FLOODING INCIDENCE AT AKLAN RIVER AS AFFECTED BY RAINFALL

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Abstract: The Philippines is among the most vulnerable countries in terms of disaster and climate change scenario. Based on previous studies, the provinces in the Philippines are classified according to their vulnerability to temperature change, rainfall change, typhoons, El Niño and flooding incidence. The province of Aklan is included as one of the provinces with high risk related to rainfall change. A 24-hour rainfall of 206.4 mm in December 2005, 246.80 mm in December 2010, and 202.80 mm in November 2011, resulted to flooding in the municipality of Kalibo and a 305.30 mm rain in June 2008 had caused severe damage to the low-lying areas of the region. But rainfall of only 124.6 mm in December 2012 had inundated some areas of the province. This was due to the incidence of high tide which prevented the river from emptying into the sea. Based on the result of this study, recurring typhoons and increased precipitation were experienced in the province of Aklan specifically during the Northeast Monsoon or Amihan (November and December). There is a weak positive correlation between rainfall and height of water at the Aklan River as indicated by r^2 value of 0.011. This result suggests that changes in the independent variable (rainfall) are not associated with changes in the dependent variable (height of water). More rain and cooler temperature were noted in summer (March 2012) while least relative humidity, higher temperature, and least rainfall were recorded in August (Habagat season), and temperature ranged from 24.3 to 31.9 ^{0}C. More rainfall was observed in Madalag (295.8 mm), followed by Banga (263.0 mm) and Kalibo (243.0 mm) for 2012-2013. Based on a ten-year rainfall data, abundant rain was observed in June, September to December and started to decline from January to May and August. Aklan has a mean annual rainfall of 3,325.6 mm while mean temperature is 30.9^{0}C. Dry Spell condition occurred in 2014 since from January to June, rainfall was almost below to way below normal rainfall condition, based on the criteria set by PAGASA.

Keywords: *rainfall, Aklan river, monsoon, dry spell*

1. INTRODUCTION

In recent years, monsoon rain in the Philippines has reached its extreme level. Some parts of the country like the Aklan province has experienced an increased trend in rainfall while other parts have experienced intense drought. These two extreme weather events make it more difficult for the agriculture and aquaculture sectors which are highly dependent on weather.

Climate change leads to increasing frequency of extreme weather events happening around the world. Unusually high rainfall due to climate change is a significant cause of floods. Consequently, droughts become longer, harder and more frequent.

Severe flooding is a regular occurrence that affects the disaster-prone Western Visayas Region including the province of Aklan. During cyclones and seasonal monsoons, the Aklan River can rapidly swell to a height of six meters. This can cause loss and damage to communities. Specifically, on June 21, 2008, the province of Aklan was hit by Typhoon Frank and the normally 30 m-wide Aklan River channel overflowed carrying tons of debris and mud into the nearby towns. The damage to the local communities within the vicinity of the river was huge and it took the province almost three months to recover.

This study will give valuable information to the Disaster Risk Reduction Management group on how much the volume of rainfall and height of water at the Aklan River could result in inundation of the low-lying areas in the province. Hence, there is a need for data monitoring and recording of extreme events, and even normal values of rainfall, for farmers to be aware of the existing conditions, make necessary precautions and adjustments in their management practices, and develop a planting calendar based on this information.

2. METHODOLOGY

2.1 Study area

The areas covered in this study are Kalibo, Banga and Madalag in the province of Aklan. Kalibo is at latitude 11.699ºN, longitude 122.367'E, and has an elevation of 11.9 m. Latitude of Banga is 11.636ºN, longitude is 122.331'E, and elevation is 32m. Madalag is at 11.477ºN latitude, 122.259'E longitude, with an elevation of 83.4 m.

2.2 Design of the study

This study utilized the descriptive type of research and involves gathering of data that describe events and then organizes, tabulates, depicts and describes the data collected (Glass and Hopkins, 1984). The study documents events and conditions which attempts to find out existing relationships among variables such as rainfall and height of water of the river. Content or document analysis was used on the 2004-2013 meteorological data from Aklan State University–Bureau of Soils & Water Management (ASU-BSWM) Agromet Station; extreme condition such as flooding and rainfall in 2012-2013 were also analyzed.

2.3 Collection of climatic data

Rainfall data was obtained from Madalag Automated Weather Station; data for Banga is from ASU-BSWM Agromet Station; and data for Kalibo is from the Automated Weather Station situated at Capitol, Kalibo, Aklan (Figure 1). However, data of rainfall in Madalag started from May 2012 when the Automated Weather Station was established in this municipality while rainfall and temperature for 2004 to 2013 were taken from ASU-BSWM Agromet Station at Aklan State University, Banga, Aklan.

2.4 Determining percent normal rainfall based on the historical data from the Agromet Station and AWS (10 years)

2.4.1 The formula used to determine the percent (%) normal rainfall condition is:

$$\text{Percent of Normal Rainfall} = \frac{\text{actual rainfall}}{\text{normal rainfall}} \times 100$$

This formula was used to forecast the yearly rainfall condition in Banga for 2014.

Figure 1. Map of Aklan indicating the Automated Weather Stations (AWS) where weather data are taken.

2.4.2 Criteria for Rainfall Deficit (Source: Daisy F. Ortega, PAGASA Regional Services Division (PRSD) Mindanao PAGASA-DOST)

Dry Spell –	3 consecutive months of below normal (41%-80%) rainfall condition
Drought –	3 consecutive months of way below normal (<40% of normal), or 5 consecutive months of below normal (41%-80%) rainfall condition.

2.5 Source of data for the height of water at Mobo Kalibo Gauging Station

Height of water at Mobo Gauging Station in Kalibo, Aklan was taken from the observer assigned by the Department of Public Works and Highways (DPWH). The data were tallied and computed to obtain the mean height of water daily.

Table 1. Percent and textual interpretation for monthly rainfall.

Percentage	**Rainfall Condition**
<40%	Way below normal
41% - 80%	Below normal
81% - 120%	Near normal
>120%	Above normal

2.6 Data analysis

Data were analyzed using mean and percentage. A simple regression analysis (r^2) was used to find out the relationship between rainfall and height of water at Mobo Bridge. The Statistical Tool for Agricultural Research (STAR) version 2.0.1 was the program used to analyze the data. The variable water level is the dependent variable in this equation and β_0 (intercept) and β_1 (coefficient) are the unknown parameters to be estimated. The variable rainfall is the independent variable and ε is the unknown error. ε_i are the residuals that cannot be explained by the variables in the model. The equation used in determining water level is:

$$\text{Water level} = \beta_0 + \beta_1 \text{ Rainfall} + \varepsilon$$

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \text{ where } i = 1, 2\ldots, n \text{ observations}$$

3. RESULTS AND DISCUSSION

3.1 Inundation-causing 24-hour rainfall events in Aklan from 2005 to 2012

Rainfall of 206.4, 246.80 and 202.8 mm were recorded on December 9, 2005, December 9, 2010 and November 15, 2011, respectively, had caused flooding in the municipality of Kalibo, and a 305.30 mm of rain during typhoon Frank had caused severe damage in the low-lying areas of the region (Table 2). However, rainfall of only 124.6 mm during typhoon Quinta (December 2012) which yielded almost 7.0 meters height of water at Aklan River caused inundation in some parts of the province (Figure 2). This was due to high tide, preventing the river from emptying into the sea. Extreme rainfall resulting to flooding in Aklan mostly occurred during the Northeast Monsoon or Amihan.

3.2 Water level (m) at Kalibo Gauging Station and mean climatic data from March 2012 to February 2013

Temperature is almost constant throughout the year which ranges from 23.7 to 30.3^{o}C. The coldest temperature is usually in January (23.3-28.3^{o}C) and the warmest is in May (24.3-31.9^{o}C). Cloudy conditions occur from October to December when Northeast monsoon or amihan prevails (Table 2). A cooler temperature observed in summer (March 2012), resulted in high relative humidity, more rainfall and higher water level at the Aklan River. While higher temperature in August despite habagat season resulted in low relative humidity and less rainfall. The low temperature in December 2012 resulted in increased relative humidity and the highest water level of 4.11 meters. The statement of Undersecretary Yumul is true that with the climate change scenario, "what we consider as abnormal we should now consider as normal weather condition."

Table 2**.** Inundation-causing 24-hour rainfall events in Aklan from 2005 to 2012. (Source: ASU-BSWM Agromet Station)

	Weather Parameter		
Month/Year	**Rainfall (mm)**	**Tropical Cyclone**	**Season**
December 9, 2005	206.4 mm	Low Pressure	NE Monsoon (Amihan)
June 21, 2008	305.3 mm	Typhoon Frank	SW Monsoon (Habagat)
December 9, 2010	246.8 mm	Low Pressure	NE Monsoon (Amihan)
November 15, 2011	202.8 mm	Low Pressure	NE Monsoon (Amihan)
December 26, 2012	124.6 mm	Typhoon Quinta	NE Monsoon (Amihan)

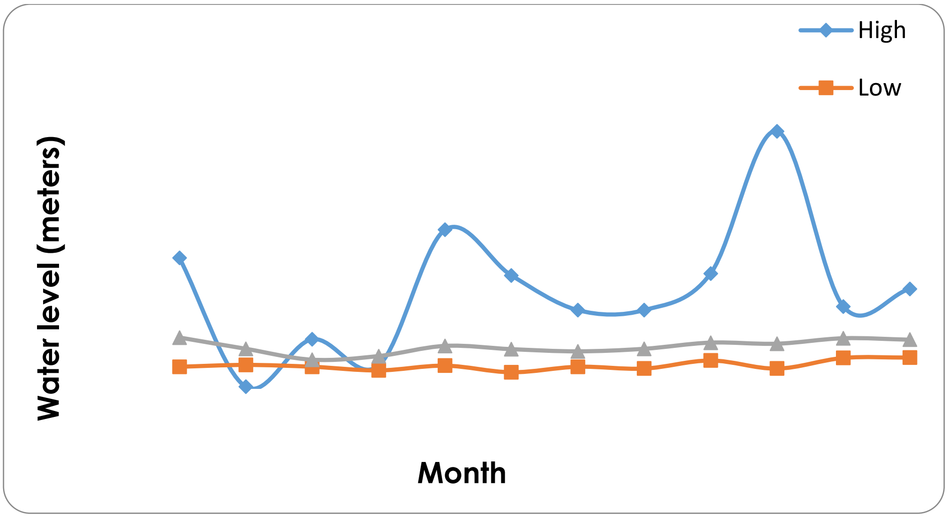

Figure 2. Monthly highest/ lowest/ mean water level (m) at Kalibo Gauging Station from March 2012 to February 2013.

Table 3. Mean water level (m) at Kalibo Gauging Station and mean weather data from March 2012 to February 2013.

Month	Water Level (m)	Daily Rainfall (mm)	Temperature (^{0}C)			Relative Humidity (%)
			Max	Min	Mean	
2012						
March	1.35	12.1	28.9	23.8	26.4	74.7
April	1.04	4.3	30.6	23.8	27.2	72.3
May	0.74	4.9	31.9	24.3	28.1	70.9
June	0.84	11.2	30.9	23.8	27.4	70.2
July	1.12	15.8	30.4	24.2	27.3	75.2
Aug	1.03	4.3	32.1	23.8	28.0	67.0
Sept	0.97	12.4	32.1	23.6	27.9	76.4
Oct	1.04	10.1	32.1	23.0	27.6	72.0
Nov	1.21	12.5	29.2	23.9	26.6	75.0
Dec	4.11	7.2	29.1	23.9	26.5	73.7
2013						
Jan	1.33	6.7	27.9	23.3	25.6	74.7
Feb	1.29	5.9	28.3	23.4	25.9	75.1
Mean	-	9.0	30.3	23.7	27.0	73.1
r^2value	0.011					

Latitude: 11^0 37.913'N; Longitude: 122^0 19.999'E; Elevation 32m (ASU Agromet) for 2012-2013

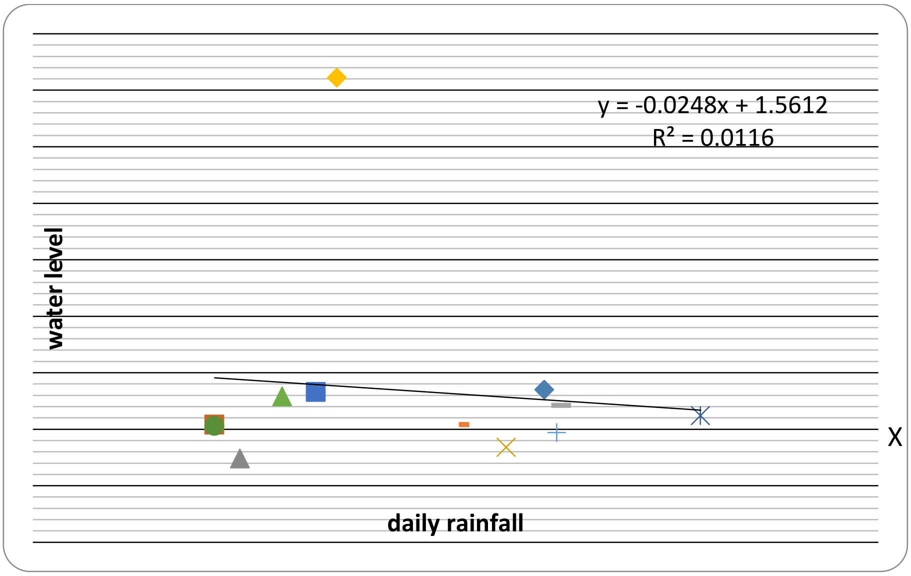

Figure 3. Relationship between daily rainfall (mm) and water level (m) at the Aklan River for 2012-2013.

Daily rainfall and water level at the Aklan River for 2012-2013 was tested using the regression analysis (r^2) to find out the relationship between the volume of rainfall (mm) and height of water. The results revealed an r^2 value of 0.011 which indicates a weak correlation (Figure 3). The parameter estimates show that β_0 is 1.56 and β_1 is -0.024. This indicates that for every increase of daily rainfall, water level is not expected to rise by an average of 0.024 m.

The F-statistic for the overall model reflects that F-value is 0.12 and the p-value is 0.74 which is insignificant. The result suggests that changes in the independent variable (rainfall) are not associated with changes in the dependent variable (water level). The result further implies that other factors such as frequency of rainfall, rate of evaporation, and other weather factors have affected the volume of water at the Aklan River.

3.3 Rainfall (mm) from the three (3) sampling sites from March 2012 to February 2013

Figure 4 shows that maximum rain period at the upstream (Madalag) occurred in the months of July, September and November, while from February and May (summer) and even August (*habagat*), less rainfall was recorded.

Midstream (Banga) recorded the highest rainfall of 485.0 mm in March followed by July, and November for 2012-13. However, August (despite habagat season) registered the least rainfall of 111.5 mm.

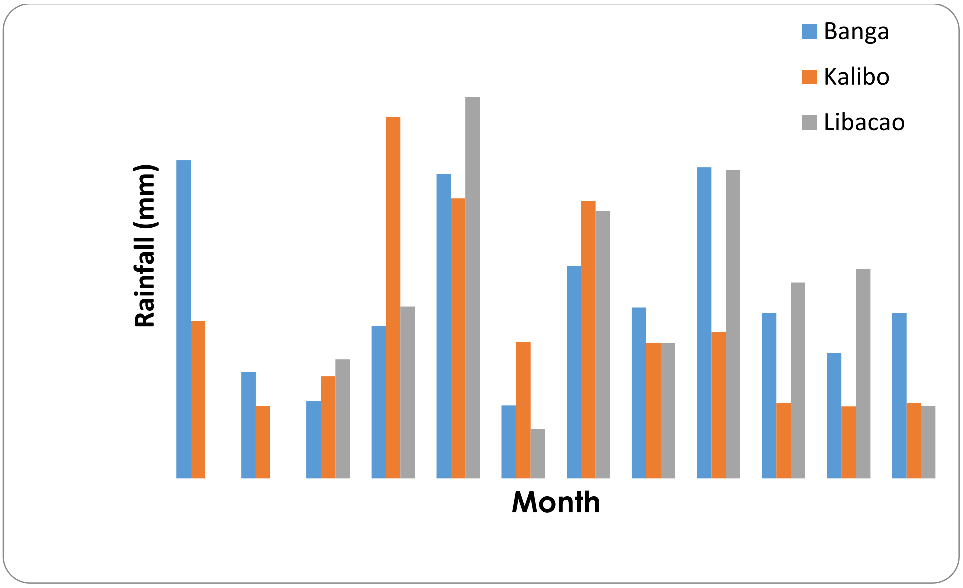

Figure 4. Monthly rainfall (mm) from various sites of the Aklan River during March 2012 to February 2013.

Maximum rainfall occurred in Kalibo in June, July and September, and declined drastically in October to February as well as from April to May. Maximum rainfall in Kalibo occurred only for three months while the rest of the months had less rainfall.

More rainfall was recorded in the upstream portion (Madalag) which had an average monthly rainfall of 295.8 mm, while 263.0 mm was registered in Banga, and 243.0 mm in the downstream portion in Kalibo (Figure 4a).

3.4 Mean monthly and annual rainfall (mm) and temperature from 2004-2013

It is important to evaluate how climate has varied and changed in the past. The mean monthly historical rainfall and temperature data can be mapped to show the baseline climate and seasonality by month, for specific years, and for rainfall and temperature. Figures 5, 5a and 5b show the mean historical monthly and annual rainfall and temperature for Aklan during the period 2004-2013. They show that rainfall poured out abundantly starting June and from October to December, and started to decline from January to May and even August. Historical data further revealed that typhoons were frequent during the months of June, November and December when extreme rainfall occurred. Increased annual rainfall was noted in 2008 (4,474 mm), followed by 2011 (3,940 mm), 2012 (3,539 mm) and 2010 (3,151mm) due to typhoon and low pressure (Figure 4a). The highest temperature was recorded in May at 33.0ºC, and the lowest was noted in January (28.8ºC). Similar results were observed for temperature in 2012 and 2013.

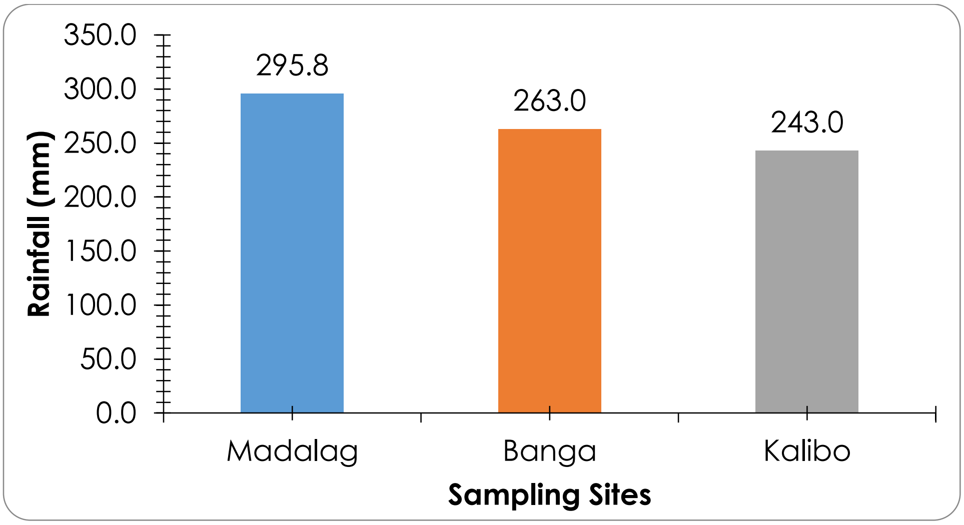

Figure 4a. Mean monthly rainfall (mm) at the three sampling sites in Aklan during 2012-2013.

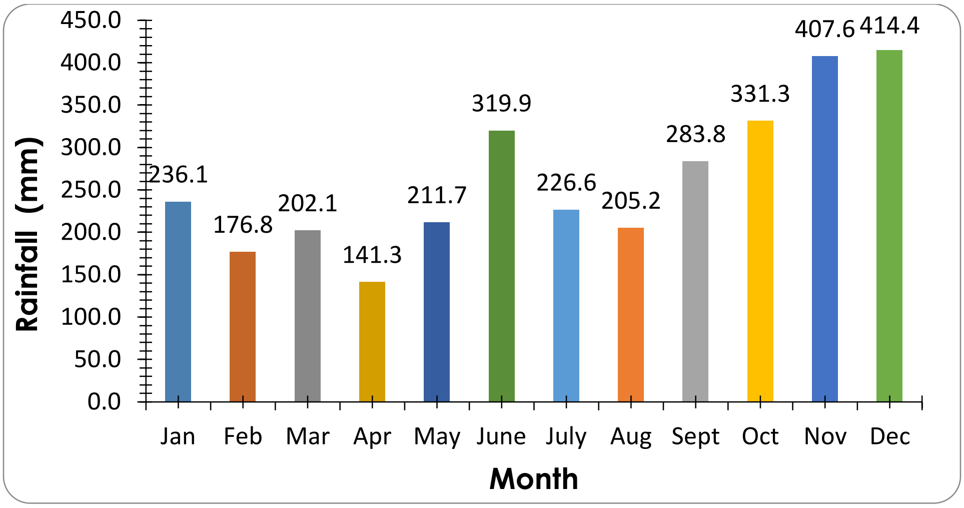

Figure 5. Mean monthly rainfall (mm) from 2004 to 2013. (Source: ASU Agromet-BSWM Agromet Station)

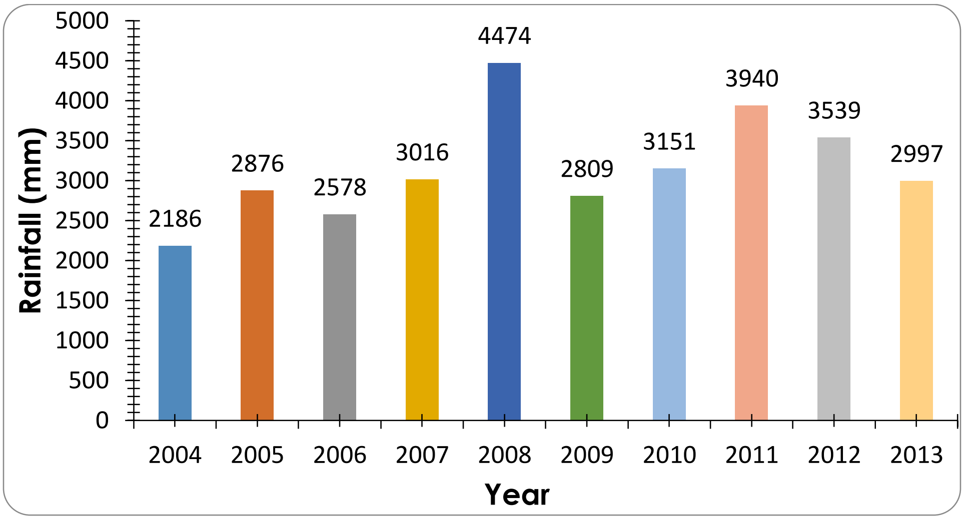

Figure 5a. Mean annual rainfall (mm) in Aklan for 2004-2013. (Source: ASU Agromet-BSWM Agromet Station)

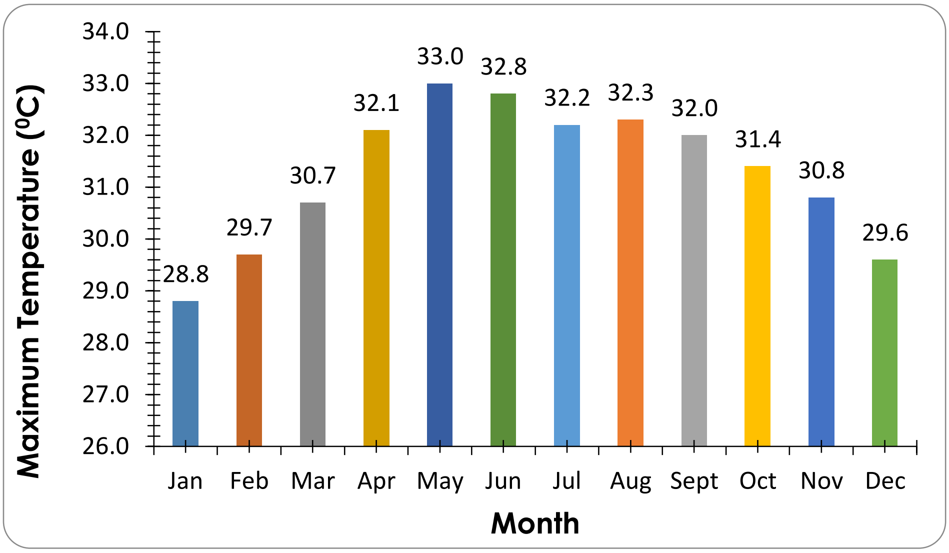

Figure 5b. Mean monthly temperature (°C) in Aklan for 2004-13.

Table 4. Forecast of rainfall for 2014 based on 2004-2013 historical pattern. (Source: ASU-BSWM Agromet)

Month	Rainfall (10 years)	Monthly Rainfall (mm)	% Normal	Interpretation
	2004-13	2014	2014	
January	237.6	146.0	61.4	BN
February	176.8	49.6	30.9	WBN
March	201.6	83.6	41.5	BN
April	140.8	127.7	90.7	NN
May	218.0	107.8	49.4	BN
June	319.9	104.5	32.7	WBN
July	246.5	220.9	89.6	NN
August	203.3	225.5	112.8	NN
September	293.8	166.9	60.2	BN
October	358.9	550.8	153.5	AN
November	407.6	337.6	83.2	NN
December	414.8	451.3	104.6	NN

Legend: NN- near normal; AN- above normal; BN- below normal; WBN- way below normal

3.5 Forecast of Rainfall for 2014 based on the history of rainfall from 2004 to 2013

More rainfall was recorded in June and from October to December based on the ten-year data (2004-2013). Below normal to way below normal conditions were observed from January to June 2014 which indicates that the province of Aklan experienced dry spell condition during these periods which is not favorable for the agricultural sector.

4. CONCLUSIONS

Rainfall of 202.80 to 246.80 mm in one day had caused flooding in the municipality of Kalibo, and 305.30 mm of rain during typhoon Frank had caused severe damage in the low-lying areas of the region. However, rainfall of only 124.6 mm had also inundated some areas of the province. This was due to the incidence of high tide which prevented the river from emptying into the sea. Severe rainfall resulting to flooding in Aklan mostly occurred during the Northeast Monsoon. A weak positive correlation existed between rainfall and height of water at Aklan River as indicated by r^2 value of 0.011. The F-statistic for the overall model has an F-value of 0.12 and p-value of 0.74 which is insignificant. The result suggests that changes in the independent variable (rainfall) are not associated with changes in the dependent variable (water level). Other factors such as frequency of rainfall, rate of evaporation, and other weather parameters have affected the volume of water in the river.

The three sites, Madalag, Banga and Kalibo, had more rain in July and September to November 2012. Banga also had more rain in March. Less rain was observed in April, May and even August. A greater volume of rainfall in 2012-2013 was recorded in Libacao with an average of 295.8 mm, in Banga with 263.0 mm, and in Kalibo with 243.0 mm. Hence, the ten-year rainfall data show that rainy months in Aklan were June and September to December, and rainfall declined from January to May and even August. December and January experienced cooler temperature, while it is warmest in May and June. Aklan has a mean annual rainfall of 3,325.55 mm. Dry spell condition occurred in 2014 from January to June were below to way below normal conditions. This made farmers in rainfed areas start planting rice after July 2014 due to rainfall deficit.

5. RECOMMENDATIONS

Information dissemination for the community/residents should be conducted in order for them to be aware of the identified threshold value of rainfall and temperature that result in flooding to save lives and properties.

To validate the results of this study, historical data on climate parameters such as rainfall, temperature and relative humidity should be taken at different sites for at least five (5) years and correlated with the height of water at specific water gauging stations and Automated Weather Stations (AWS) in the province of Aklan.

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