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RAINFALL-RUNOFF MODELING OF TUMAGA RIVER USING ARTIFICIAL NEURAL NETWORK

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Artificial Neural Network, Discharge Modeling, Rainfall, Runoff, Tumaga River, Zamboanga City

ABSTRACT
Artificial Neural Network is used in predicting the amount of rainfall-runoff that will predict the future amount of discharges in Tumaga River, Zamboaga City, Philippines. The study used five (5) meteorological parameters for the model - rainfall, humidity, maximum temperature, minimum temperature and average temperature. Actual river discharge data were also gathered that is part of the output data in the model. These parameters were gathered from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA) and were used as the input parameters in the MatLab. The study produces a model that has good correlation coefficient and the trend graph is similar to that of the data gathered from PAG-ASA and the predicted values. The findings concluded that the generated model could be utilized for predicting river discharges.

INTRODUCTION

Tumaga River is one of the main sources of water of Zamboanga City, Philippines. The river supplies 90 million litres of water every day to supply the commercial business in the city, domestic use and agriculture. The river is categorized as Water Quality Management Area under Department of Agriculture (DAO) No. 2013 – 01 [1]. It is a water path, which provides the 105.6 kilometer square Pasonanca Watershed. It ensues along the north-west direction and empties into the Arena Blanco with a river flow of 6,126 litres per seconds. It is 12.8 kilometres in length and 0.03 kilometres in width from the upper side. The river water way intersects in straight paths which lead from the most populated areas in Zamboanga City, Philippines namely: Sta. Maria, Guiwan, and Tetuan [2]. The study purposely chose Tumaga River in Zamboanga City as the area of the study because of its lack of discharge data that can be utilized by Zamboanga City Water District (ZCWD).

Another river in Zamboanga City monitored by DPWH is the Mercedes River. The DPWH has accumulated discharge data for 17 years but it is insufficient, since some data are missing. In relevance to this study, the model derived from this research could be useful in filling the missing and needed data. The input parameters required are relative humidity, maximum temperature, minimum temperature, average temperature, rainfall data and actual river discharge. These are the parameters needed to produce a model that can predict discharge data [3]. The model was derived to build a relationship between the given parameters and existing discharge data. The output model can also be used to predict the discharge data that did not yet exist, or was yet to be determined [4]. The minimum number of years that is required to derive an accurate model is one (1) year along with four (4) parameters. As the number of years increase, the number of parameters will increase as well. With this in consideration, the model that could be derived would simulate accurate results. In order to test the accuracy of the parameters, 15% of the data had been used for testing [5].

Artificial Neural Networks develops algorithms that are possible to be used for modelling non-linear web, and predict problems by utilizing the brain as a basis [6]. After learning from the initial inputs and their relationships, it has the ability to determine the unseen relationships on unseen data as well, thus making the model organized and able to predict unforeseen data. It then processes the given input or information to produce satisfactory results [7].

The findings will impart in the field of engineering by being able to predict the discharge of Tumaga River. The data produced in this study could be used by the government and non-government agencies who want to determine the discharge data of Tumaga River that can be utilized in its water management.

MATERIALS AND METHODS

The daily precipitation was utilized in the ANN, which was compiled from the ZCWD. The data period was of one (1) year; however, the researchers took the data of 2014 with the end goal to calibrate each year. The data that the researchers utilized were the daily maximum and minimum temperature, daily humidity and daily rainfall. These were gathered from PAGASA, under Science Garden station and ZCWD.

Figure 1 shows the ANN process that has three layers – input, hidden layer and output. First was the information layer where the data gathered are encoded - relative humidity, maximum temperature, minimum temperature, average temperature, and rainfall data. The second layer was known as the hidden layer performed by the software MatLab to simulate the most ideal result. Lastly, the output layer contained the most ideal result from the hidden layer. MATLab is a multi-paradigm numerical processing environment and fourth-age programming language which is equipped for production of user interface.

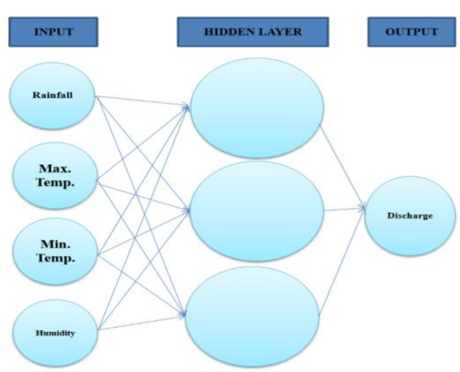

Figure 1. The ANN Connections of Nodes

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RESULT AND DISCUSSION

The graphs show the values of the parameters that served as the input data in training the Rainfall-Runoff model using Artificial Neural Network via MatLab software. The target data that was used in this study are from Zamboanga City Water District (ZCWD). These are the data that were set by the researchers as default data.

Figure 2 presents the rainfall data for the year 2014 in the study area. The data records a minimum value of Rainfall as 0 while the maximum value is 96 mm recorded on the month of March 2014, and records an average rainfall of 2.9 mm for the whole year of 2014.

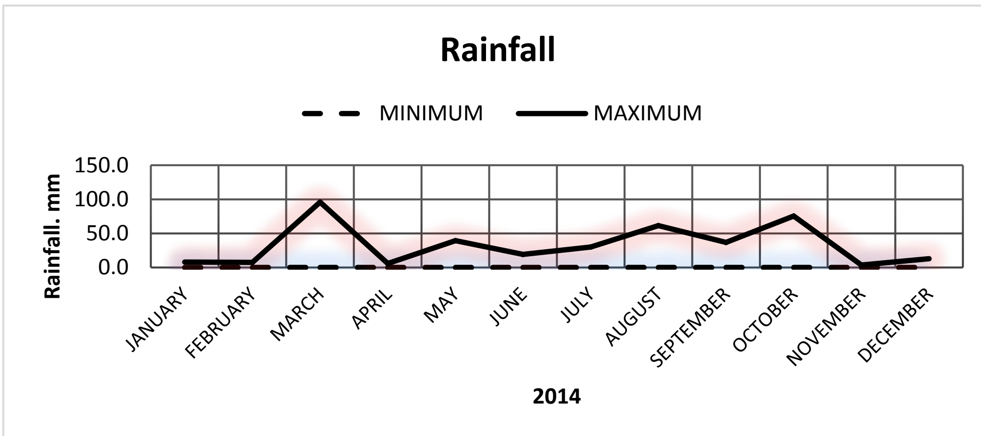
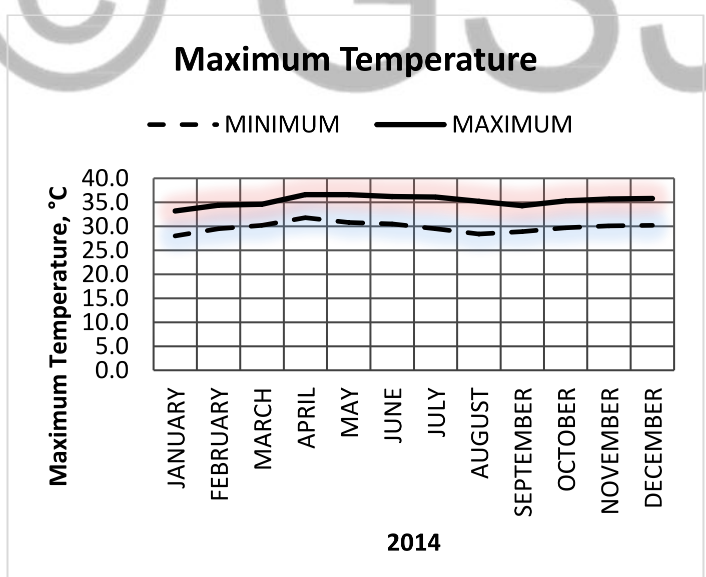


Figure 2. Rainfall Data

Figure 3 shows the maximum monthly temperature records for the year 2014. The data reveals that among the maximum records, the minimum temperature is 28° in the month of January, while the maximum temperature is 36.6° in the month of April and May, while the average temperature is 33.2° for the whole year of 2014.



.Figure 3. Maximum Temperature

Figure 4 shows the minimum monthly temperature records for the year 2014. Based on the minimum records, the maximum temperature is 26.6° in the month of March and April, while the minimum temperature is 19.5° in the month of February, while the average is 24.2° for the whole year 2014.

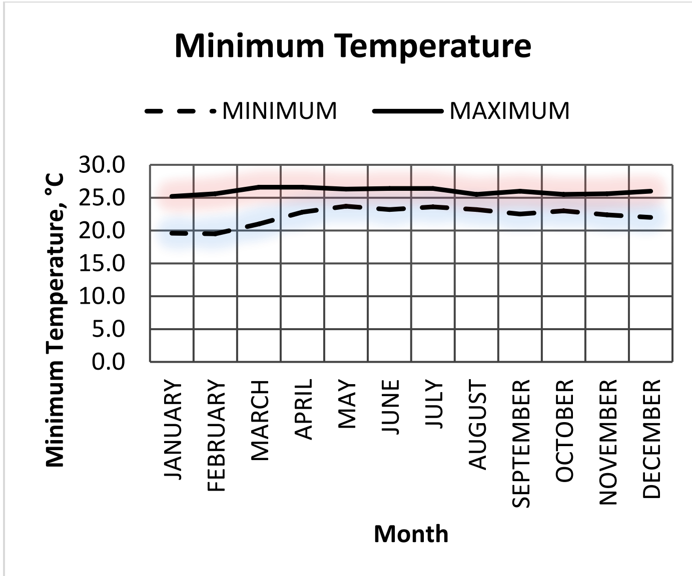


Figure 4 Minimum Temperature

Figure 5 presents the relative humidity in the study area. The maximum relative humidity is 94.1% recorded in the month of January and December, while the minimum relative humidity is 68.1% in the month of March, while the average is 81.3% for the whole year of 2014.

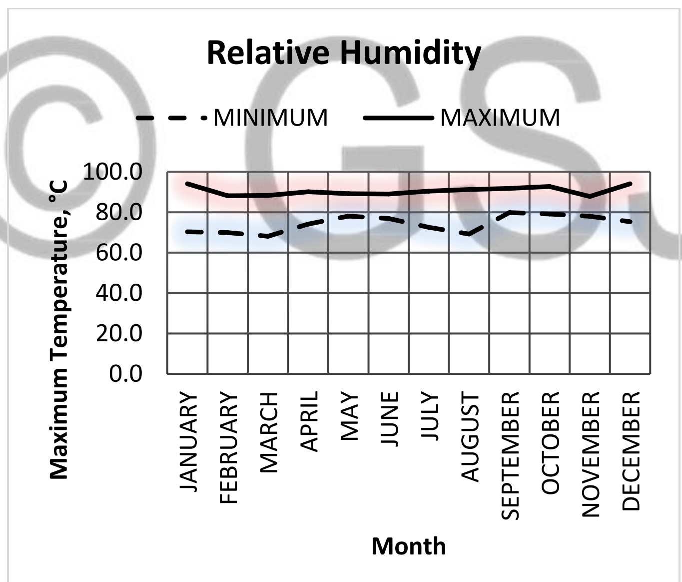


Figure 5 Relative Humidity

Figure 6 reveals that the maximum discharge recorded is 18.7 cms in the month of October, while the minimum discharge is 1.13 cms in the month of March, and the average is 3.5 cms for the whole year of 2014.

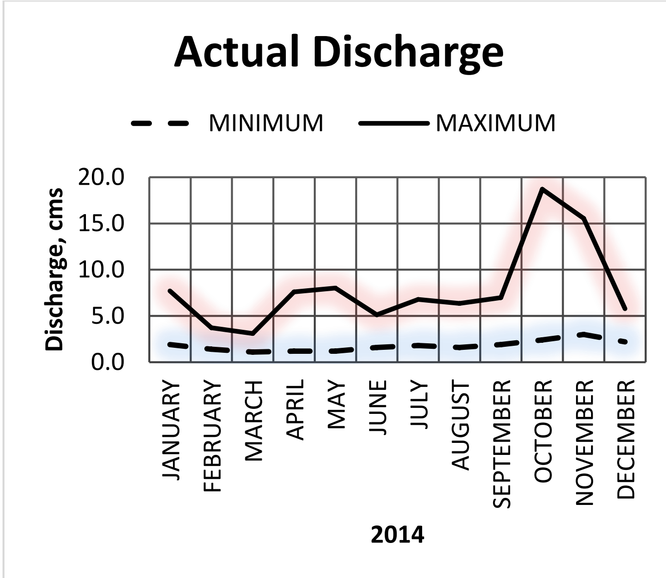


Figure 6. Actual Discharge

Mean Squared Error (MSE)

The Mean Squared Error was used in order to determine the accuracy of the model that was trained. Figure 7 shows the best Mean Squared Error (MSE). The best Validation Performance is 4.1777 at epoch 30. The figure also reveals that the trend lines of the Train, Validation and Test are almost similar which can be interpreted as good model.

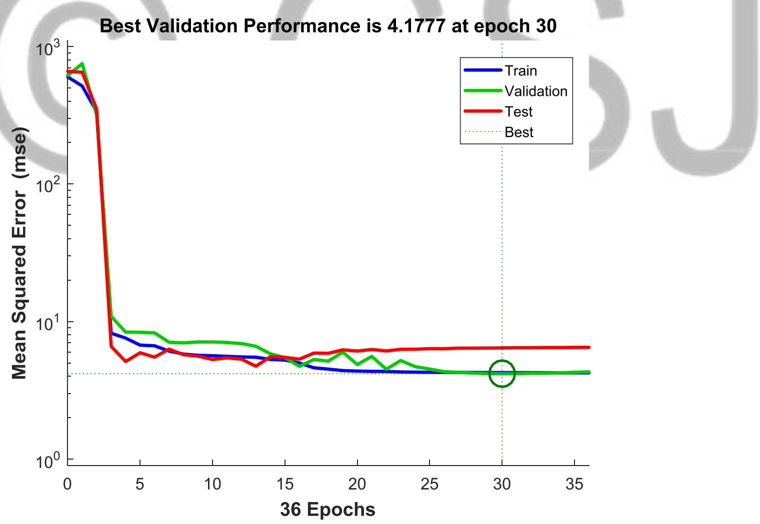


Figure 7. Mean Squared Error

Regression Analysis

Regression analysis allows examining the relationship of two or more variables of interest. The Regression “R” depends on the training of the model and is capable of producing accurate results. As shown in Figure 8, the Regression “R” after training using 6 nodes, the model were able to get a value of 0.66077. Despite the low value, the model can be considered satisfactory since the trend lines in the Mean Squared Error are almost similar for the train, validation and test, and further, it is shown in Figure 9 that is was able to produce computed discharge that are similar to the actual discharge data.

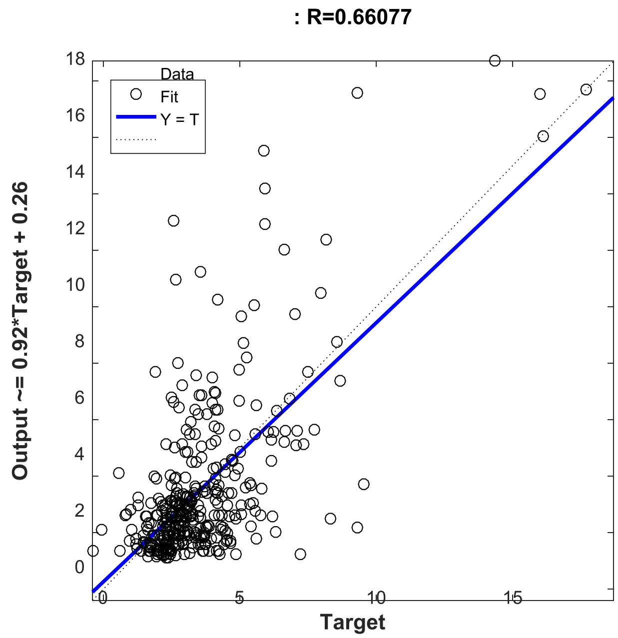


Figure 8. Regression Analysis

Actual Discharge and Computed Discharge

Figure 9 is a graph shows to compare the calculated discharge to the actual discharge. It reveals that some of the values almost reached the actual discharge and shows a similar trend. This can be implied that the model produced is satisfactory that can be utilized in predicting discharge.

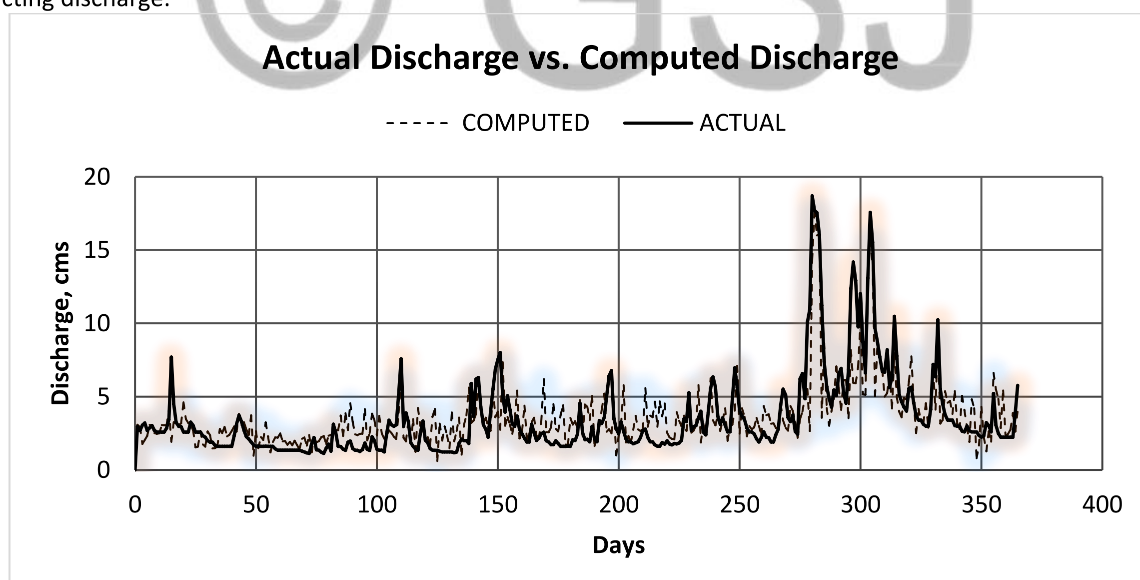


Figure 9. Actual Discharge vs Computed Discharge

Conclusion

Based on the produced model, the results were classified as very good as it follows the trend line of the actual discharge data. The computed discharge has an average of 43.185% percent error. The calibrated model can also be used to predict future discaharge data.

Based on the sensitivity analysis, the findings show that the Rainfall and Relative Humidity presents an increasing trend while the Maximum and Minimum temperature shows a decreasing manner.

The researchers recommend gathering more meteorological parameters from at least two (2) rainfall stations for a more comprehensive analysis.

Acknowledgment

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