STATISTICAL ANALYSIS TO FIND THE ASSOSIATIONS OF DAILY FLOWS AT ELLAGAWA WITH RAINFALL AND TEMPERATURE

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ABSTRACT: Kalu ganga is one of the main rivers use for water supply in Sri Lanka. There are many agricultural areas and plantations around Kalu ganga bellow the Ellagawa catchment. Studying the relationship of flows of Kalu ganga at Ellagawa catchment with the rainfall and the temperature is very important. Objective of this study was to find the associations of rainfall and temperature with the flows of Kalu ganga at Ellagawa. The data was collected on over the period of January 2001 to December 2006. Daily flow in m^3/s at the Ellagawa gauging station was obtained from the Hydrology Division of Irrigation Department. Daily rainfall in mm in the selected eleven rainfall stations within the catchment area (Galathura, Wellandura, Eheliyagoda, Keragala, Balangoda, Alupola, Hapugastenna, Rathnapura, Landsdown, Halwathura and Deepedena) and Maximum daily temperature in centigrade at the Rathnapura Meteorology station was obtained from the Department of Meteorology. Regression analysis was used in the analysis. **Natural logarithm of flow (Ln-Flow)** was used in model building instead of flow. Average Ln-Flow per day for each month in every year at Ellagawa was the response variable(Y). Thiessen Polygon Technique was used to find the **average rainfall (Av-Rf)** of the Ellagawa catchment. Average Av-Rf per day of the Ellagawa catchment(X1) and average maximum daily temperature at Rathnapura per day(X2) for relevant month in relevant year were the predictors. The fitted model is Y = 6.49 + 0.0805 X1 - 0.115 X2 (R-Sq = 85.4%, PRESS = 2.42829, tolerance > 0.9). According to the fitted model the Response Y is collectively associated with the predictors X1(p=0.00) and X2 (p=0.00). The ratio (Daily Flow / Fitted Daily Flow) for the period of January 2001 to December 2006 was estimated and results indicate that the model is fairly good for predict the daily data.

Keywords : Kalu ganga, Natural logarithm of flow, average rainfall, maximum daily temperature

1. INTRODUCTION

Kalu Ganga is the second largest river in Sri Lanka in terms of annual volume of runoff to the sea. Being situated entirely in the wet zone of Sri Lanka, it has a high rainfall to runoff response. The water recourse management is very important for agriculture, water supply for day to day work, Industry, etc.. Kalu ganga is one of the main rivers use for water supply in Sri Lanka. There are many agricultural areas and plantations around Kalu ganga bellow the Ellagawa catchment. Therefore studying the relationship of flows of Kalu ganga at Ellagawa catchment with the rainfall and temperature is very important. Objective of this study was to find the associations of rainfall and temperature with the flows of Kaluganga at Ellagawa.

2. METHODOLOGY

The data was collected on over the period of January 2001 to December 2006. Daily average discharge in cubic meters per second at the *Ellagawa* gauging station was obtained from the Hydrology Division of Irrigation Department. Daily rainfall in mm in the selected eleven rainfall stations within the catchment area (Galathura, Wellandura, Eheliyagoda, Keragala, Balangoda, Alupola, Hapugastenna, Rathnapura, Landsdown, Halwathura and Deepedena)(De Silva,2006, Siriwardana,2011) and Maximum daily temperature in

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centigrade at the *Rathnapura* Meteorology station was obtained from the Department of Meteorology. Regression analysis was used to find the associations of stream flow at Ellagawa with rain fall and temperature. **Natural logarithm of flow (Ln-Flow)** was used in model building instead of flow (Siriwardana,2011). Thiessen Polygon Technique was used to find the **average rainfall (Av-Rf)** of the Ellagawa catchment(Siriwardana,2011). Average Ln-Flow per day for each month in every year (January 2001 to December 2006) at *Ellagawa* were calculated from the collected flow data. Similarly Average Av-Rf per day of the Ellagawa catchment for each month in every year and **Average** maximum daily temperature at *Rathnapura* per day for each month in each year were calculated from the collected data.

Response Variable(Y)

Average Ln-Flow per day for a given month in given year at Ellagawa in m^3/s (Y) =

$$\sum_{i=1}^{n} \frac{Ln - Flow_i}{n} \quad ; \quad n = no\ of\ days\ of\ the\ month,\ Ln - Flow_i = Ln - flow\ of\ the\ i^{th}\ day$$

Predictor Variables(X1,X2)

Average Av-Rf per day of the Ellagawa catchment for a given month in given year in mm (X1) =

$$\sum_{i=1}^{n} \frac{Av - Rf_i}{n} \quad ; \quad n = no\ of\ days\ of\ the\ month,\ \ Av - Rf_i = Av - Rf\ of\ the\ i^{th}\ day$$

Average maximum daily temperature at *Rathnapura* per day a given month in given year in centigrade (X2) =

$$\sum_{i=1}^{n} \frac{Temp_i}{n}\ ;\ n = no\ of\ days\ of\ the\ month,\ \ Temp_i = Maximum\ Temperature\ \ of\ the\ i^{th}\ day$$

The Regression model

$$Y_j = \alpha + \beta_1 X_{1,j} + \beta_2 X_{2,j} + \in_j\ ;$$

$$Y_j\ , X_{1,j}, X_{2,j}\ are\ j^{th}\ observations\ \ and\ \ \in_j\ \ -\ random\ error of\ the j^{th}\ observation$$

Model assumptions

a. Linear relationship
b. Multivariate normality
c. No or little multicollinearity
d. No auto-correlation
e. Homoscedasticity

Analysis of variance was used to check the statistical significance of the fitted model. R^2 – Coefficient of determination was used to check the proportion of variation explained by the model. Hypothesis testing (T tests) was used to check the statistical significance of the contribution of variables. Residual analysis was used to check the model assumptions and the variables are specified correctly (Plots of residuals against the fitted values and the Normal probability plots were used). Plot of autocorrelations of residuals was used to detect the presence of the autocorrelation.

Testing the model

The Fitted Daily Flow and observed Daily Flow for all the days during the period January 2001 to December 2006 was compared using the ratio (Daily Flow / Fitted Daily Flow).

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RESULTS AND DISCUSSION

Results of the Analysis of variance are given in table 1. The fitted model is Y = 6.49 + 0.0805 X1 - 0.115 X2 (p=0.00). 85.4% of the total variation of the regressor variable is explained by the fitted model. According to the model the average Ln-Flow per day for a given month in given year is collectively associated with the average Av-Rf per day(p=0.00) and average maximum daily temperature (p=0.00)at *Rathnapura* per day in the relevant month and the year. Graph 1, Graph 2, Graph 3 gives the plot of residuals vs the fitted values, probability plot of residuals and the autocorrelation function of the residuals. Gaph 1 indicates that model assumptions (a). and (e) are satisfied. Gaph 2 indicates that model assumption (b) is satisfied. Gaph 3 indicates that model assumption (d) is satisfied. Gaph 4 indicates model assumption(c) is satisfied (tolerance > 0.9). The PRESS statistic 2.4 indicates that model is suitable for predictions. Using the model the ratio (Daily Flow / Fitted Daily Flow) was estimated. The results are given in the table 2. The results indicate that the model fairly good for predict the daily data.

3. CONCLUSION

Average Ln-Flow per day for a given month in given year is collectively associated with the average Av-Rf per day and average maximum daily temperature at *Rathnapura* per day in the relevant month and the year. The relationship is Average Ln-Flow per day for a given month in given year = 6.49 + 0.0805 average Av-Rf per day(in the relevant month and the year) - 0.115 average maximum daily temperature at *Rathnapura* per day(in the relevant month and the year).

Regression Analysis: Y versus X1, X2

The regression equation is
Y = 6.49 + 0.0805 X1 - 0.115 X2

Predictor	Coef	SE Coef	T	P
Constant	6.4938	0.6550	9.91	0.000
X1	0.080518	0.005330	15.11	0.000
X2	-0.11461	0.01999	-5.73	0.000

S = 0.192772 R-Sq = 85.4% R-Sq(adj) = 84.9%
PRESS = 2.42829 R-Sq(pred) = 83.52%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	12.5757	6.2878	169.21	0.000
Residual Error	58	2.1553	0.0372		
Total	60	14.7310			

Table 1

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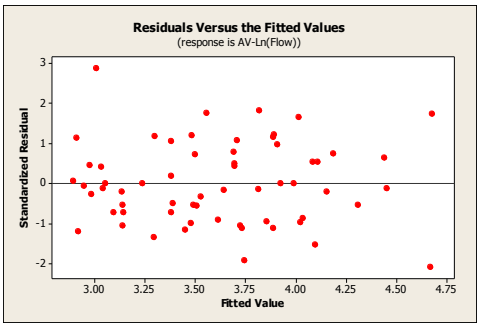
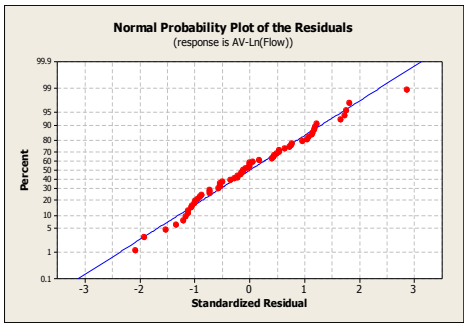
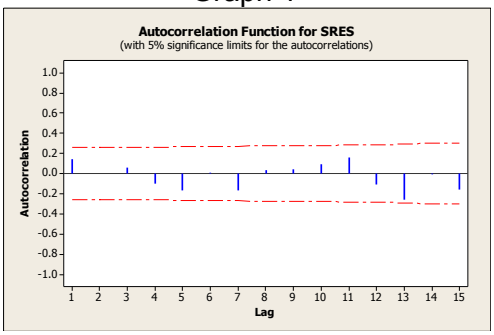


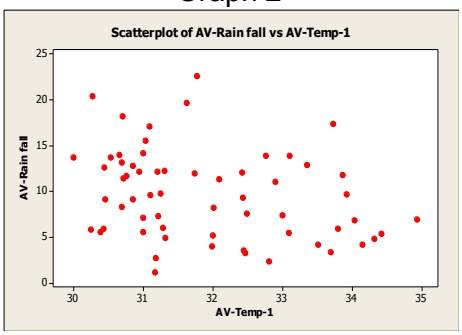
Graph 1



Graph 2



Graph 3



Graph 4

Flow/Fitted Flow	Percentage
0-0.5	14.5474
0.51-0.7	9.1056
0.71-1.3	40.0862
1.31-1.5	8.2974
1.51-2.00	10.4526
>2	17.5108

Table 2

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