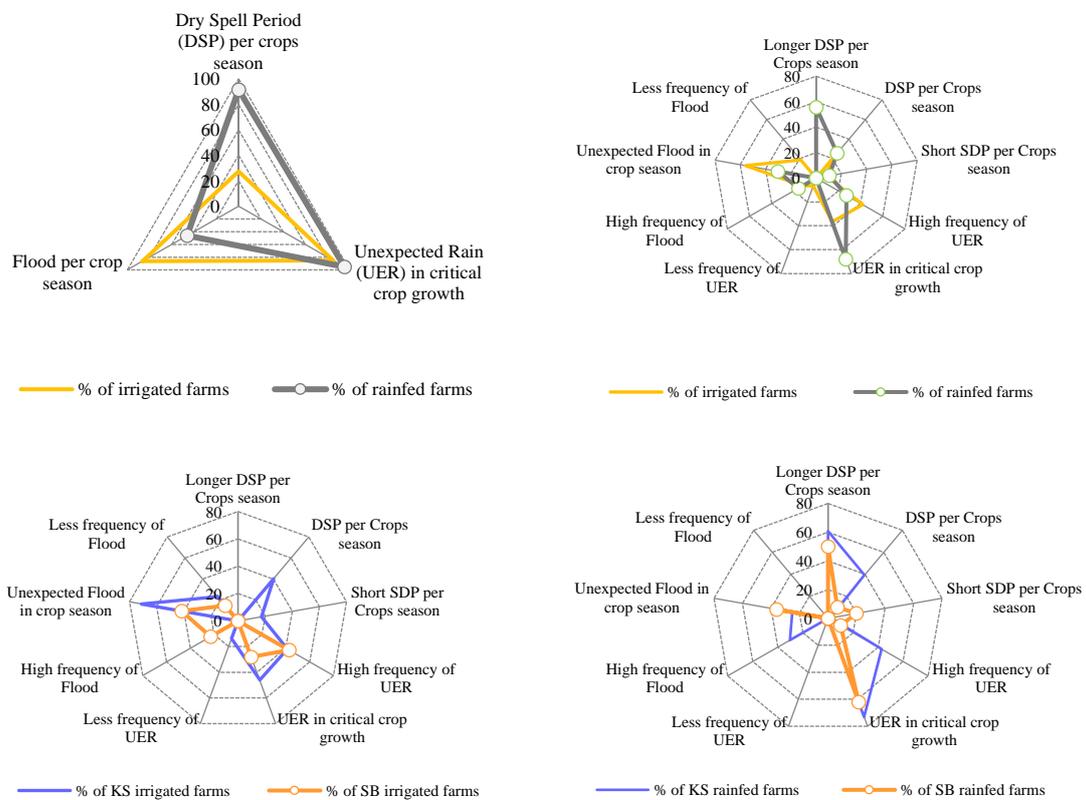


Figure 8. Specific climate stresses by irrigated and rainfed conditions.

As shown in Figure 8, unexpected rain in a critical crop growth stage was the most serious climate stress in the study area, and there were three categories of unexpected rain events. The first was a high frequency of unexpected rain, which occurred almost every season. The second was unexpected

rain events, which happened in three- to four-season intervals. The last was a lower frequency of unexpected rain, which occurred in more than five season intervals. In the case of unexpected rain, 27% of rainfed farmers and 47% of irrigated farmers reported they suffered unexpected rain in a critical crop growth stage, especially during seeding time and harvesting time, in almost every season. Specifically, 41% of KyautSe irrigated farms and 43% of ShweBo irrigated farms experienced a high frequency of unexpected rain.

The study highlighted that irrigated farms had a high frequency of unexpected rain in critical crop growth stages because irrigated farming followed the irrigation schedule of the local department of irrigation and did not adjust their farming activities in accordance with the monsoon onset and offset periods. To reduce a high frequency of unexpected rain in irrigated farms, the irrigation schedule of the department should be adjusted with the local monsoon onset conditions.

The dry spell period was grouped into three levels; (i) longer dry spell, which occurred for more than 45 days in a growing season, (ii) dry spell periods, which had a duration of between 30 to 45 days, and (iii) short dry spells, which lasted for less than 30 days in a season. In the study, dry spell periods were the second major climate stress. It was observed that 56% of the rainfed farms encountered a longer dry spell period in a growing season, including 60% of the KyautSe rainfed farms and 50% of the ShweBo rainfed farms.

Unexpected flood was also one of the climate stresses in the study area, and 56% of irrigated farms and 30% of rainfed farms reported that this occurred in 3- to 4-year intervals, with 71% of KyautSe irrigated farms and 41% of ShweBo irrigated farms reporting these events. The study observed that an unexpected flood event was more likely to occur in irrigated farming, as there was poor maintenance of irrigation infrastructure and a lack of drainage systems on the farms, resulting in serious flash flooding if there was an excessive amount of rain water overflow from the canal.

3.2. Farmers' Perceptions of Climate Variability

To observe farmers' perceptions of climate variability, this study collected data from sampled farms, which were rice-based farming households including irrigated and rainfed farming in two locations, ShweBo township and KyautSe township. The socioeconomic characteristics of the irrigated and rainfed farm households are listed in Table 3. The descriptive analysis showed that the average age of the farmers was 50.64 years, ranging from 28 to 74 years, for the total sample. The average age was 50.52 years for the irrigated farmers and 50.86 years for the rainfed farmers. The average schooling years of the farmers was nearly the same for all categories; 5.82 years for the total sample, 5.89 years for the irrigated farmers, and 5.71 years for the rainfed farmers, ranging from 0 to 16 years. The average family size for the whole sample, irrigated farm households, and rainfed farm households was about 4.6, the average family labor was 2.3, and the average farm size was 7.45 ac for the whole sample, 7.65 ac for the irrigated farms, and 7.10 ac for the rainfed farms. These variables were not significantly different in between the irrigated and rainfed farms. However, the rice farming experience, non-rice farming experience, and livestock farming experience of both groups were significantly different at the 1% level. The average rice farming experience of the irrigated farm households was 27 years, higher than that of the rainfed farmers (22 years). The average non-rice farming experience of the irrigated farmers was 7 years, lower than that of the rainfed farmers (15 years). For livestock farming, it was observed that only rainfed farm households had any livestock farming experience, and there were very few commercial livestock farms in the study area.

Table 3. Descriptive analysis on sample households' profile.

	Total Samples (N=289)			Irrigated Farms (N=183)			Rainfed Farms (N=106)			P value
	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD	
Age of farmer (years)	50.64	28.00–74.00	9.72	50.52	28.00–74.00	10.04	50.86	31.00–69.00	9.17	0.7753
Schooling years of farmer	5.82	0.00–16.00	2.55	5.89	0.00–16.00	2.62	5.71	0.00–14.00	2.43	0.5689
Rice farming experience (years)	25.09	3.00–56.00	10.55	26.97	3.00–56.00	10.67	21.83	3.00–39.00	9.55	0.0001
Non-rice farming experience (years)	10.53	2.00–30.00	7.22	7.49	2.00–29.00	6.42	15.05	4.00–30.00	5.89	0.0000
Livestock farming experience (years)	2.82	1.00–9.00	1.66	0.00	0.00–0.00	0.00	2.82	1.00–9.00	1.66	0.0000
Family member (no.)	4.56	2.00–8.00	1.40	4.56	2.00–8.00	1.40	4.58	2.00–7.00	1.42	0.9161
Family farm labor (no.)	2.28	1.00–5.00	0.76	2.27	1.00–5.00	0.81	2.28	1.00–4.00	0.66	0.9160
Non-farm employee (no.)	1.30	1.00–2.00	0.46	1.32	1.00–2.00	0.48	1.25	1.00–2.00	0.45	0.6614
Household dependency ratio	0.43	0.00–0.80	0.20	0.43	0.00–0.75	0.20	0.43	0.00–0.80	0.20	0.9271
Farm Size (ac)	7.45	2.00–32.00	4.67	7.65	2.00–32.00	5.24	7.10	2.00–19.00	3.37	0.3373
Lowland irrigated farm (ac)	7.65	2.00–32.00	5.24	7.65	2.00–32.00	5.24	0.00	0.00–0.00	0.00	0.0000
Lowland rainfed farm (ac)	5.33	2.00–12.00	2.42	0.00	0.00–0.00	0.00	5.33	2.00–12.00	2.42	0.0000
Upland rainfed farm (ac)	2.89	1.00–7.00	1.71	0.00	0.00–0.00	0.00	2.89	1.00–7.00	1.71	0.0000
Irrigation Status (% of farm size)	63.38	0.00–100.00	48.28	100	100.00–100.00	0.00	0.00	0.00–0.00	0.00	0.0000

Considering climate perceptions of farmers, this study revealed that farmers had a wide variation in climate perceptions (Table 4.). According to the nine perception indicators, as discussed earlier, the local farmers had more accurate perceptions of the changes in rainfall duration within a season. Generally, it was observed that 85% of the farmers perceived the changing climatic patterns in their environment as either increasing or decreasing trends of rainfall and temperature, 10–15% of the farmers reported that they did not know the rainfall trends, and 15–21% of farmer did not perceive any changes of temperature in the monsoon and winter period. In this study, the analysis of farmers' perception was, more than in the general trends of climate change, emphasized the in-seasonal nature of rainfall (early, mid and late-monsoon periods), and the seasonal nature of temperature (summer, monsoon, and winter).

Table 4. Accuracy of farmer's perception by meteorological data analysis.

Perception Indicators	Percentage of the Farmers Who Give the Response as:					Percentage of Farmers Who Have Consistent Perception with Recorded Data Trends
	Increase Trend during Last Five Years	Decrease Trend during Last Five Years	Same Trend during Last Five Years	Irregular	No Response	
<u>Rainfall intensity</u>						
in Early Monsoon	10.73	32.87	20.10	25.61	10.04	32.87 (75.47/8.20)
in Mid Monsoon	16.64	24.91	15.91	30.79	12.07	15.91 (28.30/8.74)
in Late Monsoon	27.68	9.34	20.79	26.64	15.88	27.68 (50.94/14.20)
<u>Duration of rainfall</u>						
in Early Monsoon	15.22	48.79	12.11	20.41	3.46	48.79 (75.47/33.33)
in Mid Monsoon	33.56	10.38	30.79	18.68	6.92	33.56 (41.51/28.96)
in Late Monsoon	44.64	14.87	10.38	13.15	16.96	44.64 (61.31/34.97)
<u>Temperature</u>						
in Summer	58.13	6.92	11.15	13.14	0.00	58.13 (69.81/51.36)
in Monsoon	3.46	13.84	26.29	41.52	15.22	3.46 (0.94/4.91)
in Winter	6.57	12.80	20.79	38.72	21.45	6.57 (3.77/8.19)

Specifically, the study revealed that 49% of the farmers perceived a decreasing trend of rainy days in the early-monsoon period, 34% of farmers perceived an increasing trend in the mid-monsoon period, and 45% of farmers perceived a decreasing trend of rain duration in the late-monsoon period. These results corresponded to the findings of the previous meteorological data analysis, showing the majority of local farmers had an accurate perception of the rainy-day changes within a season.

However, regarding the perception to the change in rainfall intensity within a season, the farmers had an accurate perception mainly in the early-monsoon period and late-monsoon period. It was

found that 33% of farmer perceived a decreasing trend of rainfall intensity in the early-monsoon period, and 28% of farmers perceived an increasing trend in the late-monsoon period, as observed in meteorological records.

In terms of the perception of temperature, most of the farmers had an accurate perception in the summer period; 58% of the farmers perceived the increasing trend of temperature in that period, in line with the results of historical temperature analysis.

It was observed that 42% of farmers thought there was an irregular change in the monsoon temperature, and 39% of farmers perceived an irregular temperature trend in the winter period. These perceptions, however, were inconsistent with the findings of meteorological data analysis. Only a few farmers had the same perception as the historical data analysis.

In these cases, lack of location specified climate information distribution would be the reason for inconsistent perception issues. Detailed changes of the climate during specific periods were difficult for the farmer to realize themselves, without knowing accurate weather information. Moreover, the weather focused news the farmers accessed only covered the regional situation generally, and was not for their specific location.

Overall, the farmers had a more accurate perception of the changes in rainfall, in terms of intensity and duration, than the changes in temperature. It can be concluded that the majority of farmers perceived the actual trends of rainfall changes in the early, mid, and late-monsoon periods, and also temperature changes in the summer period. These results were in line with the findings of Ayanlade, Radeny [10]. They also compared the farmers' perceptions of climate variability with the results of historical trends from meteorological data. Their study indicated that most of the farmers perceived the changes in onset of rainfall (40% of farmers) and drought and long dry spells (50.6% of the farmers), but fewer perceived the temperature changes (only 35% of the farmers). Moreover, the results of this study were in agreement with the McKinley, Catharine [17] report of "Climate Change Perceptions and Policies in Myanmar, 2014". In their report to Climate Change, Agriculture and Food Security (CAAFS), rainfall trends, flood events, extreme heat stresses, and temperature trends were threatening the agriculture sector and farming community, and most of the farmers perceived more accurately the rainfall trends than the temperature trends.

The findings of (a) the high accuracy of farmers' perceptions of the precipitation in the early monsoon period, mid-monsoon period, and late-monsoon period, and the temperature in summer, and (b) the low accuracy of farmers' perceptions of the temperature in the monsoon and winter periods, were not the same as found in other studies in different countries. The study by Abid, Scheffran [5] showed a high accuracy of perceptions of temperature changes (75% of farmers had accurate perceptions), and less accuracy of perceptions of precipitation (lower than 30%). In the study by Gebrehiwot and van der Veen [11], the farmers' perceptions of the changes in temperature and precipitation were also confirmed by the historical meteorological data analysis. Their study showed that 78% of the farmers perceived an increase in the temperature, and 69% of the farmers perceived a decrease in rainfall, corresponding accurately to the climate data analysis. Moreover, in the study by Aymone Gbetibouo [9], 91% of farmers perceived the increasing temperature trend and 81% perceived the decreasing trend of precipitation, and these perceptions were verified by the recorded meteorological data. Msafiri Y. and Xinhua [18] also proved that the farmers' perceptions of temperature and rainfall were in line with the meteorological data analysis, with 80% of the farmers perceiving the increasing trend of temperature and 60% of the farmers perceiving the decreasing trend of rainfall. In the study by Sahu and Mishra [13], 48% of the farmers noticed an erratic pattern of rainfall, and 98% of the farmers perceived an increase in temperature; the same result as the recorded data analysis.

In this study, the percentages of farmers whose perceptions were consistent with the meteorology data seemed to be lower than that of other studies, because this study focused on the details of in-season trends and seasonal trends, rather than annual trends as in other studies. However, it was clearly observed that there was a need to improve the accuracy of farmers' perceptions of climate variability, and sharing of specific local weather information with the community would be one possible way of

solving this issue. A daily rainfall and temperature recording system of the Department of Agriculture already exists in each township.

After comparison of the farmers' perceptions with the historical data analysis, the individual farmer's perceptions were categorized into three levels; (a) low consistency of farmers' perception, (b) medium consistency of farmers' perception, and (c) high consistency of farmers' perception, to the recorded climate trends, according to the frequency and distribution of their scores. Table 5 shows the farmer perception consistency for the total sample, irrigated farm households, and rainfed farm households in the study. It reveals that 45% of the total sample, including 60% of irrigated farms and 20% of rainfed farms, were in the group of low perception of climate variability level. A total of 25% of total households, together with 14% of irrigated farms and 44% of rainfed farms, were in the high perception group. The results indicated that rainfed farmers had a higher perception to local climate variability than the irrigated farmers, as rainfed farmers rely on the climate conditions more, especially the local precipitation. Then, these three consistency levels of farmers' perceptions were analyzed in the ordered probit model, to assess the factors influencing farmers' perception.

Table 5. Farmer's perception level to local climate variability.

	Total Sample Households		Irrigated-Farm Households		Rainfed-Farms Households	
	No.	%	No.	%	No.	%
Low consistency of perception	131	45.33	109	59.56	22	20.75
Medium consistency of perception	85	29.41	48	26.23	37	34.91
High consistency of perception	73	25.26	26	14.21	47	44.34
	289	100.00	183	100.00	106	100.00

3.3. Factors Influencing Farmers' Perceptions of the Climate

Table 6 shows the results of the ordered probit model, examining the factors influencing farmers' perceptions. In this study, three ordered probit models were utilized to observe the farmers' perceptions in the full sample, irrigated farm households, and rainfed farm households. All models performed well according to the values of Pseudo R^2 , with 0.5956, 0.6042, and 0.6484 in the models of the full sample, irrigated farm households, and rainfed farm households, respectively. For the factors influencing the perception consistency level, the study observed the following:

1. Farming experience, education and gender: It was assumed that more experienced and educated farmers would have more accurate perceptions of climate change. The positive significant values of FEX and EDU of the total sample and irrigated farm household analysis proved that assumption. Farming experience (FEX) was highly significant at the 1% level in the total sample and significant at the 5% level in irrigated farms, meaning that experienced farmers of the total sample and irrigated farms were likely to have a high consistent perception of climate change. The farmers' education variable was significant at the 1% level in irrigated farms, and at the 5% level was significant for the total sample, indicating that educated farmers were likely to have highly accurate perceptions. The dummy for gender (GEN) was significant at the 5% level in irrigated farms only. This means that male farmers were likely to have more accurate perceptions. These three variables, however, were not statistically significant in the rainfed farms model.

2. Primary occupation, major crops grown: Although the study initially expected that higher consistency of perception would occur in the farmer group if their primary occupation was in farming activities (POF=1), or if their crops grown were cash crops (MCF = 1 i.e., if major crop of farm (MCF) was cash crop, highly profitable to the farmers, the farmers would pay more attention on the production of such a cash crop and he might be more aware on the production reequipment of that crops including farm management and weather condition), non-significant values of POF and MCF in all three models did not support this assumption.

3. Farm-income share and farm size: The positive significant value of FIS in the total sample model indicated that the farmers were more likely to have a higher consistent perception of climate change if their farm income share was a greater proportion of their family income. Agricultural land

operated (ALO) was highly significant in the irrigated farms and rainfed farms models. Its negative value in irrigated farms indicated that the small-scale irrigated farmers were likely to have more accurate perceptions of climate change. The positive value of ALO in rainfed farms suggested the large-scale rainfed farmers were more likely to perceive the actual trends of climate change.

4. Weather information, agricultural extension service, agricultural training participation: The study expected that farmers who have access to weather information and agricultural training would have a higher consistent perception of climate change as there were regular broadcasting of daily weather news and weekly focus by the radio and TV channel for the regional situation, and agricultural training programs offered by the Department of Agriculture and some other NGOs in the study area. The empirical results of ordered probit analysis verified this initial statement. Regular access to weather information (RAW) was 1 if the farmers noticed and paid attention to the regular broadcasting of weekly weather focus by the radio and TV channel, and if not, 0. In this case, RAW was positively significant at the 1% level in the total sample and irrigated farms, and at the 5% level in rainfed farms, meaning that the farmers were likely to have a high consistent perception of climate change if they had regular access to weather information. Participation in agricultural training meant the farmers were also more likely to have a high consistent perception of climate change, as the PAT values were positively significant at the 1% level in all three cases. However, AAE was negatively significant in rainfed farms, and indicated that the rainfed farmers were more likely to have a high consistency of perception if there were fewer farming problems to be given to extension agents.

5. Irrigation: Farmers' perceptions were influenced by the infrastructure. Irrigation infrastructure is arguably an important management strategy that farmers utilize to cope with climatic constraints. Irrigation can provide additional water to crops and overcome sporadic shortfalls in soil moisture for growing crops, consequently resulting in low awareness of climate conditions whenever there are irrigation facilities. In the study, the negative values of ISL were highly significant at the 1% level, and supported this statement. This means that irrigated farmers were likely to have low perception levels compared with rainfed farmers.

Table 6. Ordered probit model result for all sample households: Dependent variable: Farmers' perception (1 = Low consistency of perception, 2 = Medium consistency of perception, 3 = High consistency of perception).

Independent Variables	Total Sample			Irrigated Farm			Rainfed Farm		
	Coef.	S.E	P > z	Coef.	S.E	P > z	Coef.	S.E	P > z
FEX _i	0.0384	0.0096	0.000	0.0272	0.0122	0.026	0.0151	0.0206	0.462
EDU _i	0.1003	0.0454	0.027	0.1736	0.0676	0.010	0.1203	0.0775	0.120
GEN _i	0.3956	0.2828	0.162	1.0069	0.4089	0.014	0.1118	0.5942	0.851
POF _i	-0.1481	0.3779	0.695	-0.0336	0.3769	0.929	2.7264	1.9656	0.165
MCF _i	0.5000	0.3388	0.140		omitted		0.0379	0.4339	0.930
FIS _i	0.0209	0.0099	0.034	0.0139	0.0206	0.497	-0.0017	0.0152	0.913
ALO _i	0.0146	0.0663	0.825	-0.3495	0.0989	0.000	0.9012	0.2756	0.001
RAW _i	1.0505	0.2411	0.000	0.9405	0.3013	0.002	1.5870	0.6525	0.015
AAE _i	-0.1093	0.0728	0.133	0.1559	0.1013	0.124	-0.5256	0.1956	0.007
ATP _i	0.8785	0.1579	0.000	1.4575	0.2574	0.000	0.8615	0.2870	0.003
ISL _i	-0.0164	0.0034	0.000		omitted			omitted	
EDS _i	-0.0705	0.1387	0.612	0.1241	0.2505	0.620	-0.2326	0.2057	0.258
EUR _i	0.3793	0.0883	0.000	0.3405	0.1199	0.005	0.7151	0.2096	0.001
EFE _i	0.2111	0.0677	0.002	0.2218	0.0878	0.012	0.6642	0.1864	0.000
HAF _i	-0.6884	0.1393	0.000	-0.9341	0.1886	0.000	-0.5338	0.3512	0.128
LDA _i	0.5455	0.2774	0.049	0.6214	0.4534	0.170	0.8207	0.5844	0.160
/cut1	2.6671	1.2057		3.3262	2.2914		5.1945	2.6214	
/cut2	4.9736	1.2389		6.0081	2.3667		8.8136	2.8563	
Obs.	289			183			106		
Log likelihood	-124.293			-67.647			-39.297		
Pseudo R ²	0.5956			0.6042			0.6484		

6. Experience of dry-spell periods, unexpected rain and flood events: It was clearly observed that farmers’ experience of unexpected rain in critical crop growth stages, and experience of flood events during a growing season, were influencing their perception of climate change. Positive values of EUR and EFE were statistically significant in all three cases and indicated that if the farmer had an experience of an unexpected rain or flood event during a crop season, they were more likely to perceive the changing climatic conditions. However, experience of a dry-spell period was not significant in the analysis, as it was a less visible event to the farmer.

7. Holistic affect: Farmer perceptions of climate change and their concern over specific climate variability were also systematically related to personal beliefs about climate change. The empirical results showed that those farmers who believed climate change is occurring and that its impacts are positive for farming, were more likely to have a lower perception of climate change, as per the statistically significant values of HLA (−0.6884 for the total sample and −0.9341 for irrigated farms).

8. Location: The positive significant value of LDA in the total sample analysis showed that the farmers in ShweBo were more likely to perceive the changes of temperature and rainfall in their area.

From these empirical results, it was revealed that farming experience, education and gender of the farmer, their farm size and farm income share, regular access to weather information, agricultural training participation, experience of unexpected rain and floods, irrigation infrastructure, holistic considerations of climate change, and location were the major factors influencing on farmers’ perceptions of climate change. The results were consistent with other studies. Gutu, Bezabih [19] also found that a high level of perception was a result of access to awareness raising activity, weather information, agricultural extension services, educational level, and age of household heads. Furthermore, Aymone Gbetibouo [9] pointed out more specifically that the farming experience of the farmer is a more critical factor in the perception of temperature changes, and education level is a significant factor to perceive rainfall changes. Patrick, Edilegnaw [12] also observed that age, individual experience, and gender of the farmer positively influenced their perception, and educational level has a negative effect as more educated farmers relied more on non-farm income.

3.4. Marginal Effects of Ordered Probit Models

Table 7 indicates the results of the marginal effects of the ordered probit model for the total sample households.

Table 7. Marginal effects of ordered probit models for all sample households.

	Low Perception		Medium Perception		High Perception	
	dy/dx	P > z	dy/dx	P > z	dy/dx	P > z
FEX _i	−0.0136	0.000	0.0106	0.001	0.0029	0.008
EDU _i	−0.0355	0.026	0.0277	0.033	0.0077	0.065
GEN _i *	−0.1479	0.179	0.1244	0.208	0.0235	0.102
POF _i *	0.0507	0.685	−0.0379	0.668	−0.0127	0.727
MCF _i *	−0.1591	0.089	0.1065	0.030	0.0526	0.295
FIS _i	−0.0074	0.039	0.0058	0.052	0.0016	0.060
ALO _i	−0.0052	0.825	0.0041	0.825	0.0012	0.825
RAW _i *	−0.3748	0.000	0.3009	0.000	0.0738	0.002
AAE _i	0.0386	0.135	−0.0302	0.144	−0.0084	0.116
ATP _i	−0.3105	0.000	0.2430	0.000	0.0675	0.005
ISL _i	0.0058	0.000	−0.0045	0.000	−0.0013	0.003
EDS _i	0.0249	0.611	−0.0195	0.611	−0.0054	0.616
EUR _i	−0.1341	0.000	0.1049	0.000	0.0292	0.005
EFE _i	−0.0746	0.002	0.0584	0.005	0.0162	0.016
HAF _i	0.2433	0.000	−0.1904	0.000	−0.0529	0.002
LDA _i *	−0.1912	0.050	0.1482	0.060	0.0429	0.078

(*) dy/dx is for discrete change of dummy variable from 0 to 1.

In this model, the significant marginal effect of farmers’ experience (FEX) shows that a year’s increase in experience decreases the probability of having low level of perception consistency by 0.0136, while increasing the probability of having medium and high perception by 0.0106 and 0.0029, respectively. The marginal effects of education level of the farmer (EDU) were significant in the model, indicating that a year increase in education reduces the probability of having low consistency of perception by 0.0355.

On the other hand, it increases the probability of having medium perception by 0.0277, and the probability of having high consistency of perception by 0.0077. The significant MCF values in the model showed the probability of having a low perception will be decreased by 0.1591, and the probability of having medium perception will be increased by 0.1065 if the major crop of farming is a cash crop.

If there is a change in access to weekly weather information (RAW), it decreases the probability of having low perception by 0.3748, and increases the probability of having medium and high consistencies of perception by 0.3009 and 0.0738, respectively. One time participation in an agricultural training program (ATP) increases the probability of having medium consistency of perception by 0.2430, and the probability of having high consistency of perception by 0.0675, but decreases the probability of having low perception by 0.3105. A one percent increase in irrigation area in the total farm land (ISL) increases the probability of having low consistency of perception, and decreases the probability of having medium consistency of perception and high consistency of perception by 0.0045 and 0.0013, respectively.

A year’s increase in the experience of unexpected rain (EUR) decreases the probability of having low perception by 0.1341, and increases the probability of having medium perception by 0.1049 and high perception by 0.0292. Similarly, a year’s increase in flood experience (EFE) decreases the probability of having low consistency of perception by 0.0746, while increasing the probability of having medium and high consistencies of perception by 0.0584 and 0.0162, respectively. If the farmer’s opinion changes regarding the belief that the impacts of climate change are positive (HAF), it will increase the probability of having low perception by 0.2433, but decrease the probability of having medium perception by 0.1904 and high perception by 0.0529.

Table 8 describes the marginal effects of ordered probit models for irrigated-farm households. A year’s increase in experience (FEX) of irrigated farmers decreases the probability of having low perception by 0.0107, but increases the probability of having medium perception by 0.0105. Similarly, a year’s increase in irrigated farmers’ education (EDU) decreases the probability of having low perception by 0.0683, but increases the probability of having medium perception by 0.0671.

Table 8. Marginal effects of ordered probit models for irrigated-farm households.

	Low Perception		Medium Perception		High Perception	
	dy/dx	P > z	dy/dx	P > z	dy/dx	P > z
FEX _i	−0.0107	0.026	0.0105	0.027	0.0002	0.326
EDU _i	−0.0683	0.012	0.0671	0.013	0.0012	0.313
GEN _i *	−0.3404	0.002	0.3370	0.002	0.0034	0.323
POF _i *	0.0132	0.929	−0.0129	0.929	−0.0002	0.929
FIS _i	−0.0055	0.490	0.0054	0.498	0.0001	0.567
ALO _i	0.1375	0.000	−0.1351	0.001	−0.0024	0.293
RAW _i *	−0.3567	0.001	0.3486	0.001	0.0080	0.264
AAE _i	−0.0614	0.124	0.0603	0.127	0.0011	0.362
ATP _i	−0.5735	0.000	0.5635	0.000	0.0100	0.274
EDS _i	−0.0488	0.620	0.0479	0.620	0.0009	0.649
EUR _i	−0.1339	0.004	0.1316	0.005	0.0024	0.308
EFE _i	−0.0873	0.012	0.0857	0.014	0.0015	0.306
HAF _i	0.3676	0.000	−0.3611	0.000	−0.0065	0.281
LDA _i *	−0.2402	0.155	0.2356	0.155	0.0046	0.419

(*) dy/dx is for discrete change of dummy variable from 0 to 1.

If a farmer is a male farmer (GEN), there will be a decrease in the probability of having low perception by 0.3404, and an increase in the probability of having medium perception by 0.337. A one hectare increases in farm size (FSZ) increases the probability of having low consistency of perception by 0.1375, and decreases the probability of having medium consistency of perception by 0.1351 for irrigated farm households. If the irrigated farmer has more access to the weekly weather information (RAW), this would decrease the probability of having low perception by 0.3567, and increase the probability of having medium perception by 0.3486. Moreover, one additional participation in agricultural training (ATP) decreases the low perception probability by 0.5735, and increases the probability of having medium perception by 0.5635. A year’s increase in the experience of unexpected rain (EUR) decreases the probability of having low consistency of perception by 0.1339, and increases the probability of having medium consistency of perception by 0.1316 for the irrigated farm households. In the same way, a year’s increase in flood experience (EFE) decreases the probability of having low consistency of perception by 0.0873, while increasing the probability of having medium consistency of perception by 0.0857. If the farmer’s opinion changes regarding the impacts of climate change being positive (HAF), it will increase the probability of having low perception by 0.3676, but decrease the probability of having medium perception by 0.3611.

Table 9 shows the marginal effects of the ordered probit models for rainfed-farm households. The results of this rainfed farms model observed that ALO, RAW, AAE, EUR, and EFE were statistically significant at the 1% level, and ATP was significant at the 5% level, for the probabilities of medium and high perception levels.

Table 9. Marginal effects of ordered probit models for rainfed-farm households.

	Low Perception		Medium Perception		High Perception	
	dy/dx	P > z	dy/dx	P > z	dy/dx	P > z
FEX _i	−0.0001	0.592	−0.0041	0.460	0.0042	0.459
EDU _i	−0.0010	0.502	−0.0324	0.138	0.0334	0.137
GEN _i *	−0.0010	0.872	−0.0288	0.843	0.0299	0.844
POF _i *	−0.0235	0.500	−0.7342	0.171	0.7578	0.169
MCF _i *	−0.0003	0.930	−0.0103	0.931	0.0106	0.931
FIS _i	0.0001	0.913	0.0004	0.913	−0.0005	0.913
ALO _i	−0.0078	0.464	−0.2427	0.003	0.2505	0.003
RAW _i *	−0.0590	0.335	−0.2385	0.002	0.2975	0.000
AAE _i	0.0045	0.461	0.1415	0.006	−0.1461	0.005
ATP _i	−0.0074	0.461	−0.2319	0.016	0.2394	0.014
EDS _i	0.0020	0.540	0.0626	0.264	−0.0647	0.264
EUR _i	−0.0062	0.462	−0.1926	0.002	0.1987	0.002
EFE _i	−0.0057	0.460	−0.1789	0.002	0.1846	0.002
HAF _i	0.0046	0.502	0.1437	0.113	−0.1484	0.112
LDA _i *	−0.0079	0.500	−0.2225	0.154	0.2305	0.155

(*) dy/dx is for discrete change of dummy variable from 0 to 1.

In rainfed farming, if there is a one hectare increase in the rainfed farm size, it will decrease the probability of having medium consistency of perception by 0.2427, and increase the probability of having high consistency of perception by 0.2505. If the access of the rainfed farmer to weekly weather information changes, there will be a decrease in the probability of having medium consistency of perception by 0.2385, and an increase in the probability of having high consistency of perception by 0.2975. Moreover, a one-time increases in the participation in an agricultural training program decreases the probability of having medium consistency of perception by 0.2319 and increases the probability of having high consistency of perception by 0.2394 in the rainfed farming community. A year’s increase in the unexpected rain experience decreases the probability of having medium consistency of perception by 0.1926, and the probability of having high consistency of perception by 0.1987. Similarly, a year’s increase in the flood event experience increases the probability of having

high consistency of perception by 0.1846, but decreases the probability of having medium consistency of perception by 0.1789. In the rainfed farming households, if there is an increase farming issues requiring contact with an extension, meaning the farmer could not solve their farming problem, it decreases the probability of having high perception by 0.1461, and increases the probability of having medium consistency of perception by 0.1415.

4. Conclusions and Policy Implications

The essence of this study was to provide insights into how much farmers' perceptions are precise to the local climate trends, and the factors influencing these accurate perceptions of farmers.

From the historical climate data analysis, it can be concluded that there was a significant variation of rainfall through the season, with an increasing trend. Moreover, within monsoon season, lower precipitation was observed in the early growing season, and higher precipitation occurred in the late growing season, compared to the 30 year average rainfall. Concerning the temperature trend, there was a general increase in temperature, resulting in severe drought if there was lack of rain, especially in the July drought period. In addition, the occurrence of early drought and a high intensity of rainfall in the late monsoon period highlighted the need to adjust the cropping calendar of local farming.

Focused on the farmers' perceptions of climate variability, the majority of farmer perceived the changes in climatic conditions. However, in terms of the accuracy of perception, 35–50% of farmers had precise perceptions of rainfall trends and patterns within the three phases of the monsoon season, and 58% of farmers perceived the increasing temperature trends in summer correctly, but had much less accurate perceptions of the monsoon and winter temperatures. It can be concluded there was a certain degree of accuracy of farmers' perceptions of climate variability, however, it should be improved by the improved sharing of specific local weather information with the respective farming community.

The empirical results of the ordered probit models and their marginal effects proved that regular access to weekly weather information and agricultural training programs were the key factors influencing the consistency of farmers' perceptions, resulting in a greater probability of a high consistency of perception level. Therefore, it can be concluded that higher accuracy of farmer perceptions of climate change will be achieved by encouraging agricultural training and ensuring access to regular weather information for the local farming community.

Concerning the current policy context of climate change, the Myanmar Climate Smart Agricultural Strategy (2015) highlights the need to promote the capacity of local agrometeorological stations [20]. Moreover, the Myanmar Climate Change Policy (2018) states that promoting access to climatic information, climate change knowledge, awareness, and training for all stakeholders, including decision-makers at all levels, is one of the national policies to enhance stakeholders' perceptions of climate change [21]. To strengthen this, the Myanmar Climate Change Strategy (2018–2030) has pointed out that the availability and dissemination of appropriate and up-to-date information on climate change is essential for promoting public awareness and perceptions of climate change, in order to take effective actions to address climate related problems [4]. Additionally, in the Myanmar Climate Change Master Plan (2018–2030), some of the government programs related to the accuracy of stakeholder perceptions are mentioned under action area 5: enhancing awareness and perception of stakeholders; as (i) establishing a climate change database management system at the Ministry of Agriculture, Livestock and Irrigation (MoALI), (2) providing training to the MoALI monitoring unit on approaches to improve climate risk analysis and related data monitoring and management, (3) capacity building to establish more agrometeorological stations to strengthen weather and climate information, and (4) training programs for farmers on using agrometeorological and climate information [22].

In line with these national policies, the findings of this study suggest the following two important policy implications to promote the accuracy of farmers' perceptions of climate change.

1. Locally specified weather information distribution. Local weather information is critically important for the accuracy of farmers' perceptions. Currently, the Department of Agriculture (DOA) in each township carries out the daily recording of the rainfall and temperature in each township.

These local weather data should be used in agricultural extension services, and shared with the respective farming community in the form of infographics that the farmer can easily understand. In addition, these daily rainfall and temperature recording systems should be transformed into local agro-metrological stations. Moreover, the township level Department of Meteorology and Hydrology should provide their meteorological station's data to the inline departments, such as the DOA and local community, via the proper channels.

2. Integration of weather information applications with agricultural training programs. Agricultural training programs enhance the accurate perceptions of farmers. Therefore, the context of agricultural training should include local weather information utilization whenever the training program is performed, such as the knowledge of local rainfall distribution patterns in the framing of local farmers' crop calendars. The farmer should have knowledge of the application of weather information to their farming activities.

Most importantly, in the cases of the local weather information distribution and conducting agricultural training programs, the targeted farmers should be those with less experience and lower education levels, and female farmers in general, as well as small-scale farmers in rainfed farm communities and large-scale farmers in irrigated farm households.

Author Contributions: Conceptualization, Y.H., K.V., W.A. and P.J.; Formal analysis, Y.H.; Investigation, Y.H.; Methodology, Y.H.; Supervision, K.V., W.A., and P.J.; Writing—original draft, Y.H.; Writing—review & editing, Y.H.

Funding: This research was funded by Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) and Deutscher Akademischer Austauschdienst (DAAD), award number 91638482 under the joint scholarship program of DAAD-SEARCA. There is no funding agency for APC.

Acknowledgments: The authors would like to express the sincere gratitude to "Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA)" and "German Academic Exchange Service (DAAD)" for their scholarship to the first author. In addition, authors are also grateful to anonymous referees and the journal editors for their comments and suggestions that substantially improved the article quality.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Parry, M.L.; Canziani, O.F.; Palutikof, J.P.; Van der Linden, P.J.; Hanson, C.E. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Available online: https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf (accessed on 5 May 2019).
2. Myint Myint, A. *Seasonal Climate Outlook*; Department of Meteorology and Hydrology: Nay Pyi Taw, Myanmar, 2015.
3. Ruby Rose, P. *Historical Data Analysis: Climate Variability, Extremes and Trends in Myanmar*; Department of Meteorology and Hydrology: Nay Pyi Taw, Myanmar, 2015.
4. MONREC, Myanmar Climate Change Strategy (2018–2030). NayPyiTaw: Republic of the Union of Myanmar, Ministry of Natural Resources and Environmental Conservation. 2018. Available online: <https://policy.asiapacificenergy.org/sites/default/files/MCCSAP-Feb-Version.pdf> (accessed on 5 May 2019).
5. Abid, M.; Scheffran, J.; Schneider, U.A.; Elahi, E. Farmer Perceptions of Climate Change, Observed Trends and Adaptation of Agriculture in Pakistan. *Environ. Manag.* **2019**, *63*, 110–123. [[CrossRef](#)] [[PubMed](#)]
6. Niles, M.T.; Mueller, N.D. Farmer perceptions of climate change: Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. *Glob. Environ. Chang.* **2016**, *39*, 133–142. [[CrossRef](#)]
7. Brulle, R.J.; Carmichael, J.; Jenkins, J.C. Shifting public opinion on climate change: An empirical assessment of factors influencing concern over climate change in the U.S., 2002–2010. *Clim. Chang.* **2012**, *114*, 169–188. [[CrossRef](#)]
8. Hamilton, L.C.; Stampone, M.D. Blowin' in the Wind: Short-Term Weather and Belief in Anthropogenic Climate Change. *Weath. Climat. Soc.* **2013**, *5*, 112–119. [[CrossRef](#)]
9. Gbetibouo, G.A. Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. 2009: International Food Policy Research Institute. Available online: <http://www.ifpri.org/publication/understanding-farmers-perceptions-and-adaptations-climate-change-and-variability> (accessed on 5 May 2019).

10. Ayanlade, A.; Radeny, M.; Morton, J.F. Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. *Weather and Climate Extremes*, 2016. Available online: <https://www.sciencedirect.com/science/article/pii/S2212094716300755> (accessed on 5 May 2019).
11. Gebrehiwot, T.; Van der Veen, A. Farm level adaptation to climate change: The case of farmer's in the Ethiopian highlands. *Environ. Manag.* **2013**, *52*, 29–44. [[CrossRef](#)] [[PubMed](#)]
12. Patrick, H.; Edilegnaw, W.; Gerald, O. Assessing farmers' perceptions about climate change: A doublehurdle approach. *Climat. Risk Manag.* **2017**, *17*, 128–138.
13. Sahu, N.C.; Mishra, D. Analysis of Perception and Adaptability Strategies of the Farmers to Climate Change in Odisha, India. *APCBEE Procedia* **2013**, *5*, 123–127. [[CrossRef](#)]
14. Menapace, L.; Colson, G.; Raffaelli, R. Climate change beliefs and perceptions of agricultural risks: An application of the exchangeability method. *Glob. Environ. Chang.* **2015**, *35*, 70–81. [[CrossRef](#)]
15. Tun Oo, A.; Van Huylenbroeck, G.; Speelman, S. Determining factors for the application of climate change adaptation strategies among farmers in Magwe District, dry zone region of Myanmar. *Int. J. Climat. Chang. Strat. Manag.* **2017**, *9*, 36–55. [[CrossRef](#)]
16. McFadden, D. Modeling the choice of residential location., in *Spatial interaction theory and planning model. Transp. Research Record.* **1978**, 75–96.
17. McKinley, J.; Adaro, C.; Pede, V.O.; Setiyono, T.; Aung, N.M.; Hom, N.H.; Htwe, N.M.; Hein, Y.; Than, S.M.; Swe, K.L.; et al. Current State of Climate Change Perceptions and Policies in Myanmar: 2014 Report. Available online: <https://hdl.handle.net/10568/68583> (accessed on 5 May 2019).
18. Mkonda, M.; He, X. Are Rainfall and Temperature Really Changing? Farmer's Perceptions, Meteorological Data, and Policy Implications in the Tanzanian Semi-Arid Zone. *Sustainability* **2017**, *9*, 1412. [[CrossRef](#)]
19. Gutu, T.; Bezabih, E.; Mengistu, K. Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. *Int. Res. J. Agr. Sci. Soil Sci.* **2012**, *2*, 347–363.
20. Hom, N.H.; Htwe, N.M.; Hein, Y.; Than, S.M.; Kywe, M.; Htut, T. Myanmar Climate Smart Agriculture Strategy. Available online: <https://hdl.handle.net/10568/69091> (accessed on 5 May 2019).
21. MONREC, Myanmar Climate Change Poilcy. NayPyiTaw: Republic of Union of Myanmar, Ministry of Natural Resources and Environmental Conservation. 2018. Available online: <https://policy.asiapacificenergy.org/sites/default/files/MCCSAP-Feb-Version.pdf> (accessed on 5 May 2019).
22. MONREC, Myanmar Climate Change Master Plan (2018–2030). NayPyiTaw: Republic of the Union of Myanmar, Ministry of Natural Resources and Environmental Conservation. 2018. Available online: <https://policy.asiapacificenergy.org/sites/default/files/MCCSAP-Feb-Version.pdf> (accessed on 5 May 2019).



© 2019 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).