VARIABILITY OF RAINFALL AND TEMPERATURE IN ILOCOS NORTE, PHILIPPINES

Evangeline S. Galacgac
Science Research Specialist II
Crops Researh Laboratory
Mariano Marcos State University
City of Batac, Ilocos Norte

Charito G. Acosta
Professor
College of Agriculture, Food, and Sustainable Development
Mariano Marcos State University
City of Batac, Ilocos Norte

Nathaniel R. Alibuyog
Professor
College of Engineering
Mariano Marcos State University
City of Batac, Ilocos Norte

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Abstract

The variability of rainfall and temperature in the Philippines had already been generally analyzed but limited studies have been conducted so far to determine the extent of this phenomenon in specific localities. Hence, 35 years of daily data on rainfall and air temperature taken from MMSU-PAGASA Agrometeorological Station in Batac City, Ilocos Norte, and 30-year tropical cyclone data from Laoag City, Ilocos Norte Synoptic Station were analyzed. This study aimed to determine the variability of rainfall, air temperature, and cyclone patterns in Ilocos Norte to provide decision-makers with the needed information and tools to manage or mitigate the risks brought about by the changes of these weather parameters in the province.

Results showed that there was an increase in annual temperature and this was found to have deviated from the normal-base period. With respect to rainfall, the annual trend was variable but there was a significant change in monthly pattern and a slight change in the frequency of maximum rainfall events. On the other hand, the number and intensity of tropical cyclone increased annually and deviated from the normal. Likewise, monthly trend and intensity posted a remarkable change. Based from these results, appropriate cropping calendars suitable to a given agro-ecological zone were developed.

Keywords: cropping calendar, Ilocos Norte, rainfall, temperature

Introduction

Due to the current changes of the weather patterns leading to either insufficient or too much rainfall, as well as natural disasters such as flood and drought, tremendous crop losses are now being exhibited. With these changes, climate change has become a significant issue that needs to be addressed.

A recent study result reported that extreme precipitation events are already increasing as the globe warms. Brian Soden (2000) of the University of Miami reported that a warmer atmosphere contains larger amounts of moisture which boosts the intensity of heavy downpours. An increase in the number of cyclones and hurricanes over the past few years has been attributed to changes in temperature. Global temperatures have risen by over 0.7^{o}C in the last 100 years and eleven of the last twelve years (1995-2006) are the warmest on record. In the UK, in 1990s were very warm about 0.6^{o}C warmer than the mean 1961-1990 air temperature.

Climate change could result in a variety of impact on agriculture. Some of these effects are changes in production patterns due to higher air temperature and changing precipitation patterns. Plants need varying amounts of rainfall to survive, therefore, rain being the most effective means of watering, is important to agriculture. Too much or too little rainfall can be harmful, even devastating to crops. A drought can kill crops in massive numbers, while overly wet weather can cause occurrence of diseases and harmful fungi. Parasites, diseases, fungi and other pests tend to thrive and spread more rapaciously in warmer and more humid climates. On the other hand, Erik Runkle (2000) of Michigan State University reported that temperature is the primary factor that controls how fast or slow a plant develops. Generally, the warmer the temperature, the faster a plant grows. Also, air temperature regulates most plant processes i.e. germination, flowering, photosynthesis, transpiration, respiration, etc. Photosynthesis and respiration of plants and microbes increase with temperature, especially in temperate latitudes (*http://www.fao.org*). Forecast changes in temperature and rainfall are likely to reduce crop yields overall, increasing the risk of hunger. In the presentation of CG Lao of PAGASA (2009), rice yields are declining by as much as 10% for every degree Celsius increase in temperature in the tropics.

The Philippines have experienced temperature spikes brought about by climate change. It has been observed that warming is experienced most in the northern and southern regions of the country, while Metro Manila has warmed less than most parts. In addition, the regions that have warmed the most (northern Luzon, Mindanao) have also dried the most. Largest precipitation trends are about 10 percent during the 20th century (*http://www.doe.gov.ph*). Rainy season comes early, almost in an unexpected situation. Landslides are being reported from provinces. Flash floods are also a major problem.

The effect of climate on agriculture is related to variability in local climates rather than in global climate patterns. The most significant impact of climate change on agriculture is probably changes in rainfall. Some regions are forecast to receive more rain, others to receive less; above all, it will become more variable (*http://www.absoluteastronomy.com*).

It is therefore important to analyze the variability of temperature and rainfall in Ilocos Norte to better understand and prepare for the coming changes. Results of the study will provide decision-makers with the needed information and tools to assess the risks brought about by the variability of rainfall and air temperature. Such information will lead to an improved crop production management and a better long-term agricultural planning and operation in Ilocos Norte.

Methodology

Thirty five-year (1976-2010) daily data on rainfall and air temperature from MMSU-PAGASA Agrometeorological Station in Batac City, Ilocos Norte (18^{o} 3'N latitude, 120^{o} 32' E longitude, 17m AMSL) and 30-year (1981-2010) tropical cyclone data from Laoag City, Ilocos Norte Synoptic Station were analyzed to determine the variability of rainfall, temperature, and cyclone patterns, frequency and intensity in Ilocos Norte. Annual and monthly variations were determined using descriptive statistics. Linear regression analysis was used to determine the degree of annual change. Average data from 1976-1990 (standard base period for most climate change studies defined by the World Meteorological

Organization) considered Period 1, 1991-2010, Period 2, and 1976-2010 were compared to find out if there were changes that occurred during these periods. The anomalies from the average of 1976-2010 and Period 1 were likewise computed as follows:

$$\text{Anomaly from average 1976-2010 or Period 1} = \frac{\text{yearly data}}{\text{average yearly data of 1976-2010 or Period 1}}$$

Based from the result of the analysis, cropping calendar for a given agro-ecological zone was developed.

Results and Discussion

Rainfall

The seasonal rainfall patterns fluctuated from year to year (Figure 1). The mean annual rainfall was 2031.8 mm. Lowest recorded rainfall for the last 35 years was about 1,100 mm and highest was 3,500 mm. Although the amount is variable, it can be said that the annual change was 11.74 mm. Comparing the amount of rainfall during Period 1 (1976-1990) and Period 2 (1991-2010), it can be noted that the average rainfall increased by 92.7 mm.

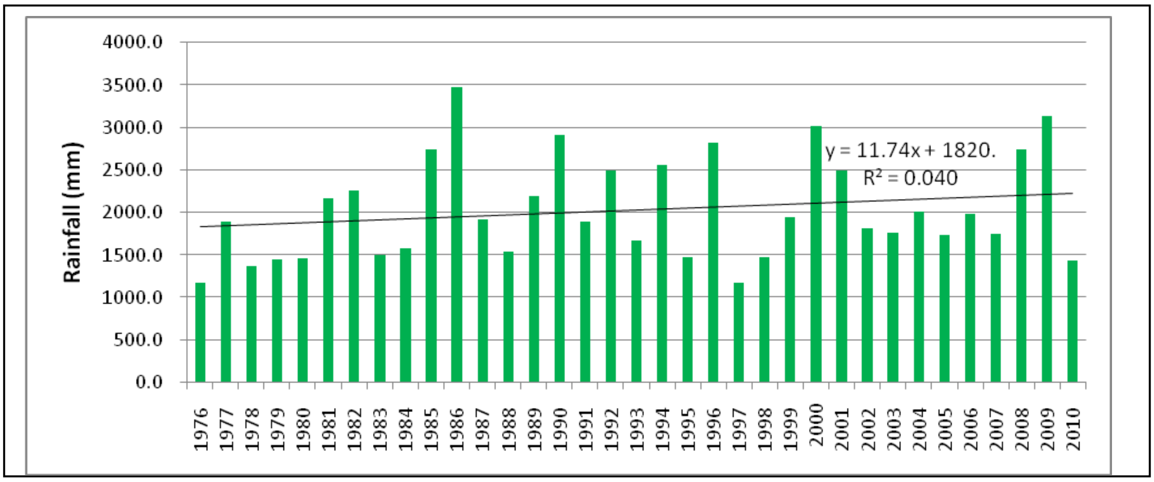

Figure 1. Yearly rainfall in Ilocos Norte, Philippines from 1976-2010.

There were more years with rainfall below the normal amount both from the mean of 1976-2010 and Period 1. Deviation was as high as 1,500 mm (Figure 2). Rainfall anomaly between 1976-2010 and Period 1 was the same. There was no consistent increase or decrease in rainfall as recorded.

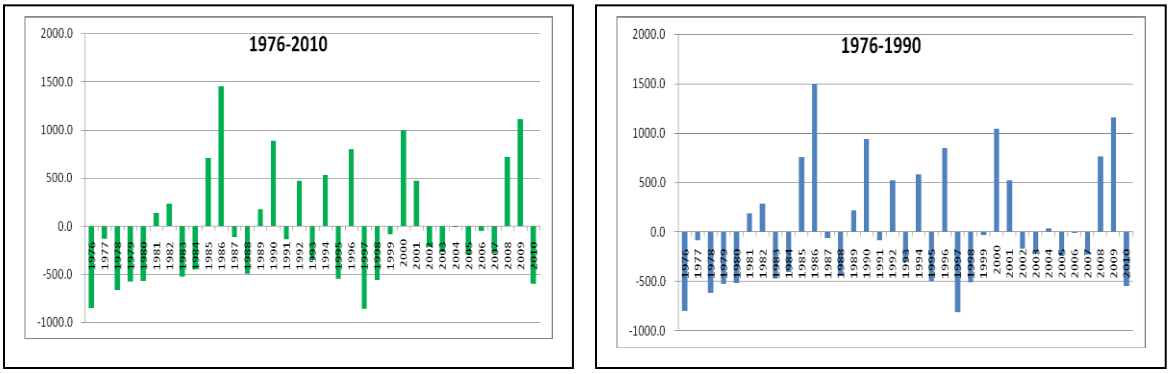

Figure 2. Rainfall anomaly in Ilocos Norte from the average rainfall of 1976-2010 and Period 1 (1976-1990).

The peak of rainfall from 1976-2010 was during August (Figure 3), However, comparing periods 1 and 2 (Figure 4), it was observed that the peak of rainfall shifted from August (Period 1) to July (Period 2). Such shifting of rainfall pattern may affect the current cropping pattern and management in the study area. Despite of this, the amount of rainfall per month did not show any abrupt change in the last 20 years except in July.

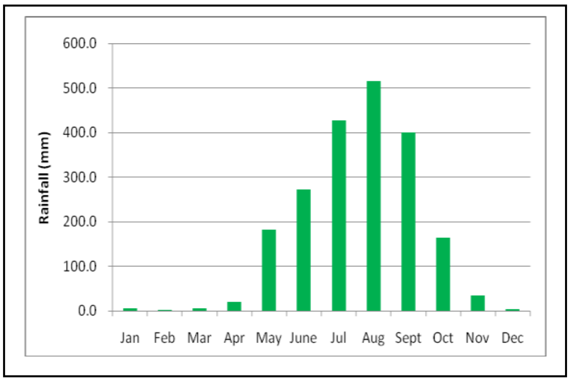

Figure 3. Monthly rainfall in Ilocos Norte from the average rainfall of 1976-2010.

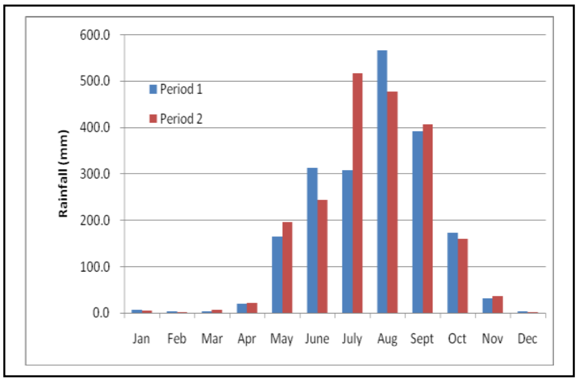

Figure 4. Comparison of the monthly rainfall in Ilocos Norte between the 2 Periods.

The number of days with moderate to heavy rainfall (>160 mm to >180 mm) was less variable from 2001-2010 compared to the other years. Over a period of 35 years however, the range was 2-15 days (Figure 5). In Figure 6, the most number of days with heavy rainfall (>180 mm) was in 2000 and 2009.

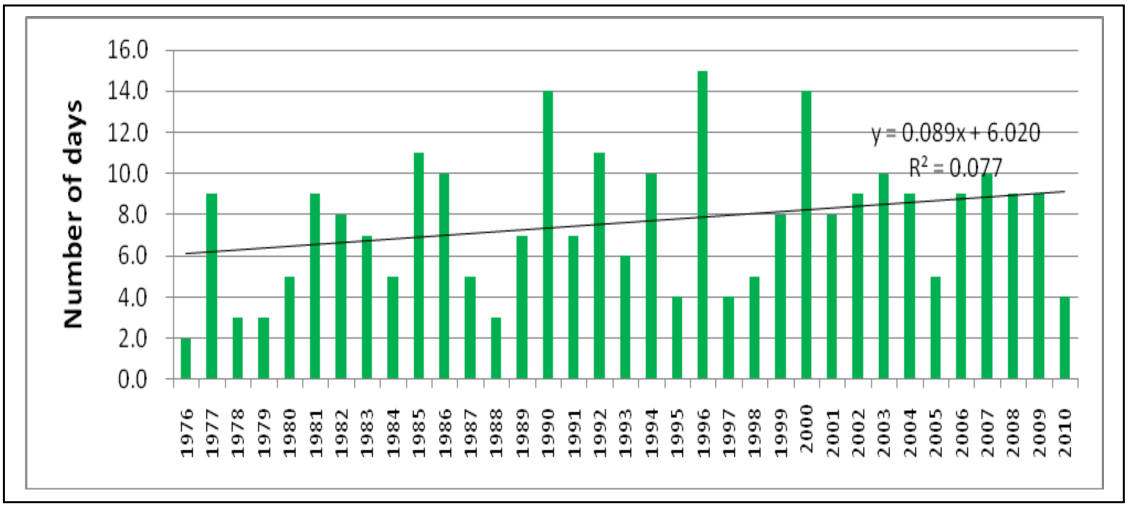

Figure 5. Number of days with moderate rainfall (>60 mm/day) per year from 1976-2010.

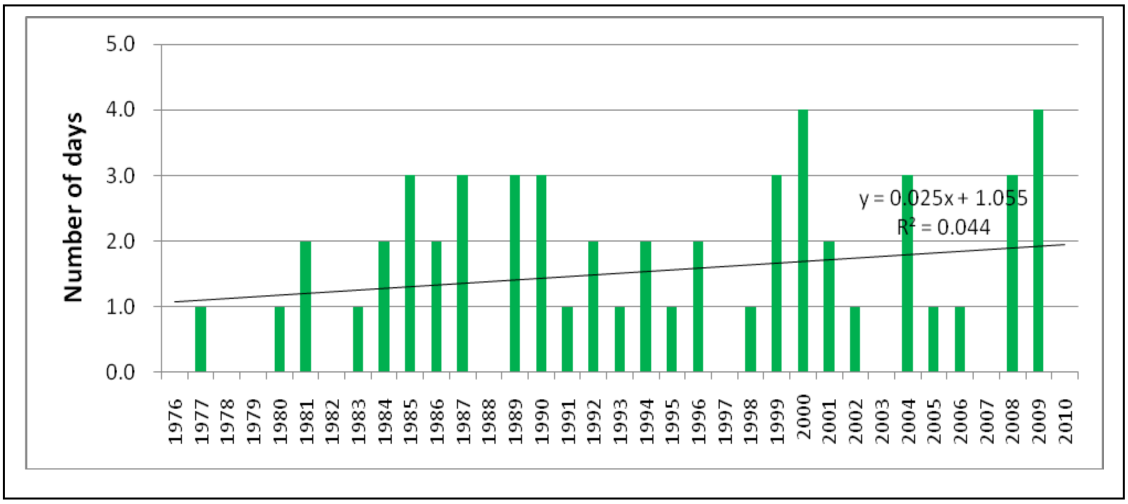

Figure 6. Number of days with heavy rainfall (>180 mm/day) per year from 1976-2010.

In spite of the fluctuation of rainfall pattern and frequency of maximum rainfall events from year to year, analysis on the mean rainfall between periods 1 and 2 showed no considerable difference (Figure 7). The frequency of maximum rainfall events however, was observed to have slightly increased from period 1 to period 2 during the months of July and August (Figure 8). This could be attributed to global climate change which triggered for more intense rainfall.

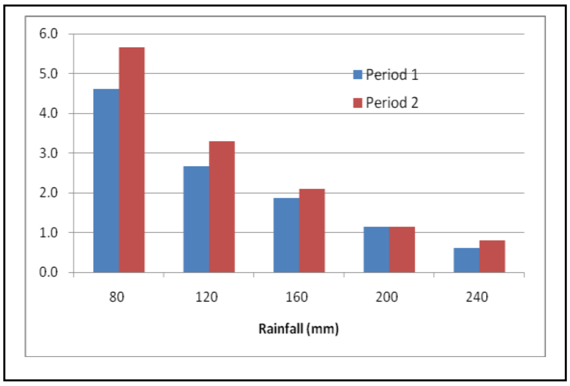

Figure 7. Comparison of frequency of occurrence of extreme rainfall events between the 2 periods.

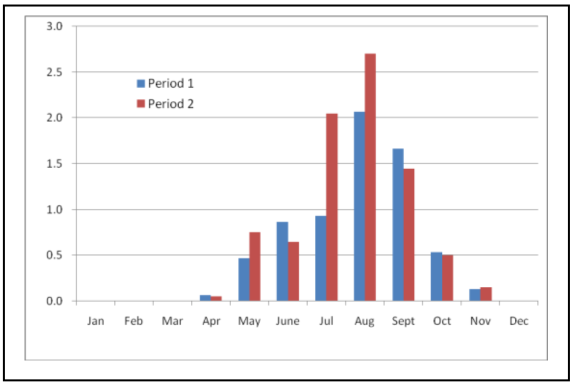

Figure 8. Comparison of frequency of occurrence of moderate to heavy rainfall between the 2 periods in monthly basis.

Air Temperature

Figure 9 shows the annual variability of air temperature. The mean annual air temperature in Ilocos Norte over a period of 35 years was 27.1 °C. The mean annual range was 25°C to 28.5°C. Lowest mean occurred in 1977 while the highest mean, in 1988. Based on linear regression analysis, the annual increase in mean air temperature is 0.017°C. The average air temperature during period 1 was 27.1°C compared to 27.3°C during period 2. In Fig. 10, lower air temperatures were noted from 1976-1985, 2002-2005, and 2009-2010 based on the 1976-2010 mean. A 2.25 °C decrease in mean air temperature occurred in 1978.

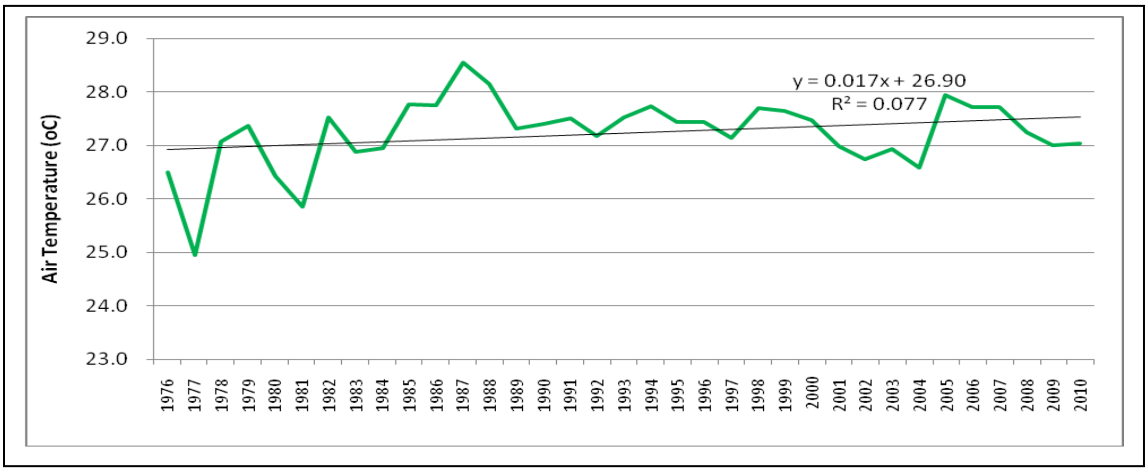

Figure 9. Yearly mean air temperature in Ilocos Norte, Philippines from 1976-2010.

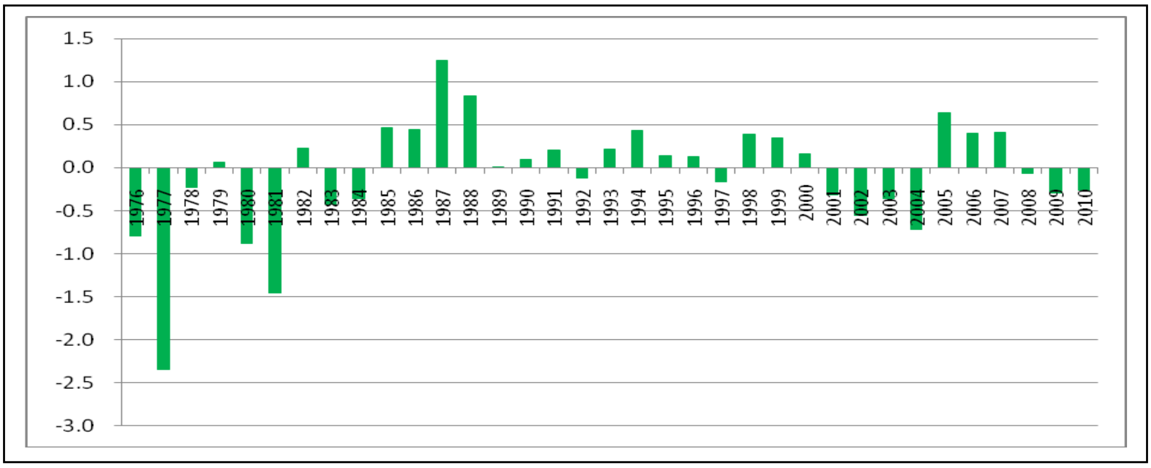

Figure 10. Yearly mean air temperature anomaly from the average mean air temperature of 1976-2010.

Generally, from 1985-2000, mean air temperature increased variably from 0.2°C to 1.4 °C. A consistent increase (from 0.4 to 0.7) was noted from 2006-2008. More consistent air temperature increase from 1985-2000 and 2006-2008 could be noted if mean air temperature was based from Period 1 (Figure 11).

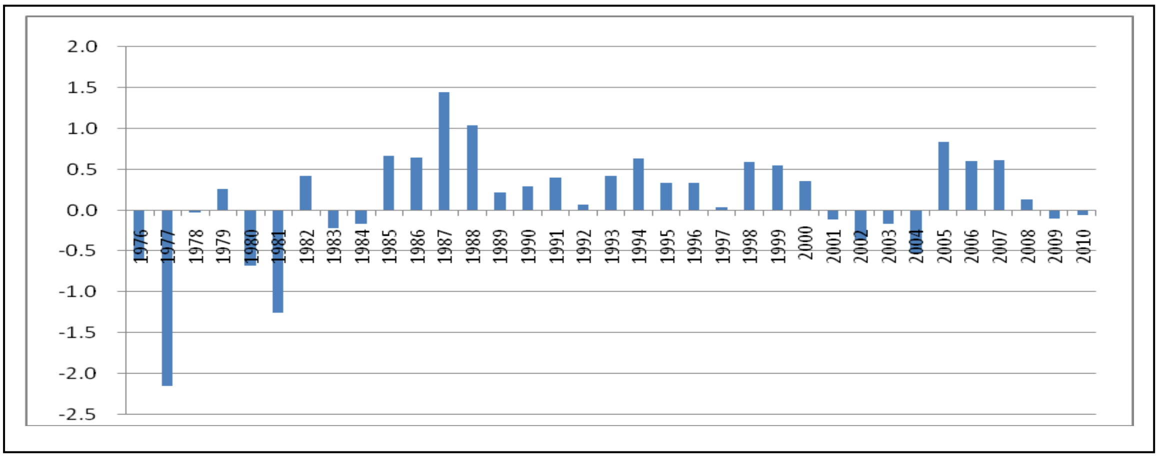

Figure 11. Yearly mean air temperature anomaly from the average mean air temperature of Period 1 (1976-1990).

The mean annual maximum air temperature was 32.5°C. The range of maximum air temperature was 31.4°C to 33.4°C, with the lowest recorded in 1981 and the highest in 1998, 2003, and 2004. Higher trend of maximum air temperature values occurred in 1998. The increase in maximum air temperature was about 0.03°C annually (Figure 12). The average maximum air temperature during Period 1 was 32.1°C compared to 32.7°C during Period 2.

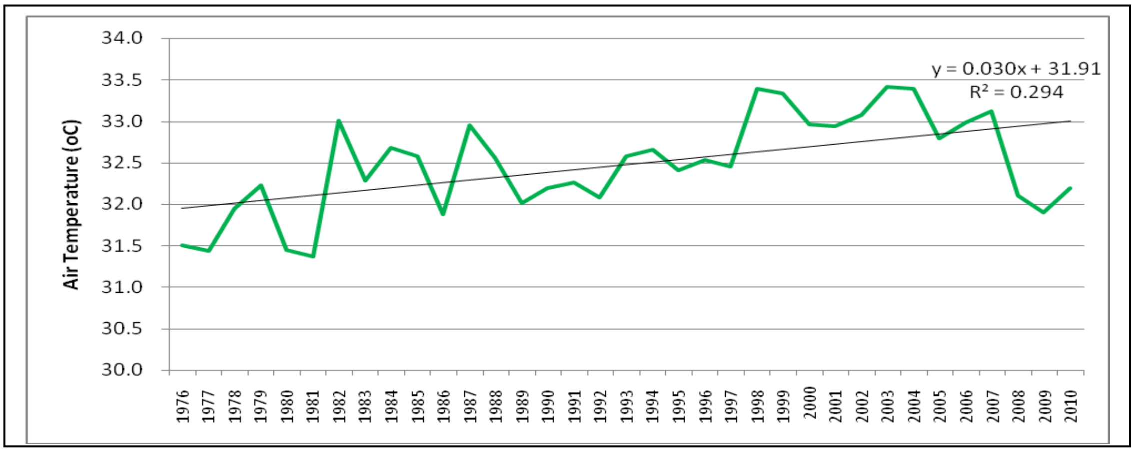

Figure 12. Yearly maximum air temperature in Ilocos Norte, Philippines from 1976-2010.

From 1998-2008, maximum air temperature was consistently higher (0.3 to 0.9°C) based on the 1976-2010 mean (Figure 13). However, based on Period 1 (Figure 14), an increase in the maximum air temperature was evident from 1993-2010 (0.3 to 1.3°C) except in 2009.

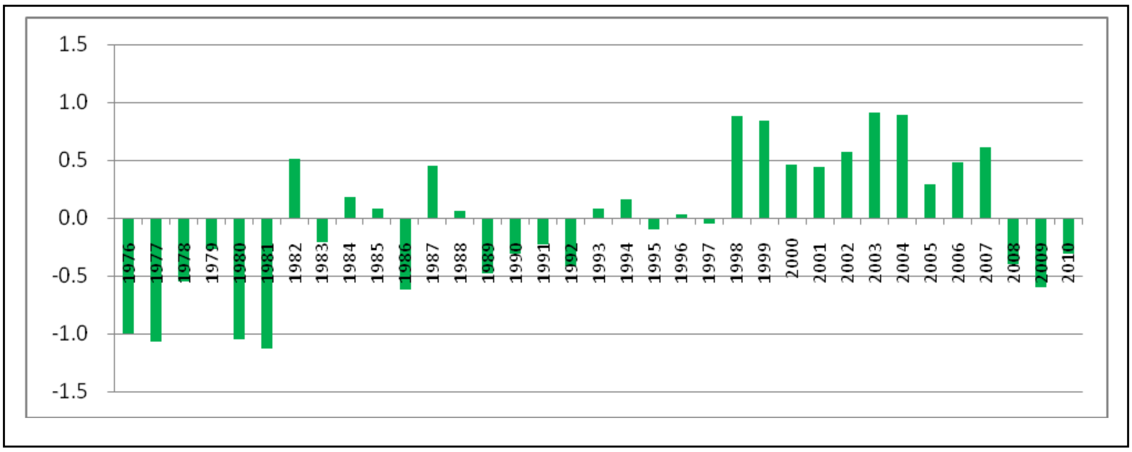

Figure 13. Yearly maximum air temperature anomaly from the average maximum air temperature of 1976-2010.

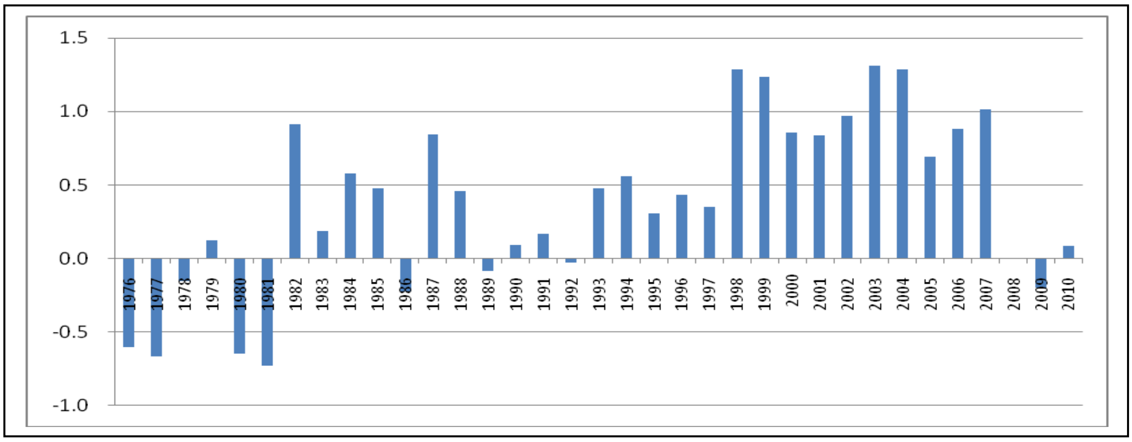

Figure 14. Yearly maximum air temperature anomaly from the average maximum air temperature of Period 1 (1976-1990).

Tropical Cyclones

Annually, the average number of tropical cyclones crossing and affecting Ilocos Norte was 7. However, the average number of cyclones during period 2 had increased to 9 cyclones as compared to that of Period 1 which was 5. Based on linear regression analysis, the annual increase on the number of cyclones crossing and affecting the study area was 0.288 (Figure 15). The number of tropical cyclones crossing and affecting Ilocos Norte varies from 2-16 per year. Since 1990, anomaly increased from the normal was evident (Figures 16-17).

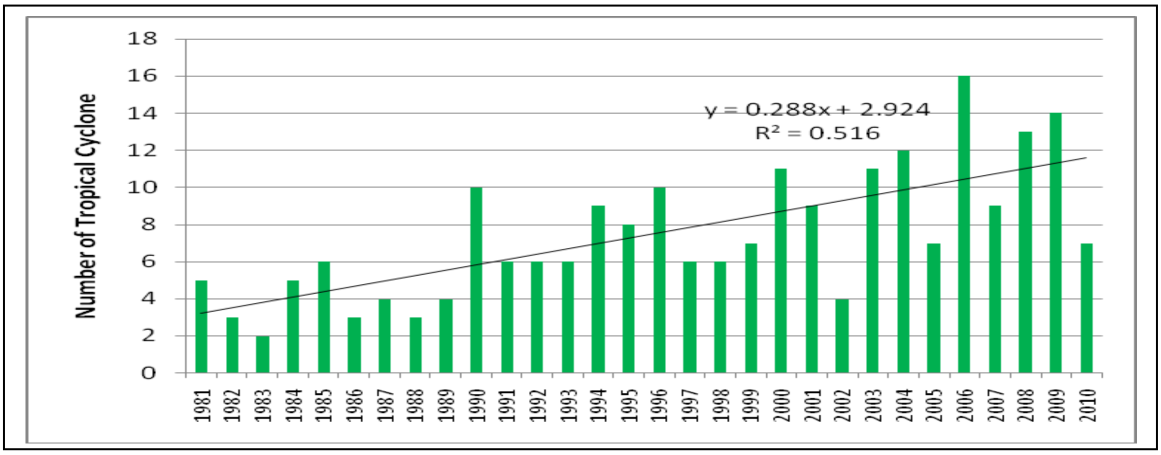

Figure 15. Yearly number of tropical cyclones that passed or crossed Ilocos Norte from 1981-2010.

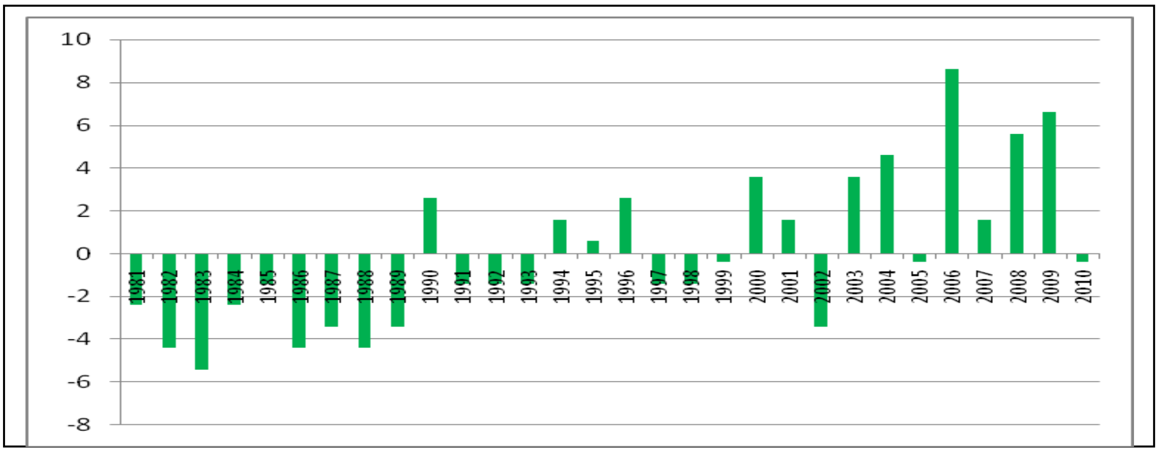

Figure 16. Yearly frequency of tropical cyclones anomaly from the average tropical cyclones of 1981-2010.

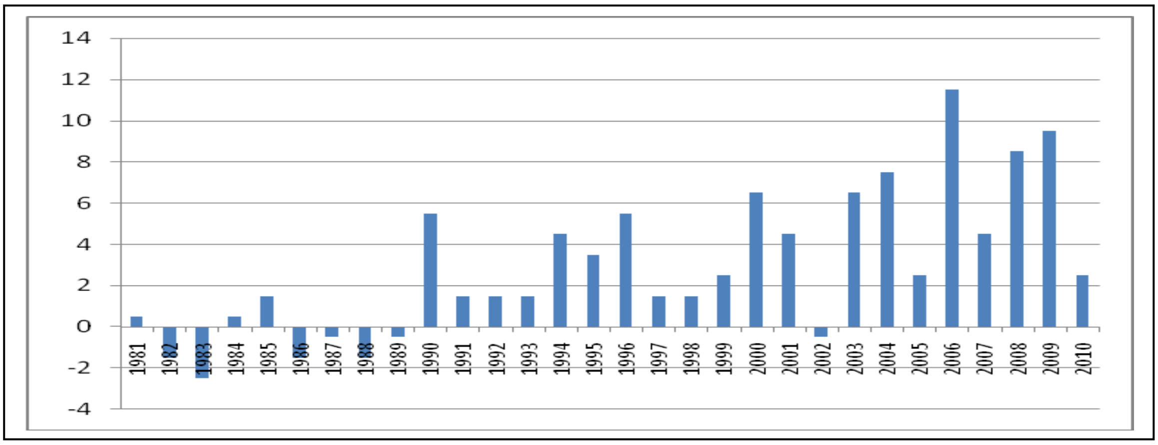

Figure 17. Yearly frequency of tropical cyclones anomaly from the average tropical cyclones of 1981-1990.

Figure 18 shows that the number of tropical depressions, storms and typhoons increased since 1990. Likewise, in Figure 19, it can be noted that tropical cyclones occurred almost every month during the wet season since 1990. From 1981-1990, tropical cyclones mostly occurred during the months of June to October but from 1991-2010, it started as early as April (2003) and ended as late as December (2004 and 2006).

Figure 20 shows that the frequency of tropical cyclones increased except in June when compared from the average of Period 1 and Period 2. The months of July, August and September increased by almost one cyclone.

Comparing the probability of tropical cyclone occurrence between the two periods, there was an evident increase from 10-40% tropical cyclone (Figure 21) either tropical depression, tropical storm, or typhoon (Figures 22-24).

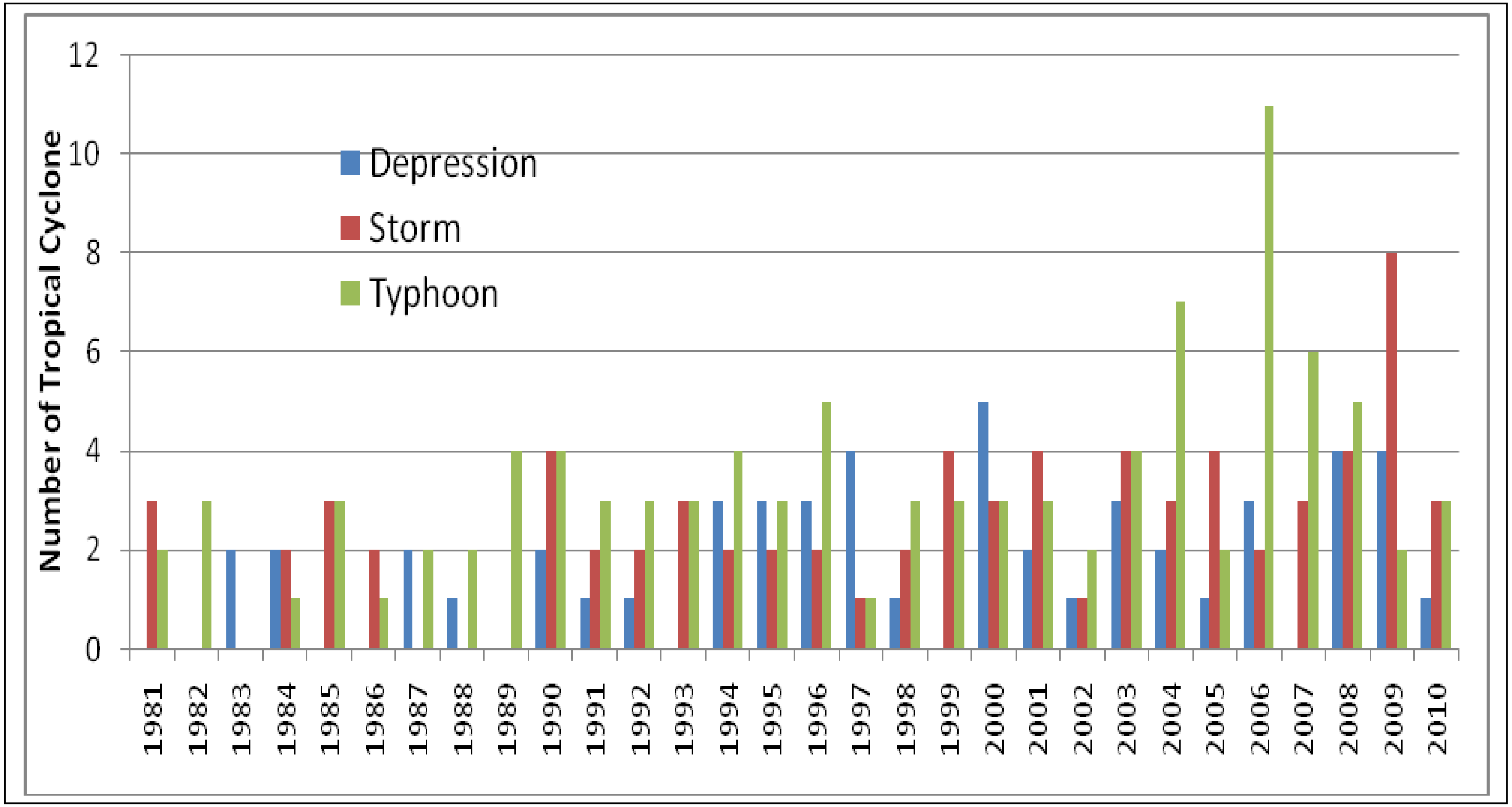

Figure 18. Yearly number of tropical cyclones according to strength that passed or crossed Ilocos Norte from 1981-

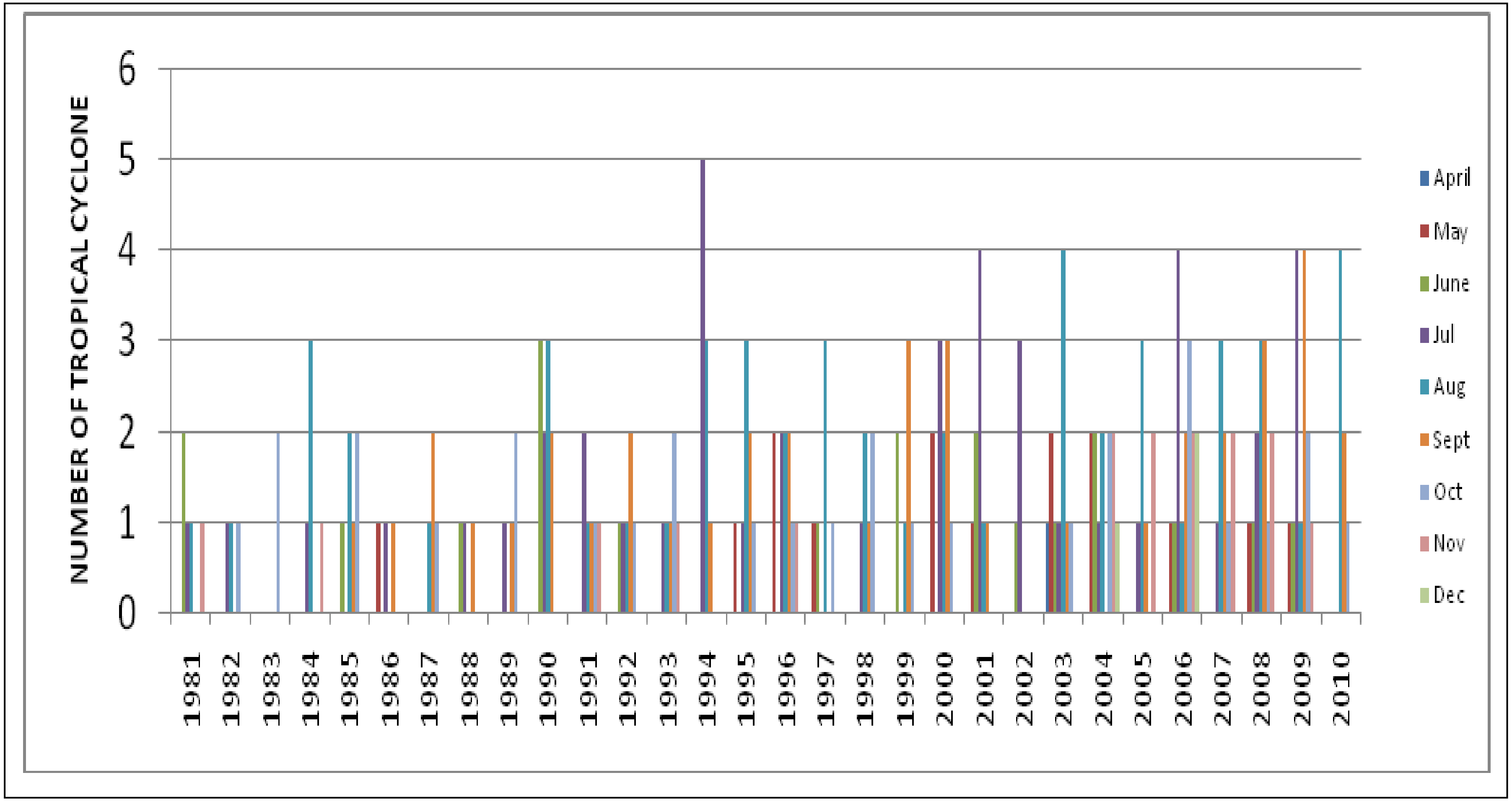

Figure 19. Number of monthly tropical cyclones in Ilocos Norte from 1981-2010.

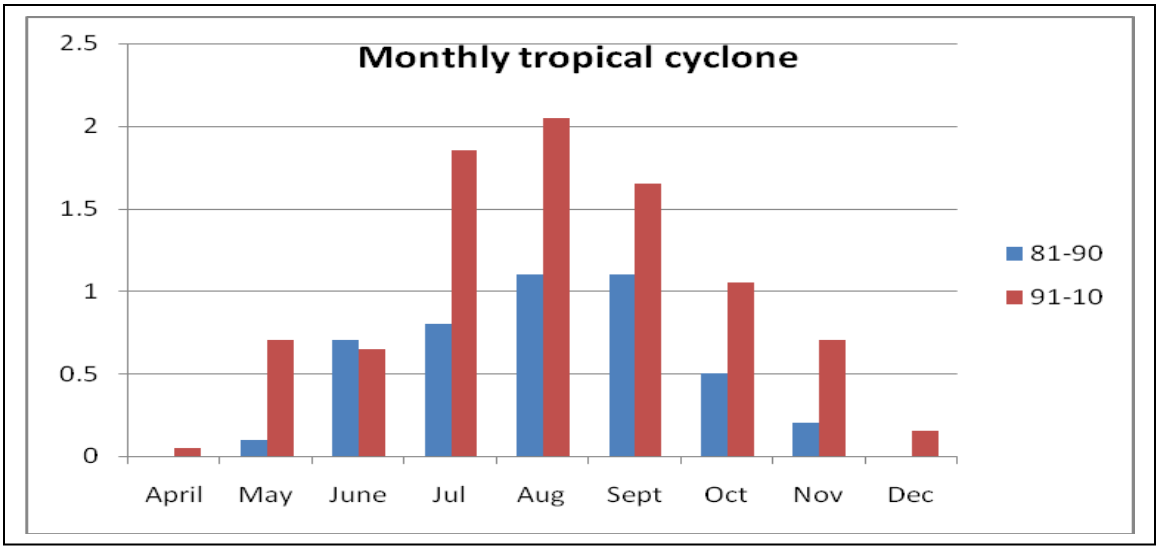

Figure 20. Comparison of the frequency of tropical cyclones between the average of 1981-1990 and Period 2 (1991-2010).

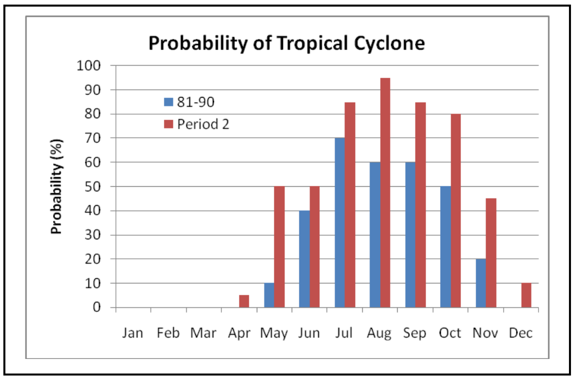

Figure 21. Comparison of the probability of tropical cyclones between the average of 1981- 1990 and Period 2.

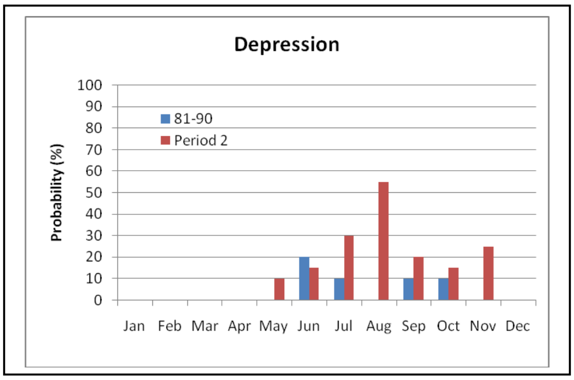

Figure 22.Comparison of the probability of tropical depression between the average of 1981-1990 and Period 2.

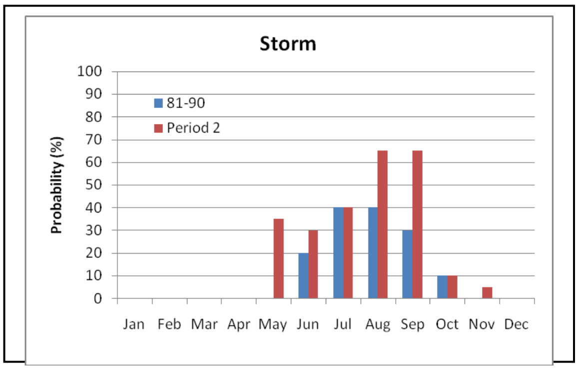

Figure 23. Comparison of the probability of tropical storm between the average of 1981-1990 and Period 2.

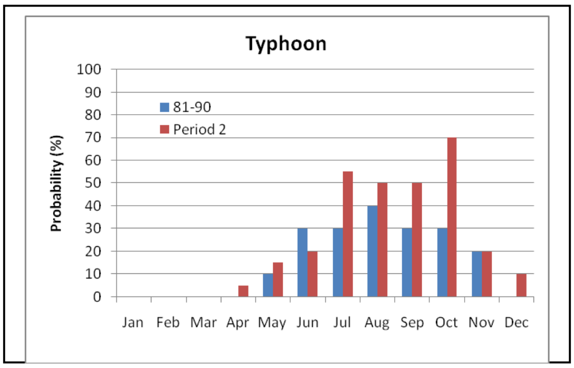

Figure 24. Comparison of the probability of typhoon between the average of 1981-1990 and Period 2.

Cropping Calendar

Based from the result of the analysis of the rainfall data and tropical cyclone occurrences, cropping calendar for a given agro-ecological zone was developed using the data from 1991-2010 (Period 2). The cropping calendars presented below are the modification of the cropping calendars developed by CG Acosta, et al.:

a. *Submerge-prone lowlands*. Cropping pattern with two (2) rice crops followed by a drought resistant crop (mungbean) is recommended in relatively low lying areas (Figure 25). The first rice crop starts as early as the 3rd decade of June when rainfall is about to set-in. Supplemental irrigation may be needed during seeding periods because there is still high probability of having a 10-day dry spell. Transplanting is done as early as the 2nd decade of July. Rainfall will be sufficient during the vegetative and reproductive stages of the rice crop considering a high rainfall amount during these stages. The risk that a farmer may face due to early transplanting is the high probability of tropical cyclone occurrences during panicle to early heading stages and wet soil condition at the time of harvesting. Harvesting is done as early as the 2nd decade of October or towards the end of October when rainfall begins to recede.

   A second rice crop may start as early as the 1st decade of November. The reproductive stage falls in the first decade of January. The ripening and harvesting stages are favorable in the third decade of February to March.

b. *Drought-prone lowlands*. For relatively high lying areas, rice – upland crops (rice-garlic-mungbean) is recommended (Figure 26). The first crop is rice which starts as early as the 1st decade of July and then followed by garlic (or corn, pepper, tomato, eggplant) which starts in the 3rd decade of November when rainfall already receded or 2nd decade of November if garlic is planted right away after the harvest of rice. The probability of tropical cyclones is negligible during these days. Although rainfall may occur in lesser amounts, this may seem favorable for crop establishment.

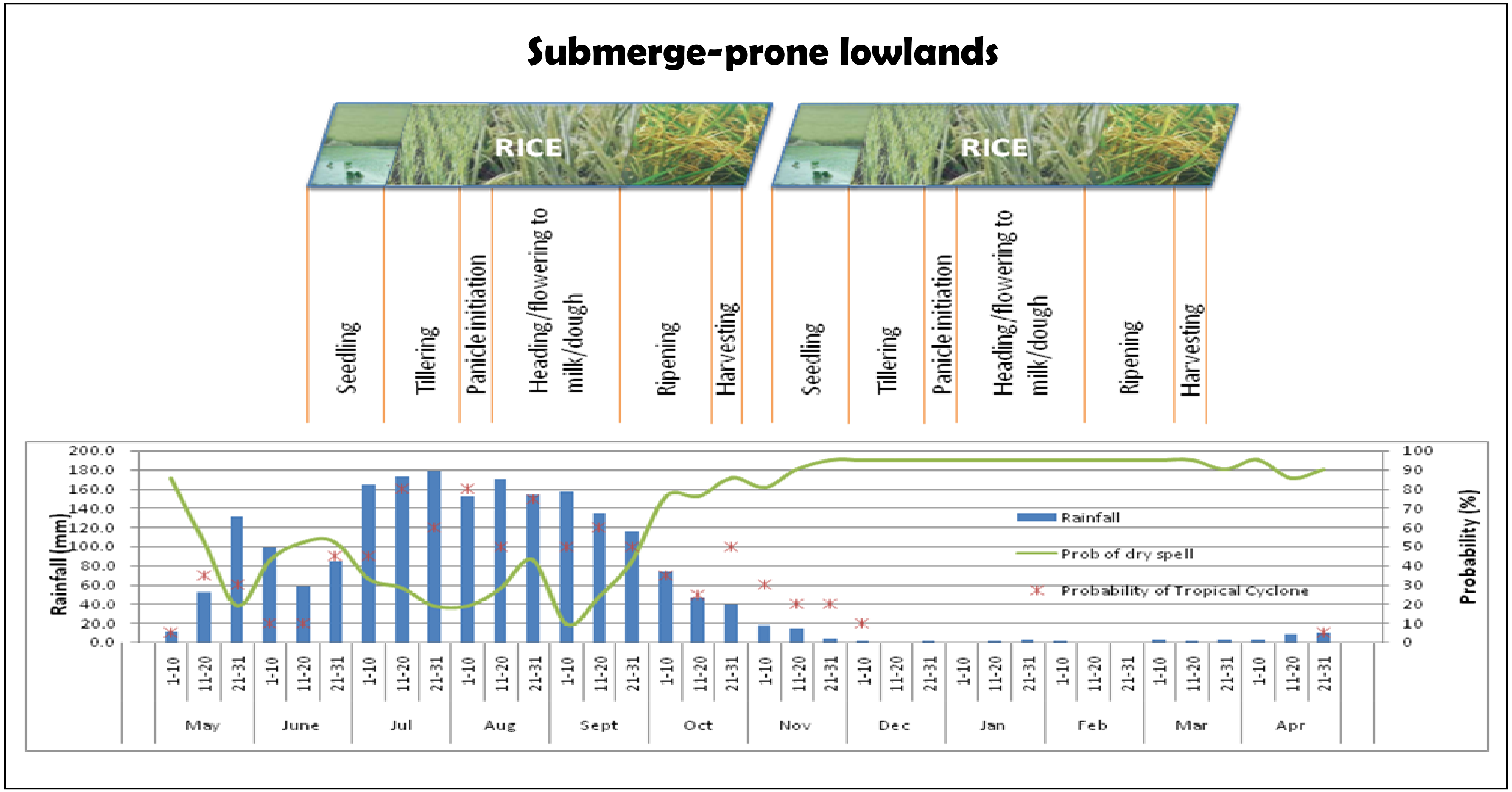

Figure 25. Cropping calendar in submerge-prone lowlands.

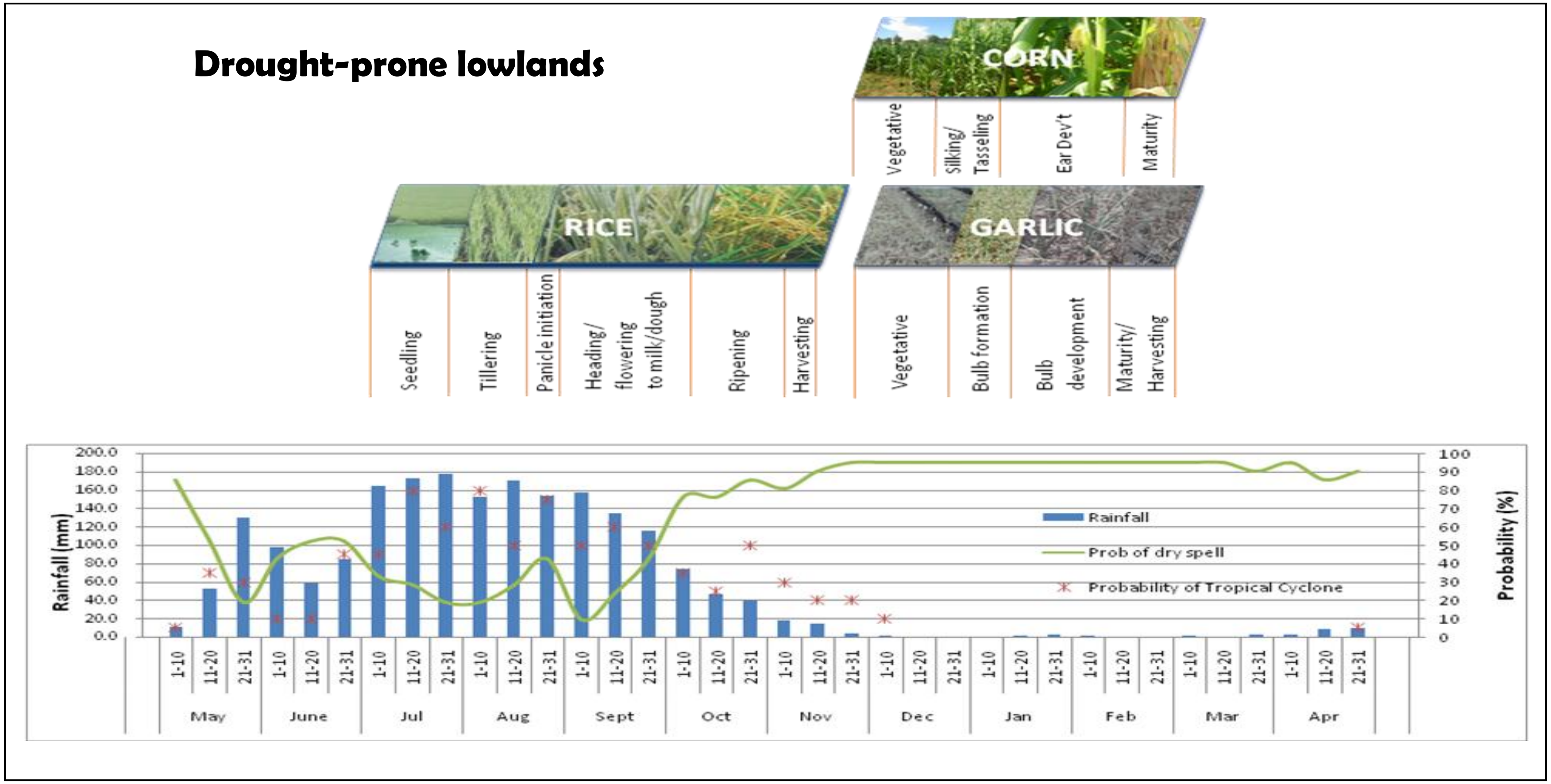

Figure 26. Cropping calendar in drought-prone lowlands.

With supplemental irrigation from shallow tubewells during periods of low moisture from late December to February, garlic and other cash crops are expected to attain their optimum yield.

Utilization of residual moisture is made possible by planting a drought tolerant crop like mungbean from first decade of March through April. This crop is preferred during these months.

c. *Upland areas* – A vegetable-based cropping pattern is recommended in upland or non-bunded areas wherein water is hard to maintain. With this pattern, off-season vegetables such as tomato, onion as shallots, ginger, gabi, peanut (unshelled), corn, etc. can be planted (Figure 27).

Conclusion and Recommendations

The evidence of climate change is clearly shown in this study and consequences are also alarming as it may hamper development effort in the province. Efficient use of water resources as policies toward working land degradation and forest denudation should be considered to minimize potential impact of climate change. On the other hand, the information derived from the study and the cropping calendars developed are useful tools to minimize the risk in farming, and helpful for agricultural planning and operation.

To showcase the importance of this information, it is therefore recommended that a demo farm or pilot area be established to show the effectiveness of the proposed cropping calendars. Likewise, a wider dissemination of the information through IEC, focus group discussion, and print and broadcast media be done.

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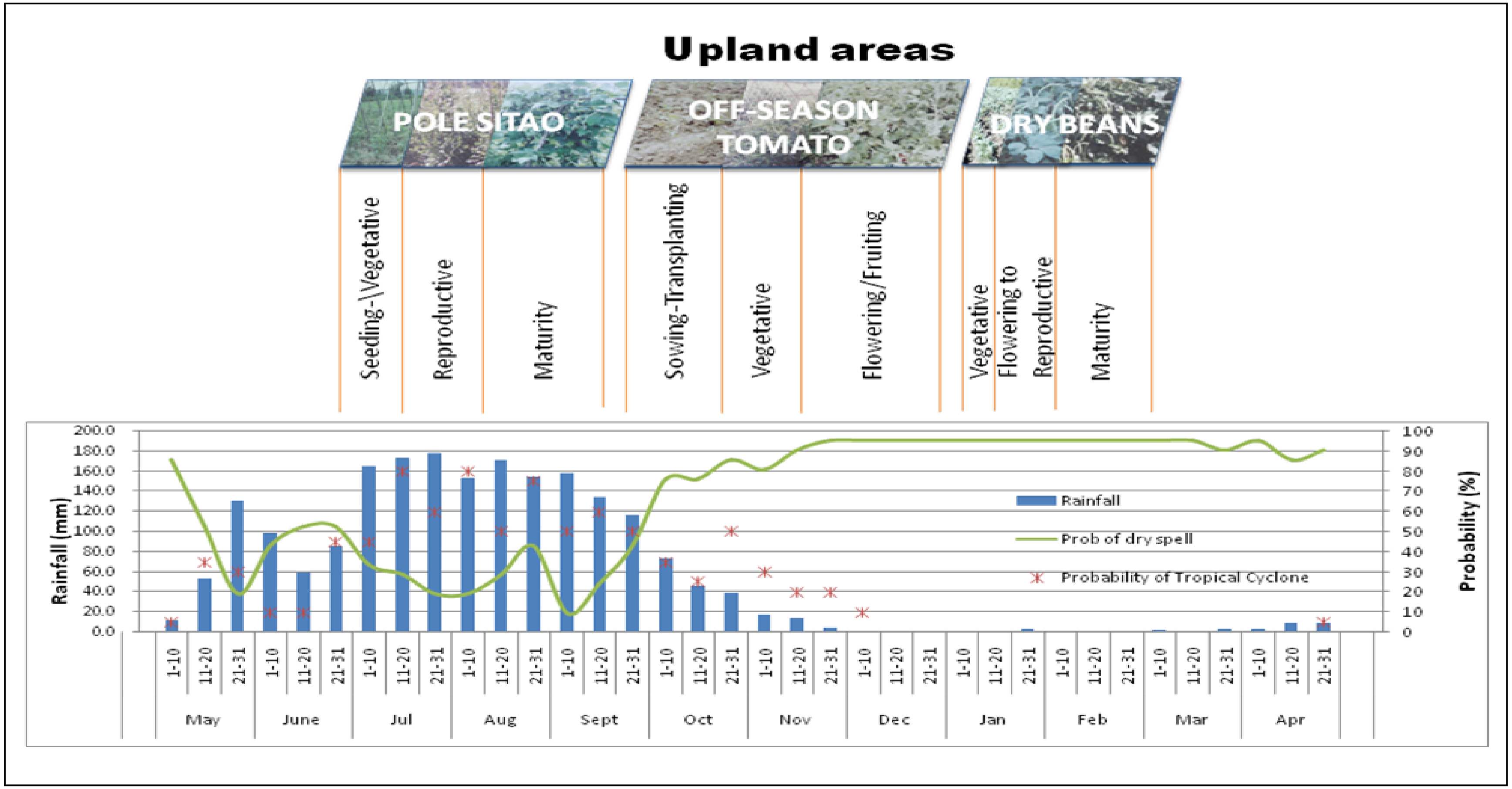

Figure 27. Cropping calendar in upland areas.