e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-5 (October 2022)
https://doi.org/10.31033/ijemr.12.5.7

Trends of Rainfall Pattern in the Island Province of Catanduanes, Philippines

Engr. Dexter M. Toyado, MM
Faculty, Department of Civil Engineering, Catanduanes State University, Virac, Catanduanes, PHILIPPINES

Corresponding Author: dtoyado@gmail.com

ABSTRACT

The Island of Catanduanes is located in the eastern most fringe of Luzon considered to be the doorstep of typhoon path. The rainfall in the province is important in producing agricultural food to make life in the province sustainable. Hence, it is necessary to establish how the effect of climate change variable on the availability of water in the island, so that impending extreme drought or flooding will be mitigated. In addition to that, Climate change in the island has an impact on human activity, and a treat from flooding of variable weather pattern like seasonal monsoon rain and inter tropical convergence zone develop near the island.

Using the data from the PAGASA-DOST, Climatology and Agro meteorology Division (CAD) of April 2020, from the Virac Doppler and Radar Weather in Catanduanes. Synoptic data were used to evaluate the rainfall for the last 30 years. The rainfall pattern caused by the southwest monsoon (Habagat) most from June to September gives an average of 73.08mm for 3 decades. Northeast monsoon (Amihan) usually arrives on November and ends on March having an average rainfall of 103.78mm for 3 decades.

It has been shown that the rainfall is increasing every year, the annual rainfall trends will increase of up to 10.76mm in the next 10 years. Studying the rainfall pattern and temperature will give us more precise assessment of the climatic condition in the island and give the community and the government the proper information for mitigating and planning on how we can handle climate change.

Keywords-- Rainfall Pattern, Trends, Forecast, Climate Variability

I. INTRODUCTION

Climate change is the variation of climate over a long period of time. This events is caused by global warming or rise in the air temperature and can cause variation or changes in the earth. One significant effect caused by climate change is the change in rainfall patterns. Previous research has shown that in recent years climate change has resulted in changes in rainfall patterns of different regions [1-4].

The Island of Catanduanes is located in Bicol Region on the eastern most fringe of Luzon. The island is considered to be located at the doorstep of typhoon path. Typhoons are hazard that is threatening the island every year. There is an average of twenty typhoons that enter the Philippine area of responsibility yearly. Many super typhoon already battered the island and caused destruction, casualty, and damage to property. Climate change is likely to worsen the situation with the extreme weather events including typhoons posing various risks and threats to the Philippines. The Philippines is the most exposed country in the world to tropical storms or Bagyo. It also lies in the cross path of Northeast Monson(Amihan) and Southwest Monsoon(Habagat). Another weather systems that affects the country during the mid-year were the North-easterly surface wind flow, ridge of High-Pressure Areas, low pressure areas, Inter-tropical Convergence Zone, and casual typhoon, easterlies and localized thunderstorm.

The rainfall in the province has a significant role to Agroclimate. It is important in producing agricultural food to make life in the province sustainable. Hence, it is necessary to establish how the effect of climate change variable on the availability of water in the island, so that impending extreme drought or flooding will be mitigated. In addition to that, Climate change in the island has an impact on human activity, and a treat from flooding of variable weather pattern like seasonal monsoon rain and inter tropical convergence zone develop near the island.

Based on the Modified Corona's climate classification system, there are four climate types occuring over the Philippines archipelago. Type II is experienced over the eastern coasts of the country that are directly facing the Pacific Ocean this includes the island of Catanduanes Areas. This area experiences no dry season and wet season with a maximum rain period from December to February and minimum rainfall during the period from March to May[5]. There is not a single dry month in these areas. A dry month is defined as a month with less than 50 mm of rainfall. A month with more than 100 mm can still be considered as dry if it is preceded by three or more very dry months. Rainfall in these areas is more or less evenly distributed throughout the year with exception of the occurrences of tropical cyclones in the vicinity, which can cause rainfall abnormalities [6]. Other months are characterized by short periods of dryer days and fine weather except in July and August, when the dry and gusty northwest monsoon winds intensify. Figure 1

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-5 (October 2022)
https://doi.org/10.31033/ijemr.12.5.7

shows the Climate map of the Philippines as categorized by PAGASA-DOST.

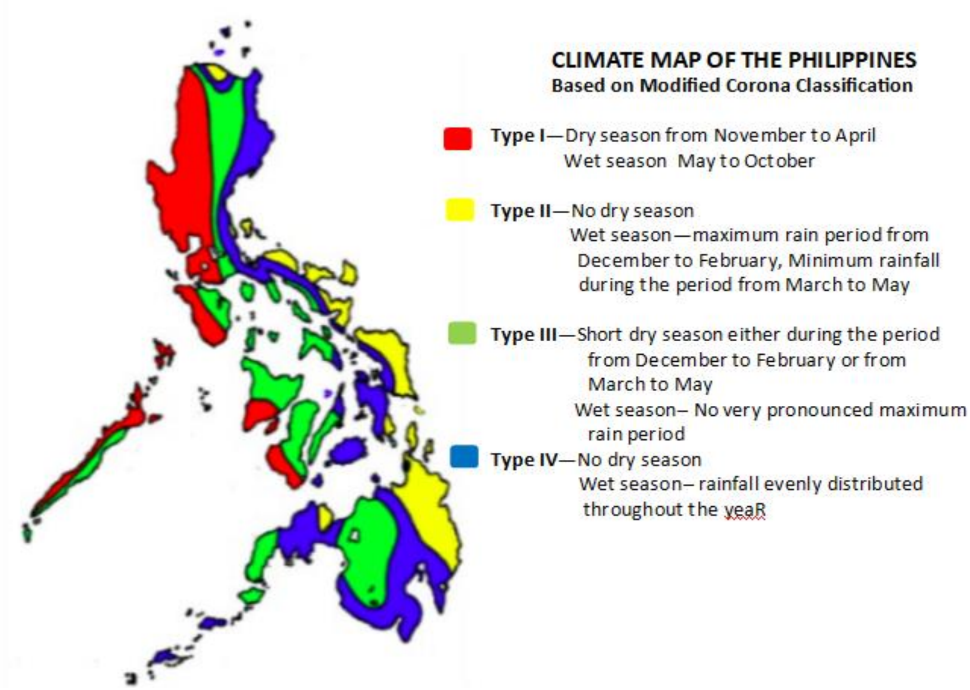


Figure 1: Climate map of the Philippines

Recent studies conducted by the Philippine Atmospheric and Geophysical Sciences Administration (PAGASA) showed that majority of the average rainfall in the country is due to the occurrence of tropical cyclones in the vicinity. The southwest and northeast monsoons are attributed to the combined effects of the Inter Tropical Convergence Zone, shorelines, easterly waves and other rainfall-causing weather patterns. Figure 2 shows the weather disturbance experience in the island of Catanduanes.

Figure 2: Map of Weather Disturbance in Catanduanes

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-5 (October 2022)
https://doi.org/10.31033/ijemr.12.5.7

The island province is found to be most prone to landslides from heavy rains cause by monsoon, ITCZ, and typhoons are within the vicinity of the island. Areas prone to landslides are the hilly portion of the more than 145 kilometers-stretch circumferential road that traverses nearly 70 percent of the province's eleven town [7]. From the report of Mines and Geoscience Bureau, the Flood prone areas in Catanduanes includes flood plain of Virac, Viga, San Andres, and Bato. This is due to the river system that run from the hinterland (center of the island) and down across these area to the shorelines. These areas are flooded when the island experiences higher and abnormal rainfall pattern. Shown below in figure 3 is the flood hazard map of Virac, Catanduanes

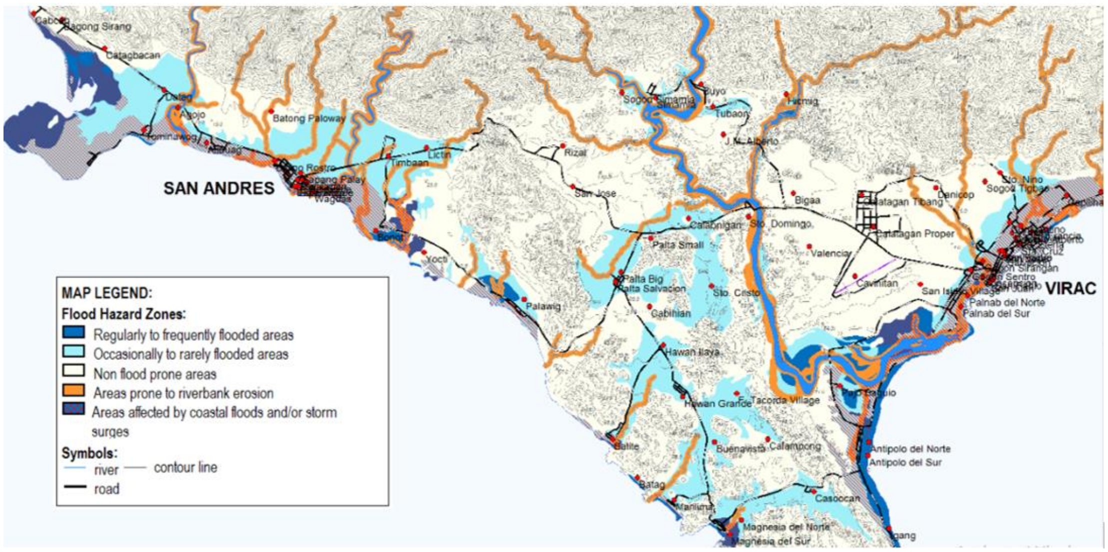


Figure 3: Flood Hazard Map of San Andres and Virac, Catanduanes

This study aims to analyse the variability of monthly and annual rainfall in 1989-2019 or 30 years for the island. The rainfall data used to characterize which rainfall type have most variability due to climate change. This study expected as the reference of detailed rainfall study and basic study of climate change to mitigate flooding and agricultural impact for further research in rainfall and climate change

II. METHODS

2.1 Study Area

Catanduanes is an Island province with a land area of 1,492 square kilometers situated in the easternmost side of the Philippines facing the Pacific Ocean with coordinates of: 13.3 to 14.1 degrees north latitudes and between 124.1 to 124.3 degrees east longitudes. The island bounded on the West by the Maqueda Channel, on the South by Lagonoy Gulf, and on the North and East by the Philippine Sea. Several islands compose the province, but majority of these are physically small to be of relative significance. The island coastlines stretches to almost 400 km are mostly jagged and embayed. The topography is mostly mountainous in the central part of the island with broadly spread growth forests and watershed.

The rainfall in the province has a significant role to Agri-weather. It is important in producing agricultural food to make life in the province sustainable. Hence, it is necessary to establish how the effect of climate change variable on the availability of water in island, to mitigate the impending drought or flooding. Climate change in the island has a big impact on human activity and there is a treat from flooding when variable weather pattern like seasonal monsoon rain and inter tropical convergence zone develop near the island

2.2 Material and Method

Using the data from the PAGASA-DOST, Climatology and Agro meteorology Division (CAD) of April 2020, from the Virac Doppler and Radar Weather in Catanduanes. The weather station is in Bato, Catanduanes and an advanced radar station system that is strategically located go gather digital synoptic data and share it with other agency for data sharing, forecasting and archiving. Synoptic data were used to evaluate the rainfall for the last 30 years [8]. The data is categorized as monthly and annual rainfall data. The annual data was chosen as the variability of annual rainfall while the monthly data depicted how the season and weather changing over the years [4]. The variability for every rainfall type showed which type of rainfall has the most variability during the climate change issue. The data is presented in the monthly

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-5 (October 2022)
https://doi.org/10.31033/ijemr.12.5.7

rainfall data in a year. The data showed the rainfall pattern in a year.

2.3 Analysis

The rainfall variability is calculated with statistical method and tools to analyse rainfall variability. The basic statistical analysis used in this study is measure of central tendencies (mean and mediation), measure the dispersion (standard deviation), and coefficient of variation (CV). The use of software was introduced for forecasting analysis. The rainfall trend was also analyse using forecasting in the next 10 years [9]. The Virac Doppler and Radar station is located at 13.5 degrees North and 124.4 degrees East and the radars provides observations of weather system coming both the West Philippine Sea and the Pacific such as rain systems associated with Southwest Monsoon and Northeast Monsoon, tail end of cold front, sea breezes, easterly waves, inter tropical convergence zone and tropical storms [10]. Data recorded from this station is from 1960-2018. However, this study utilizes only the last 30 years since some of the data in the 1970's and 1980's are incomplete.

III. RESULTS

3.1 Rainfall Pattern

The rainfall type is characterized by the monthly rainfall pattern of the peak rainfall. Monsoon widely affects the amount of rainfall in the island. This is caused by the Major wind system that seasonally reverses its direction. This was also caused of the difference between annual temperature trends over the land and sea. The winds blow from cold towards warm regions, then from the sea towards the land (southwest of the Philippines) during summer in Northern hemisphere and to the land towards the sea (northeast) during winter in the northern hemisphere. The rainfall pattern caused by the southwest monsoon (Habagat) most from June to September gives an average of 73.08mm for 3 decades. Northeast monsoon (Amihan) usually arrives on November and ends on March having an average rainfall of 103.78mm for 3 decades. There is an increasing average of 6.36mm increase every decade starting 1989-1998 or around 8.3% for southwest monsoon (Habagat). The Northeast monsoon (Amihan) rainfall pattern is fluctuating with a spike during the 2nd decade (1997-2008), but an average of 13.35mm increase in the past 3 decades, and an increase of 11.05%.Figure 4 below shows the monthly rainfall data of the island of Catanduanes.

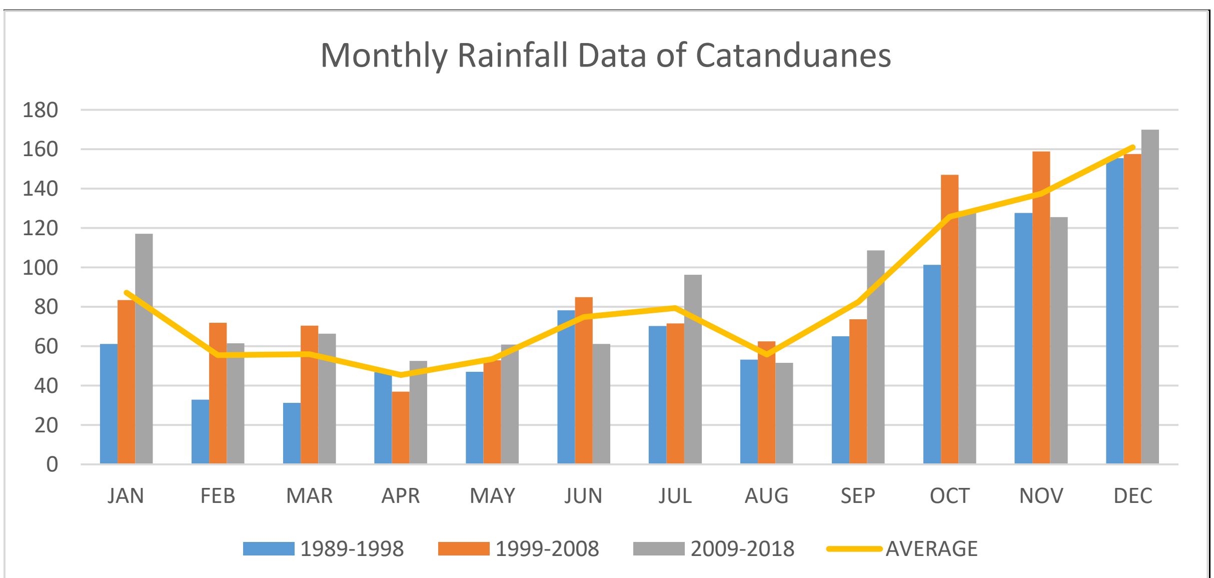


Figure 4: Monthly Annual Rainfall

Annual rainfall data from 1998-2018 years shows the fluctuation data with no certain pattern (Figure 5). In general, from the individual year looks like there are increasing and decreasing pattern of annual in one cycle occurred in 6 years. The effect of La Nina as defined by the Australian Bureau of Meteorology [11] and study of Hilario, et.al [12] was reflected on the rainfall activities in the island. For La Nina event of the year 1988-1999, 1995-1996, and 1998-2000 is shown as the fluctuation in the recorded rainfall pattern. Also, the ElNino phenomenon defined also by Wrigth[11] have been evident in the

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-5 (October 2022)
https://doi.org/10.31033/ijemr.12.5.7

rainfall pattern, El Nino in the years, 1991, 1997, and 2003.

This El Nino events was based on the National Oceanic and Atmospheric Administration's classification (www.cpc.noaa.gov), many of which have brought adverse socioeconomic impacts in the Philippines. According to Hilario et.al [12], the worst El Niño in 1982–1983 event caused an estimated 13 billion dollars in global damages, with the Philippines suffering an estimated 450 million dollars. Further, the 1997–1998 El Niño was the strongest El Niño of the century, surpassing the intensity of the 1982–1983 event [13][14]. The figure below shows Annual Average rainfall for the last 3 decades.

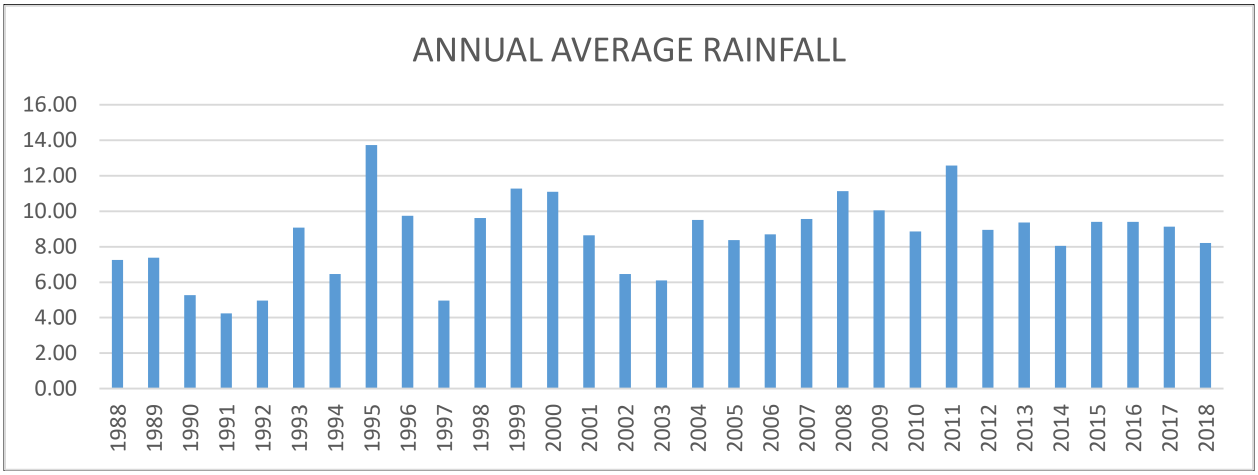


Figure 5: Annual Average Rainfall of Catanduanes

3.2 Rainfall Variability

The result of the basic statistical analysis for the parameters of the annual rainfall is presented in table below. The standard deviation shows the heterogeneity of data compared to mean. The coefficient of variation shows the similar value for rainfall which has small variability during southwest monsoon (Habagat) most from June to September. Higher variability during the northeast monsoon (Amihan) that is an indication of bigger annual rainfall fluctuation as shown in figure 6.

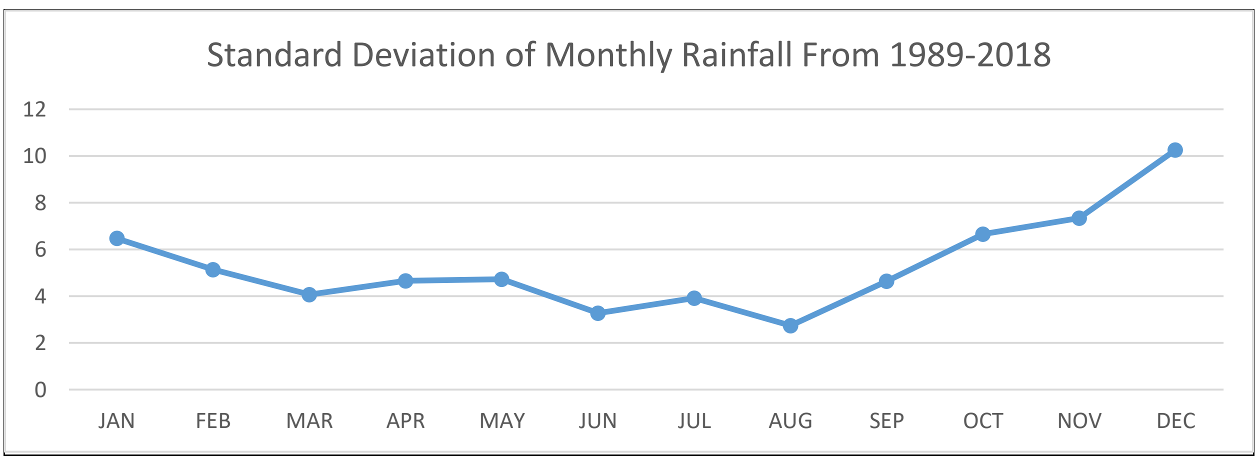


Figure 6: Standard Deviation of Monthly Rainfall from 1989-2018

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-5 (October 2022)
https://doi.org/10.31033/ijemr.12.5.7

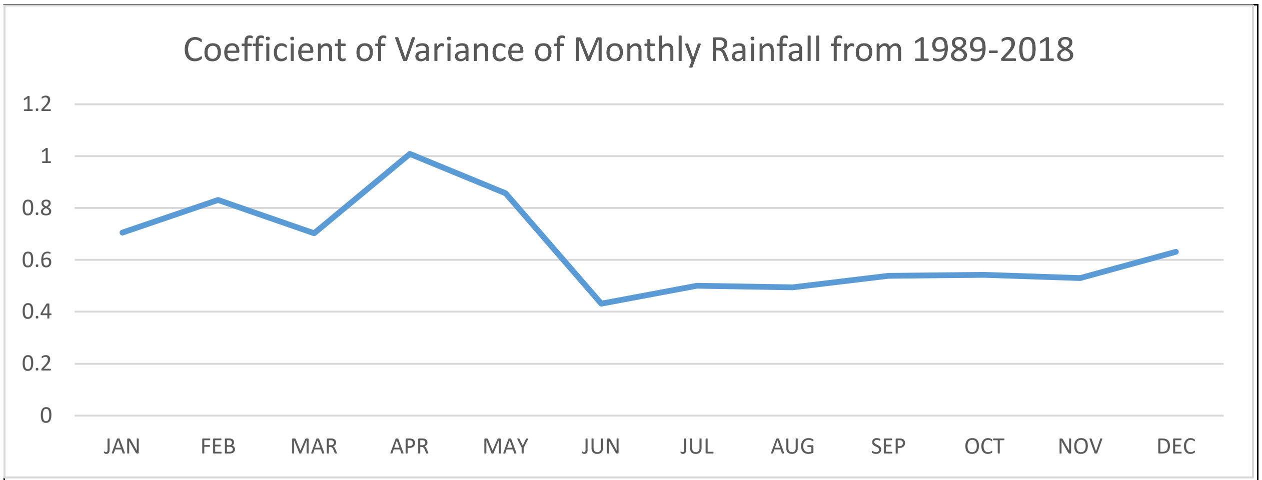


Figure 7: Coefficient of Variance of Monthly Rainfall from 1989-2018

3.3 Rainfall Trend

The trend analysis for the data uses monthly rainfall data. The following parameter for statistic introduces the stationary R square, R square and Root Mean Square was used as fit measure, goodness of fit for comparing model, stationary R square for comparing plots, and using the methods of Autoregressive Integrated Moving Average models, a forecasting technique that projects the future values of a series based entirely on its own inertia. The results are; for Stationary R-squared is Mean= 0.03, Standard Deviation = 0.031, N=2. Sequence plot as shown in Figure 8 and Table 1 below shows the result of Model Fit Summary.

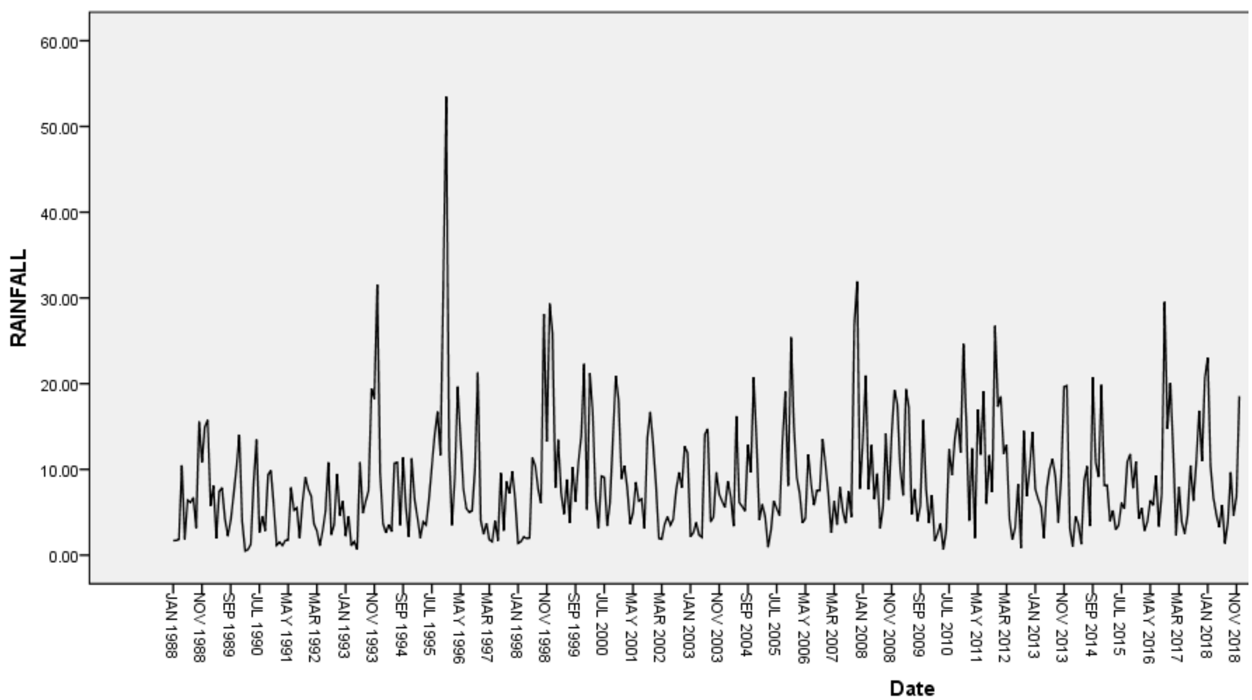


Figure 8: Sequence plot of monthly rainfall pattern

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-5 (October 2022)
https://doi.org/10.31033/ijemr.12.5.7

Model Fit

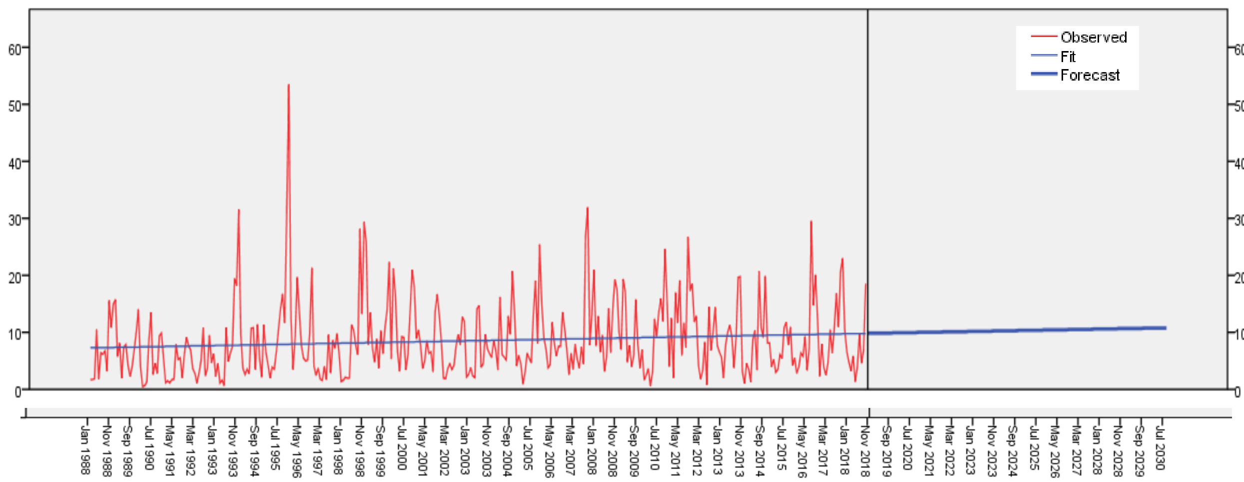
Fit Statistic	Mean	SE	Min	Max	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.034	.031	.013	.056	.013	.013	.013	.034	.056	.056	.056
R-squared	.034	.031	.013	.056	.013	.013	.013	.034	.056	.056	.056
RMSE	3.768	3.929	.990	6.547	.990	.990	.990	3.768	6.547	6.547	6.547

Model	Model Fit statistics		
	Stationary R-squared	R-squared	RMSE
RAINFALL	.013	.013	6.547

Table 1: Statistical Model Fit Summary for analysis

Model Forecast from January 2019-December 2030

For each model, forecast starts after the last non-missing in the range of the estimation period, and end at the date of the forecast period. Figure 9 shows the forecast for the next 10 years.



The trend equation is y = 0.0068x + 9.8138 and R^2 = 0.9931. The annual forecast rainfall in the next 10 years will reach approximately an additional of 10.76mm. This means that more rainfall will be expected in the island. This has also something to do with rising temperature that globally affects the rainfall pattern in the island. The higher amount of rainfall is beneficial for agriculture but could also have increase the risk of flooding. Since the island is prone to landslide because of its soil composition [7] and more rain will mean more saturation of water and that potentially trigger more landslide. Table 2 shoes the predicted annual rain forecast in the next 10 years with an average upper confidence level of 23.18 and lower confidence level of -2.57.

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast (mm)	9.85	9.94	10.02	10.10	10.18	10.27	10.35	10.43	10.51	10.59	10.68	10.76

Table 2: Annual Rainfall Forecast model (2020-2030)

IV. CONCLUSION

In this paper, it has been shown that the rainfall is increasing every year, the annual rainfall trends will increase of up to 10.76mm in the next 10 years. Studying the rainfall pattern and temperature will give us more precise assessment of the climatic condition in the island. The Island also highly influenced by the El Niño Southern Oscillation (ENSO). This higher increase in rainfall pattern is associated with an increased chance of wetter conditions or La Niña. The effect of ENSO, and other weather and climatic disturbance must be monitor and evaluated for a

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-5 (October 2022)
https://doi.org/10.31033/ijemr.12.5.7

more usable data of predicting the climate change and give the community and the government the proper information for mitigating and planning on how we can handle climate change.

ACKNOWLEDGEMENT

The authors gratefully acknowledges the Climatology and Agro meteorology Division (CAD) of the Philippine Atmospheric, Geophysical and Astronomical Services Administrations under the Department of Science and Technology for providing valuable data relevant to the study. Also the Catanduanes State University for the support that made this study possible.

REFERENCES

[1] Sipayung SB, Nurlatifah, Siswanto B & Slamet S. (2018). Analysis of climate change impact on rainfall pattern of Sambas district, West Kalimantan. *IOP Conf. Series: Earth and Environmental Science 149*(2018), 012029. DOI: 10.1088/1755-1315/149/1/012029.

[2] Storch H V, Zorita E & Cusbasch U. (1993). Downscaling of global climate change estimates to regional scales: an application to Iberian rainfall in wintertime. *Journal of Climate 61*, 161–1171.

[3] Trenberth K E. (1998). *Atmospheric moisture residence times and cycling: Implications for rainfall rates and climate change*. Berlin: Springer.

[4] Williams S E, Bolitho E E & Fox S. (2003). *Climate change in Australian tropical rainforests: An impending environmental catastrophes*. Royal Society Publishing.

[5] Weather Philippines. (2018). *Modified corona classification in the Philippines*. Available at: https://lcp.org.ph/UserFiles/League_of_Cities/file/WPF-Weather101-updated.pdf.

[6] DOST-PAGASA. (2020). Climate change scenarios. www1.pagasa.dost.gov.ph›index.php›27-climatology. Retrieved on: June 20, 2020.

[7] Toyado DM. (2012). Slope stability analysis for remediation project along the catanduanes circumferential road network system. *Electronic Journal of Geotechnical Engineering, 17*.

[8] DOST-PAGASA. (2020). *Climatology and Agro meteorology Division (CAD) data of climate for Virac, Catanduanes*.

[9] *SPSS 15.0 Command Syntax Reference. Chicago, Illinois: SPSS Inc. 2006*.

[10] DOST-PAGASA. *Weather and Climatic Condition, https://www1.pagasa.dost.gov.ph/index.php/54-northern-luzon#radar-station.*

[11] Wright, W.J. (2001). A review of Australian climate in the 20th century [online]. Preprints, CLI–MANAGE 2000. In: *Conference on Managing Australian Climate Variability, Albury, NSW, Australia, Bureau of Meteorology, pp. 127–130*. Available at: http://www.bom.gov.au/climate/enso/australia_detail.shtml

[12] Hilario, Flaviana, Guzman, R., Ortega, D., Hayman, Peter & Alexander, Bronya. (2009). El Niño Southern Oscillation in the Philippines: Impacts, forecasts, and risk management. *Philipp. J. Dev., 36*, 9-34.

[13] World Meteorological Organisation (WMO). (1998). *WMO statement on the status of the global climate in 1997. WMO No. 877(10)*. Geneva: World Meteorological Organisation.

[14] Changnon, S.A. & G.D. Bell, Editors. (2000). *El Niño 1997–1998: The climate event of the century*. United States: Oxford University Press.