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Study on Mathematical Models of Climate Change Related to Temperature and Evaporation in Taungoo

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Abstract:
Most of the country in the world have been facing climate change problem. Among them, Myanmar is one of the most suffering country from climate change problem. This problem is caused by many reasons such as forest destroying, transportation systems, urban planning and so on. Therefore, the aim of this research is the study of long term behavior of temperature and evaporation changes in Taungoo Township, Myanmar. The different regression models are developed and analyzed using average temperature and evaporation during 1982 – 2010. The temperature and evaporation can be presented by exponential and logistic regression analysis. The regression models are analyzed by using SPSS Statistics Software. The regression models are helpful tools for agricultural sectors and government authorities to consider for growing up the crops and for awareness of global warming.

Keywords —**Temperature, Evaporation, Taungoo, Exponential regression, Logistic regression**

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INTRODUCTION
Climate change is a major concern affecting all organisms. Over the past 30 years, global surface temperature has been rising approximately 0.2◦C per decade [1]. Severe weather conditions such as draught and flood have been known to result from high global temperature. Today, forest cover has decreased from the past due to timber demands for building and manufacturing and to land usage for agriculture. The phenomenon has played an important role on the behavior of rainfall in different areas of the world; it is also a major cause of extreme weathers in many regions of the world. Changes in global temperature, therefore, lead to variations in the amount of rainfall in different areas of the world, an amount which depends on the level of forest transpiration [2].

Many mathematical models in ecology have been developed to describe the relationship between climate change and extreme weathers. There is also a study to control the amount of pollution in the environment in order to restrain the global carrying capacity of population [3]. The global temperature is caused to reduce fresh water and other water resources and to increase evaporation rate. Water is an essential part of mankind's life and many processes have been constructed for the purpose of producing potable water. Rapid population growth, use of water for agricultural irrigation, and pollution of water resources have caused researchers to continually seek effective processes to address freshwater scarcity.

Fig. 1 The location map of Taungoo Township near Sittaung River (Source: Google Earth)

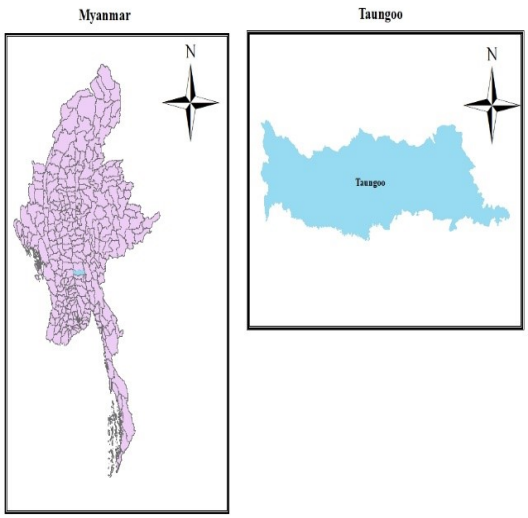

Fig. 2 Location map of Taungoo Township in Myanmar

The researcher have been selected the study area as Toungoo because it is still framed by its old moat. From the 16th to 18th centuries, Taungoo was once the capital of a huge empire although the city walls are long gone and some of the moat is now silted up with no water left. Three mountain ranges traverse it such as the Pegu Yomas, the Poung-loung, and the Nat-toung or "Great Watershed" and are covered for the most part with dense forest. Therefore, the predicted evaporation equation is needed to predict the essential tool for the living population in it.

II. METHODOLOGY

Evaporation and temperature changes data during 1982 to 2010 in Toungoo Township were obtained from Meteorological Department. Average evaporation and average temperature changes were used to analyze the regression models for the prediction of evaporation rate in that region. The regression models are got from obtaining from the SPSS Statistics Software. This software is a simplified statistical tool for the tasks of regression analysis and curve estimation and so on. The best fit model using regression analysis in this software provides the ranking goodness of the fit. The models are derived from the analyzing curve estimation models.

Exponential. Model whose equation is [4, 5]:

$$y = b_0 * (\exp(b_1 * t)) \text{ or}$$

$$\ln(y) = \ln(b_0) + (b_1 * t). \quad (1)$$

Logistic. Model whose equation is [4, 5]:

$$y = 1 / (1/u + (b_0 * (b_1 * t))) \text{ or}$$

$$\ln(1/y-1/u) = \ln(b_0) + (\ln(b_1) * t) \quad (2)$$

where,

y = the dependent variable,
t = the independent variable
b_0 = constant
b_1 = model intercepts in the regression coefficient.

In this research, y is the average evaporation and t is the average temperature. Moreover, the data is transformed as the regression equations form to analyze the relationship between temperature and evaporation rate. The data during 1982 to 2010 obtained from the Meteorological Department are shown in Fig. 1. The minimum temperature is 24.5 and the maximum temperature is 28.01 during 1982 to 2010 in Taungoo Township. In this figure, the trend is demonstrated to the relation between the evaporation and temperature changes.

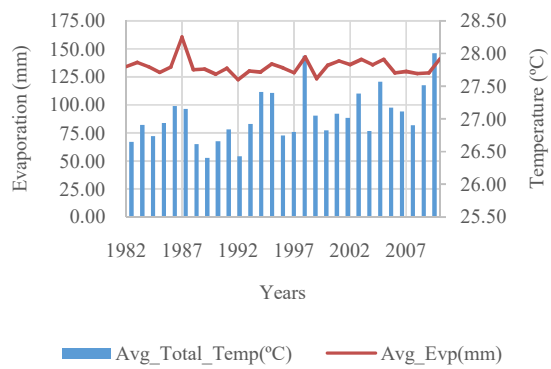

Fig. 3 Diagram of average total temperature and average evaporation in Toungoo Township

III. RESULT AND DISCUSSION

The summary of the descriptive statistics of the evaporation and temperature data is demonstrated in Table I. In this table it is revealed that the mean annual evaporation of the Taungoo Township is 1606.47 mm and median is 1596.1 mm. This indicates that the annual evaporation values are right skewed. The high standard deviation value are correlated with the high range (456 mm) of the annual evaporation values.

The range is the distinct between the maximum and minimum annual evaporation values. The standard deviation and the rate indicates the variability of the annual evaporation rate and it denotes as the reliability of the evaporation in

terms of its persistence as a constant and stable replenishing source. The p-value is less than 0.05 determining that the data is non-normal.

Therefore, the annual evaporation data is needed to test normal distribution, the skewness and kurtosis computed. Positive value of the skewness indicates that right skewness and positive value of the kurtosis is peaked distribution shown in Table I.

Table I. Summary of Descriptive Statistics

Descriptive Statistics	
Mean	1606.47
Standard Error	16.22
Median	1596.10
Mode	0.00
Standard Deviation	87.32
Sample Variance	7625.47
Kurtosis	5.42
Skewness	1.68
Range	456.00
Minimum	1470.40
Maximum	1926.40
Sum	46587.50
Count	29.00

The evaporation and temperature data are calculated by using the regression analyses in this research. Firstly, the prediction of average evaporation rate is investigated by analyzing the curve estimation models. In this curve estimation models, there are eleven models. Among then, there are two regression models in it because other regression models are not suitable for these data. The regression models are exponential and logistic analyses. In exponential regression, the coefficient of determination (R^2) is 0.27 and the significant error is not greater than 0.05 so that the model is good fit. The model intercepts are α and β in the exponential equation. The parameter calculated for the non-linear equation is shown in Table IV. The values of b_0 and b_1 are 3.5 and 0.51 in this model. The evaporation is directly proportional to the temperature change in this equation. Evaporation rates are higher at temperatures because as temperature increases. The prediction equation is expressed as follows in equation 1:

Avg_Evp = 33.5 exp (0.51 x Avg_Temp)

The Fig. 4 shows the trend between the observed and predicted average evaporation. In this figure, the trend is demonstrated relation between temperature and evaporation. In this analysis, the maximum temperature 28.01 is the hottest temperature and the evaporation (mm) 141 mm is highest data in 2010. Therefore, the temperature and evaporation is related each other according to the result data for exponential regression analysis. The evaporation rate is directly proportion to the temperature because the interception value of temperature is positive slope.

Table II. Model Summary for Exponential Regression

R	R Square	Adjusted R Square	Standard Error of the Estimate
.519	.270	.242	.035

Table III. Analysis of Variance for Exponential Regression

	Sum of Squares	Degree of freedom	Mean Square	F	Significant Error
Regression	.011	1		9.603	.005
Residual	.031	26	.001		
Total	.042	27			

Table IV. Coefficient of Exponential Regression

	Unstandardized Coefficients		t	Significant Error
	B	Standard Error		
Avg_Temp	.051	.016	3.099	.005
(Constant)	33.500	14.891	2.250	.033

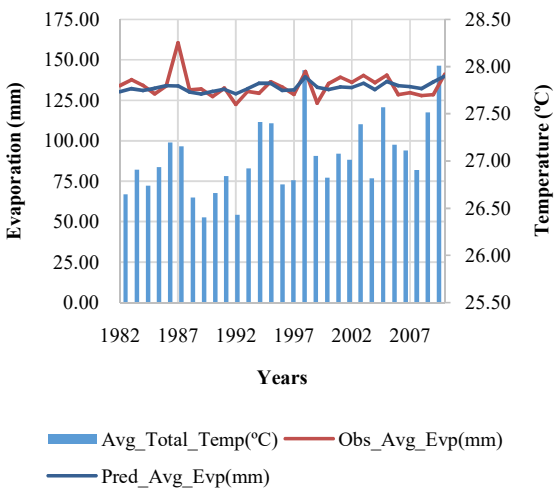

Fig. 4 Diagram of observed and predicted average evaporation by using Exponential Regression Analysis

In logistics regression analysis, the coefficient of determination (R^2) is 0.27 and significant error is less than 5% shown in Table V. Therefore, the model is good fit and is suitable to use the prediction equation. In this analysis, the average evaporation is directly proportional to the average temperature. In Table VI, the prediction equation is expressed as follow in equation 2:

$$\ln(1/\text{Avg\_Evp}) = 0.03 + 0.95\,(\text{Avg\_Temp})$$

The trend between the observed and predicted average evaporation is shown in Fig. 4. In this figure, the trend is revealed that it is related between temperature and evaporation. The interception value of temperature is positive slope so that the evaporation is directly proportional to the temperature changes.

Table V. Model Summary for Logistic Regression

R	R Square	Adjusted R Square	Standard Error of the Estimate
.519	.270	.242	.035

Table VI. Analysis of Variance for Logistic Regression

	Sum of Squares	Degree of Freedom	Mean Square	F	Significant Error
Regression	.011	1	.011	9.603	.005
Residual	.031	26	.001		
Total	.042	27			

Table VII. Coefficients for Logistic Regression

	Unstandardized Coefficients		t	Significant Error
	B	Standard Error		
Avg Total Temp	.950	.016	.595	60.833
(Constant)	.030	.013		2.250

These diagrams of the observed and predicted average evaporation are described in Figs. 4 and 5. In these figures, the observed values are a little different from the predicted values. These differences are not made to be a problem according to the result of the analyses. In this analysis, the maximum temperature is 28.01 and the maximum evaporation is 140.2 mm in 2010. Therefore, the temperature and evaporation is directly proportional to each other corresponding to the result data for logistics regression analysis. These model are to predict evaporation conditions related to the minimum and maximum temperature changes.

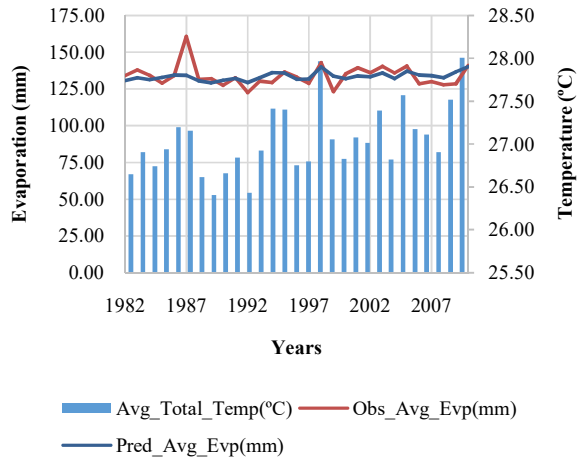

Fig. 5 Diagram of observed and predicted average evaporation by using Logistics Regression Analysis

IV. CONCLUSIONS

The study was to aim the forecasting of the evaporation rate concerning the describing data in Taungoo Township. By analyzing the describing data, the exponential and logistic regression were the good models to study evaporation conditions. These regression models were assumed to foresee the evaporation conditions concerning temperature change for severe weather. According to the results, the temperature change was directly proportional to the evaporation rate in Taungoo Township because the interception value of the temperature changes was to have positive slope. In this future study, it will be collected many temperature data from the last decades to nowadays and then the well-predicted equation will be determined. The predicted useful equation was given climate awareness for the agricultural fields in order to cause temperature changes. Therefore, these equations was the best issues for many sectors and helpful to rescue living organisms.

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