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Paddy Production and Climate Change Variation in Selangor, Malaysia

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Abstract

The North West Selangor Integrated Agriculture Development Agency (NWS-IADA) has the most productive agricultural land in Selangor. This is partly because of the inherent high fertility of the soils, and the moderate variable climate. However, with the increasing global concern about climate impacts, there is a need to examine the issue and this article presents a study that examined the relative importance of climate influences on the paddy production rate over 28 years (1980-2008). Data collection involved compiling and analyzing climate records from MARDI Tg. Karang auxiliary station (Station no. 44325, 24m m.s.l) at the coordinates of N 03° 27' 17" E 101° 09' 24". The results indicate that the average rainfall recorded was 1, 765 mm which is similar to the national rainfall trend. Meanwhile, the daily humidity varied between 94 – 96% (8.00 AM) and around 70% (2.00 PM) while the sunshine hours ranged between 2.3 to 9.5 hours. A correlation analysis between the production yield and climatic data at the studied area for the year 2000 – 2008 showed that for precipitation, rainfall is redundant during the main season while during the off season it bears direct effect on the production yield with R^2 value of -0.293 and 0.1715, respectively. Sunshine hours and temperature demonstrate their importance to production yield as suggested by their respective R^2 values.

Keywords: weather trend, paddy planting, climate trend, agriculture, irrigation

1. Introduction

Paddy planting in Malaysia is synonymous with the rural community and traditional farming. The Government of Malaysia has initiated measures to assist the local paddy producing community through the introduction of incentives such as declaring the rice crop a security crop, launching of the National Agriculture Act (1992-2010), upgrading of existing irrigation systems and building of new irrigation systems, introducing market price control and other measures to further boost local production (Mahmudul *et al.,* 2011). The local paddy producing community is self –sustainable, covering up to 86% of local market demand while the remaining unfulfilled market demand is mitigated by importing rice from the neighbouring rice producing countries such as Thailand, Indonesia, India and Cambodia. Increasing crop yield is the main agenda of most local paddy growers through measures such as the introduction of new cultivars, reviewing existing planting practices such as fertilizing and pesticide cycle, type and amount of fertilizer and pesticide used and the intensity and frequency of such cycle.

Traditionally, Malaysia is a rice-growing country in which the irrigation system has gone through evolution over the past decades where new ideas have been implemented and new technologies have also been introduced. The government, through their agencies such as the Drainage and Irrigation Malaysia (DID), Muda Agricultural

Development Authority (MADA) and Kemubu Agriculture Development Authority (KADA), plays a vital role in improving the irrigation system throughout the region. Hence, farmers currently could implement double and triple cropping of rice in a year since 1988 and 1999, respectively in comparison to the traditional irrigation system which only enables farmers to plant once a year. Although there was a substantial reduction in rainfall and overall availability of water resources for irrigation in the region in the 1980s, farmers were still able to increase the total crop output by about 16% over the decade (Alam et al., 2012). However, with uncertainties on economic production and climate variability, producing more rice has become a continuous challenge for the government and paddy farmers. This includes the efficient utilization of water resources, good management practices and precise information, such as annual effective rainfall, runoff, consumptive use, and water release policy. In this regard, ideal water management can be achieved through the delivery of the right amount of irrigation water at the right time to the fields to increase crop yield.

Paddy planting has long been documented as the main economic activity of the rural community in Malaysia, with an average planting area of 651,600 ha for the combination of main and off season in the years of 1900's. Yet, there is a steady annual decline in terms of planting area. In terms of land use, the paddy plant is the third most important crop in Malaysia after the oil palm plant (2.3 million ha) and the rubber plant (1.8 million ha) (ICDC, 2002). In the global market, Malaysia is a small rice producing country with a rice production output of only 0.4% of the global rice output. Most paddy growers in Malaysia are small scale farmers with an average planting area of 1.06 ha despite boasting a total of 286,000 paddy growers; 116,000 are full time paddy growers with no fall back as they solely rely on the outcome of their paddy production as an income source (Mahmudul *et al.,* 2010). A total of 65% of these farmers have planting areas smaller than 1 ha while only 3% of the paddy growers have planting areas of more than 3 ha (Latif, 1991). The sensitivity of the paddy crop toward the environment which directly impacts its production rate makes the factors governing its environment very crucial in the efforts to increase the production rate of the local granaries. These factors include a variety of aspects such as its fertilizing cycle, soil physical-chemical properties, plant cultivate, pesticide and weather trend (Toriman *et al.,* 2009). Among all the contributing factors, the climate trend is a factor that is beyond human control and could only be mitigated after certain events. The ability to have insight into the weather trend would greatly assist the local paddy growing community in terms of managing the effect of the weather with regard to the effect on the growth cycle of the paddy plant which in turn would increase the production rate.

Focusing on the general adaptation for irrigation of paddy in Malaysia, this article discusses the impacts of climate change in Peninsular Malaysia, particularly in irrigating such a big scheme especially when shortage of water occurs. This article also deals with the key to saving water and achieving high efficiency through proper irrigation management and distribution of water.

This article analyzes a climate-time series data of over 28 years commencing from 1980 to 2008 for the North West Selangor Integrated Agriculture Development Agency (NWS-IADA) area at Tg. Karang, Selangor, Malaysia.

2. Climate Change Scenario

Scientific assessment indicates that the coastlines of Southeast Asia including Malaysia are highly vulnerable to the effects of climate change (Belinda & Leon, 2009). In reality, the challenge of climate change is real and urgent in Southeast Asia. Global climate change scenarios predict that the region's annual temperature will increase in the order of 0.4-1.3˚C by 2030 and 0.9-4.0 deg C by 2070 while winter rainfall is projected to decrease (less than 10 per cent by 2030 and approximately 20-30 per cent by 2070). The effect of a rise in global sea level on the region may be as much as 3-16 cm by 2030 and 7-50 cm by 2070. Figure 1 shows the impact of sea level and temperature rises for Malaysia and other countries in Southeast Asia.

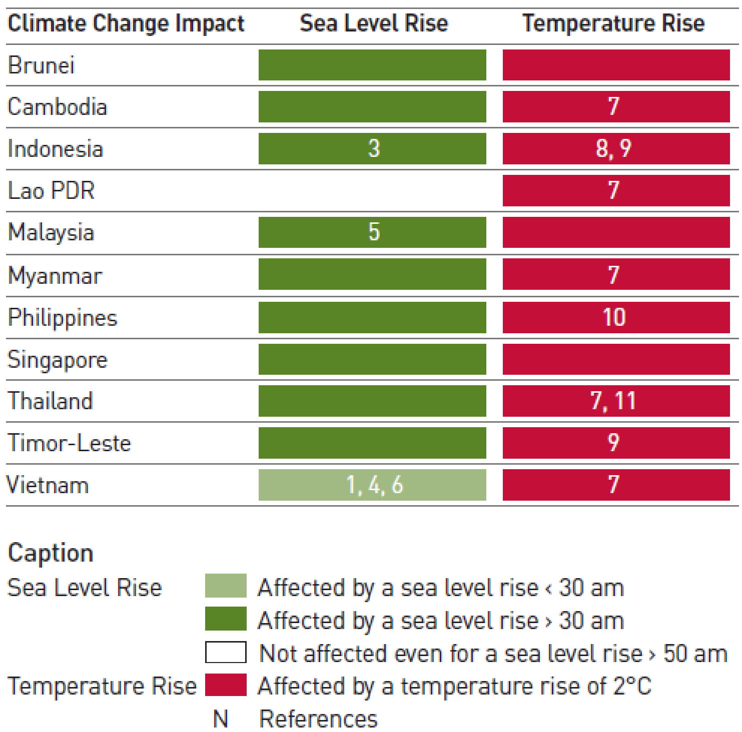

Figure 1. Estimated impact of climate change on Southeast Asia

Source: Belinda & Leon, 2009

The global aggregate effect of climate change on paddy production is likely to be small to moderate. However, regional impacts could be significant. Paddy yields and changes in productivity will vary considerably across regions. These regional variations in gains and losses will probably result in a slight overall decrease in world cereal grain productivity. The effect of the temperature on paddy mainly governs the timing of the physiological process, the rate of expansion and survival of the reproductive structures. Increases in temperature affect the moisture availability through effects on evaporation; in general, evaporation increases by about 5% for each 1°C increase in main annual temperature. This would be significant in tropical regions where most crops, particularly paddy are generally constrained by water availability (Chong & Mathews,, 2001; Al-Amin & Chamhur, 2008).

Meanwhile, the impact of climate change on rice production has been a subject of many scientific researches due to its importance for human beings. The average potential yield of rice varies at about 10 tons ha^{-1} in the tropics and over 13 tons ha^{-1} in the temperate region (Al-Amin & Chamhur, 2008). The actual farm yields in Malaysia vary from 3-5 tons ha^{-1}, (i.e. potential yield in Malaysia per ha^{-1} is 7.2 tons (Singh et al., 1996)). Based on experimental data obtained elsewhere, the rice crop in general, responds positively (up to a certain limit) to an increase in atmospheric CO^2 concentration. The development rates of rice crop accelerate in response to an increase in CO^2 concentration from 160 ppm (parts per million) to 900 ppm. However, the yields' response to CO^2 varies with cultivars, location and management practice. It is evident that the average response of the increase of potential yields is at about 10kg/ha/ppm CO^2 or about 15kg/ha/ ppm CO^2. However, negative effects occur with unexpected high or low temperature (Penning de Vries, 1993). Temperature affects rice growth in two ways; first, a critically low or high temperature defines the environment under which the life cycle can be completed. Secondly, within the critically low and high temperature range, temperature influences the rate of development of leaves and panicles and the rate of ripening, thereby fixing the duration of growth of a variety under a given environment and eventually determining the suitability of the variety to the environment (Yoshida, 1981). As the world populations is projected to reach 8.4 billion by 2030, of which over 5 billion will live on rice, it is feared that the increasing trend toward global warming and frequent outbreaks of extreme weather will be a serious blow to the rice production.

3. Methodology

The study area is located in the North West Selangor Integrated Agriculture Development Agency (NWS-IADA) area. The scheme was launched on 6th June 1978 and it covers approximately an area of 19,920 ha. The paddy planting practices carried out is based on the Bestari Planting Guide proposed by Malaysia Agriculture Research and Development Institute (MARDI) while the main cultivate used in the study area is a local cultivar (MR219). This cultivar is capable of producing high yield. A small number of paddy growers also use other local cultivars for planting (Toriman *et al.,* 2009). The paddy growers mainly use the broadcasting technique while those who could afford it would practice the transplanting technique through the help of a rented mechanical transplanter.

The data for this study was gathered from the Malaysian Meteorological Department, and the observed result for the studied area included the parameters of daily mean temperature, daily humidity, rain distribution and daily sunshine hours for the auxiliary station of MARDI Tg. Karang (Station no. 44325) at the coordinates of N 03° 27’ 17” E 101° 09’ 24” with 2.4m for mean sea level. The location of the weather station which is surrounded by paddy fields and strategically located amidst the North West Selangor Integrated Agriculture Development Agency (NWS-IADA) planting area would correctly reflect the nature of the weather trend at this granary.

4. Results and Discussion

4.1 Temperature

The study showed that the study area displayed a constant annual temperature trend with an average in the range of 23°C to 32°C with R^2 value of 0.246 and 0.0139, respectively. The data shows that it still complies within the daily mean temperature of Malaysia (Figure 2). The temperature variation recorded throughout the years was due to the influence of the monsoons where the studied area generally recorded higher temperature during the months of March until June annually which coincided as the off season for the study area. The temperature recorded shows that the trend is constant in the studied area. This is evident in the paddy plant’s growth as temperature fluctuations incur dire effects on the paddy plant such as retarded development in seedlings, delayed transplanting and reduced tiller formation during the early stages of growth; moreover, it could even lead to plant sterility if temperature stress were induced before the antacid date (Grist, 1983; Sharfi and Hashem, 2010). Although this effect could be remedied if sufficient irrigation is supplied, extremities in temperature would still affect the growth cycle of the granary area.

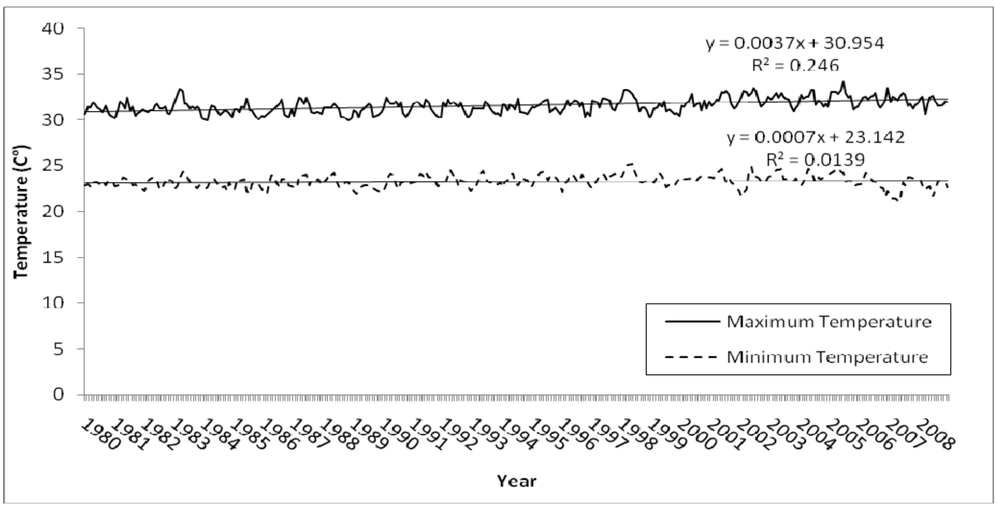

Figure 2. Daily maximum and minimum temperature trend at NWS-IADA area in Tg. Karang, Selangor

4.2 Rainfall Distribution

The study area generally displayed a higher rain distribution during the beginning and the end of the year with an average range of 1, 765 mm (Figure 3) and R^2 value of 0.0048. The frequency of precipitation was higher at the specific period of October to February, concurring with the scheduled main season of the study area. However, during the off season, rain distribution was rather low in comparison to the rain distribution recorded in the country as a whole. Planting during the off season relies heavily on the existing local irrigation scheme in terms of sustaining paddy planting where the crops could not be subjected to unfavorable conditions such as water stress to minimise the probability of facing total crop lost. Water stress inflicted upon maturing crop has been known to have dismal effect such as disruption of nutrient intake, delayed flowering and poor grain filling (Grist, 1983; Shi *et al.,* 2002). The rain distribution clearly shows a stable and coherent trend which suggests that the climate trend is still suitable for the granary area of NWS-IADA, Tg. Karang, Selangor.

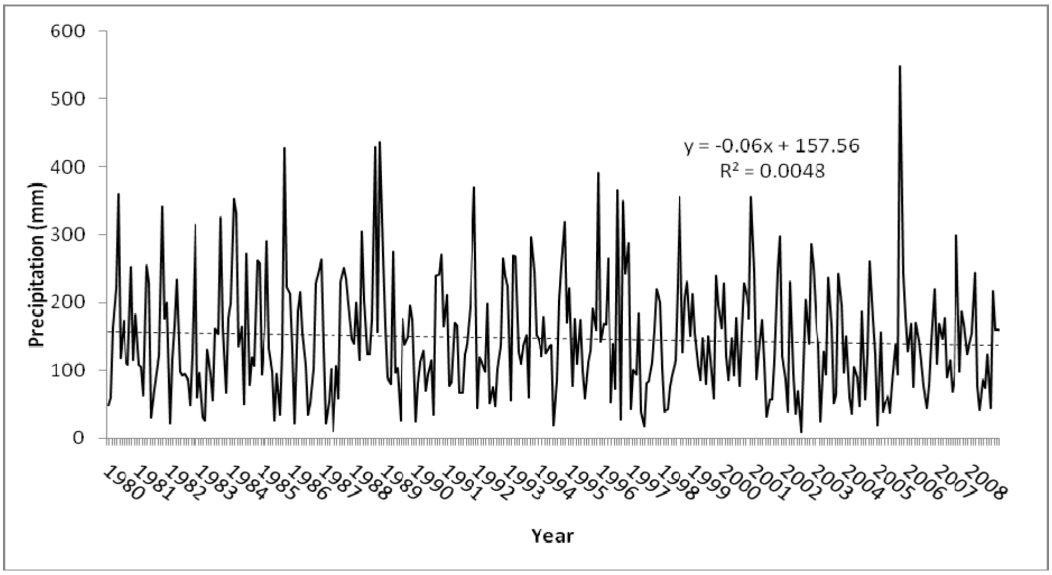

Figure 3. Monthly average rain distribution (mm) at PBLS Tg. Karang, Selangor

4.3 Daily Humidity

The percentage of the mean daily humidity recorded at the studied area falls in the range of 94 – 96% (8.00 AM) with R^2 value of 0.121 and around 70% (2.00 PM) for the years of 1983 - 2008 (Figure 4). A high percentage of daily humidity is conductive to the optimum growth of the paddy plant and thus affects its yield production. This is especially true during the off season planting where the area receives insufficient rate of precipitation. Insufficient humidity percentage in the granary area could affect the growth cycle of the paddy plant; nevertheless, the ability of the paddy plant to regulate its own microclimate would raise the relative humidity within the crop when sufficient irrigation is supplied (Grist, 1983; Mojtaba *et al.,* 2009; Sharfi & Hashem, 2010).

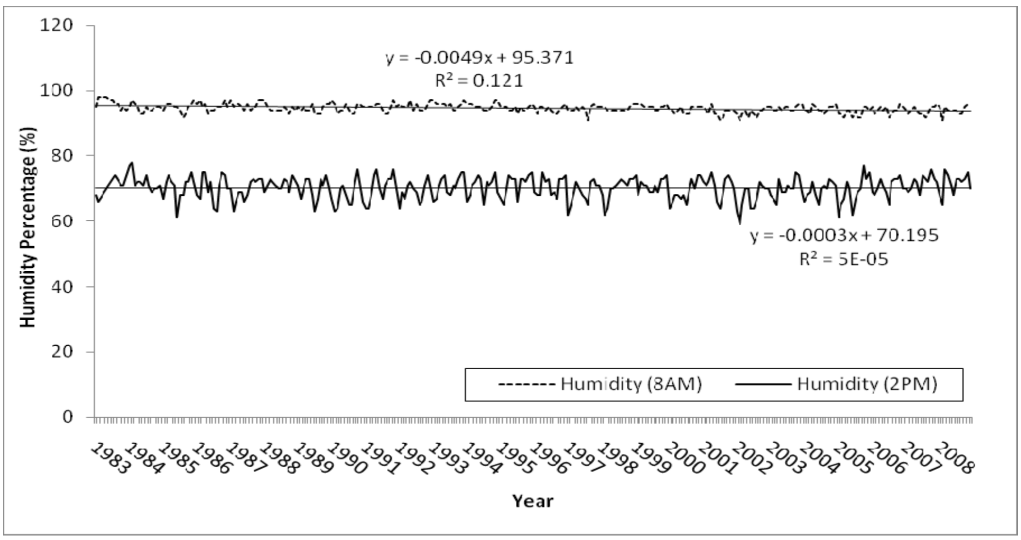

Figure 4. Monthly average of daily humidity at NWS-IADA granary area, Tg. Karang, Selangor

4.4 Daily Sunshine Hours

The study area displayed average daily sunshine hours in the range of 2.3 to 9.5 hours with R^2 value of 0.0062. The trend line shows longer sunshine hours during the middle of the year and shorter sunshine hours during the beginning and end of the year similar to the nature of the seasonal monsoon in the country. The data provided by the Malaysian Meteorological Department was constricted to the years of 1983 – 2005 but it clearly shows an existing trend for this parameter in the study area of NWS- IADA, Tg. Karang, Selangor (Figure 5). The importance of sufficient sunlight to the paddy plant can be easily recognized as the number of tillers and ears increases with the intensity and quantity of light (Grist, 1983; Shi *et al.,* 2002). As shading has been proven to decrease the number of spikelets per panicle, it demonstrates the importance of light to the paddy plant which is a high efficiency solar energy conversion plant during the ripening period.

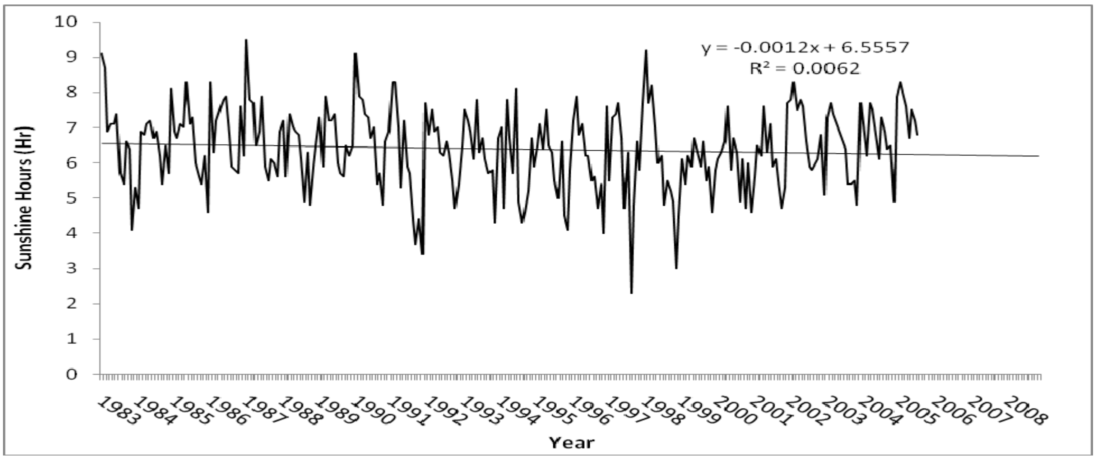

Figure 5. Daily sunshine hours for the years 1983 - 2005 at NWS-IADA, Tg. Karang, Selangor

4.5 Climate Trends and Paddy Production

Weather is of utmost importance in terms of affecting crop production. This is especially true in the case of the paddy plant which has specific needs at each stage of its growth cycle (Grist, 1983; IPCC, 2007; Ebrahim *et al.,* 2009). In accordance to the publication by the Integrated Agriculture Development Agency (IADA) (2008), the time series data for the year 1999 to 2008 showed an increase in production yield despite the annual report of a decrease in the planting area (Table 1). The correlation analysis between the production yield and climatic data available for the NWS-IADA, Selangor for the year 2000 – 2008 showed that for precipitation, rainfall is redundant during the main season while during the off season it bears direct effect on the production yield with R^2 value of -0.293 and 0.1715 respectively, while sunshine hours and temperature demonstrate their importance to production yield as suggested by the R^2 values as shown in Table 2 (Grist, 1983; IPCC, 2007). This determines the importance of the local irrigation scheme and the stable climate trend for any granary in sustaining a stable and suitable environment for the paddy plant to grow into maturity and produce an economic yield.

Table 1. Time series data for the average yield and paddy production of granary area of NWS-IADA, 1999-2008

	Main Season			Off Season		
Year	Planting Area (Ha)	Average Paddy Yield (Kg/Ha)	Paddy Production (Tone Metric)	Planting Area (Ha)	Average Paddy Yield (Kg/Ha)	Paddy Production (Tone Metric)
1999	18,669	4,087	76,300	18,691	4,325	80,839
2000	18,637	4,569	85,152	18,521	4,790	88,716
2001	18,613	5,193	96,657	18,619	4,984	92,797
2002	18,607	4,752	88,420	18,607	4,768	88,718
2003	18,565	5,492	101,959	18,583	5,269	97,914
2004	18,604	5,174	96,257	18,629	4,485	81,741
2005	18,292	5,242	95,884	18,226	4,384	79,900
2006	18,399	4,877	89,732	18,355	4,557	83,644
2007	18,340	4,942	90,636	18,176	5,143	93,479
2008	18,301	4,542	83,127	18,301	4,979	91,121

Source: IADA Crop Cutting Survey, 2009

Table 2. Correlation analysis of the production rate of granary area of NWS-IADA and climatic data for the year 1999 – 2008

	Main Season	Off Season	Precipitation	SUNH	HUM8	HUM2	TMAX	TMIN
Main Season	1							
Off Season	0.3362	1						
Precipitation	-0.293	0.1715	1					
SUNH	0.3061	-0.429	-0.423	1				
HUM8	-0.298	-0.034	-0.026	-0.672	1			
HUM2	-0.193	0.1928	-0.051	-0.7	0.463	1		
TMAX	0.6926	0.044	-0.413	0.8095	-0.772	-0.506	1	
TMIN	0.493	-0.115	0.1036	0.1048	0.0259	-0.584	0.1719	1

where,

SUNH = Sunshine Hour

HUM8 = Humidity at 8 AM

HUM2 = Humidity at 2 PM

TMAX = Maximum Temperature

TMIN = Minimum Temperature

5. Conclusion

The climate trend in the studied area shows that its impact on the local paddy productivity rate was negligible though insufficient rain was received during the off season; the water shortage was remedied through the existing local irrigation scheme. This in turn sustained a stable level of daily humidity percentage which is crucial for the growth development of the paddy plant (Grosiman *et al.,* 1999; Ekhwan, 2010; Kiyosawa & Aimi, 1959). The suitability of the studied area as a paddy planting area is apparent since the weather trend displayed is rather stable and the effects of climate change phenomenon are vaguely perceptible through the annual report of paddy production yield that displayed a positive annual increase despite reports of declining planting areas. Though the existing irrigation scheme is sufficient to replenish the fields during the low precipitation season, a planting system that requires less water should be developed for future development of paddy planting systems in less favorable conditions; an example could be the use of alternate days submerged irrigation schemes instead of the conventional fully submerged irrigation schemes which require a great volume of water.

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