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RESEARCH ARTICLE

IMPACT OF CLIMATIC PARAMATERS ON AMAN RICE PRODUCTION IN RANGPUR DISTRICT.

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Abstract

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Rice production is sensitive to the climatic factors such as rainfall, maximum temperature, minimum temperature, sunshine and humidity etc. So, any change of the climatic variables will affect the production of rice. This study investigated the effect of climate parameters on Aman rice production in Rangpur district, Bangladesh for the last 3 decade (1987-2015). The research on the effect of climatic variables on rice production is not rare in Bangladesh but the findings are not converged to any direction despite their similarities on data and study areas. The conducted studies used different analytical methods and obtained different results. Aman rice growing period partitioned into three stages: vegetative, reproductive and ripening. Maximum, minimum and average of the variables calculated by MS Excel. A dummy variable created and autocorrelation, multicollinearity, heteroscedasticity and linearity assumption checked by using Statistical Package for Social Science. Stepwise linear regression feature of SPSS had been used to fit the crop climatic regression model. The model showed that increased average humidity in ripening stage and maximum sunshine in vegetative stage decreased the quantity of yield while increased average rate of continuous day's rainfall in vegetative stage has positive effect in the yield. So, effect of average rate of continuous day's rainfall is becoming the dominant variable continuously for Aman rice production in the last three decade of Rangpur district.

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Introduction:-

Bangladesh is an agro-based country. Agriculture in Bangladesh is already under pressure both from huge and increasing demands for food, and from problems of agricultural land and water resources depletion (Ahmed et al.,2000). Among the agricultural products only rice is contributing to about 71% of total agro based production in Bangladesh (Shahid, 2011; Hasan et al, 2017). Bangladesh is facing challenges in tackling and managing the effect of uncertain climate change. According to the Third Assessment Report of IPCC, South Asia is the most vulnerable to climate change impacts (McCarthy, 2001). The international community also recognizes that Bangladesh ranks high in the list of most vulnerable countries (Climate Change Cell, 2008c). Climatic factors such as temperature, rainfall, atmospheric carbon dioxide, solar radiation etc are closely link with agriculture production. Therefore, rice production

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would be major concern in recent years due to changing climatic conditions, because there is a significant amount of rice yield may hamper for only fluctuations of those climatic parameters (Basak, 2010). The major rice crop Aman is transplanted in monsoon and facing high rainfall in monsoon at its reproductive stages. It will be more affected with increased rainfall in the future. Crop failure due to either drought or excess rainfall is already putting a significant strain on the socioeconomic structure of Bangladesh and will be more severe in the future. Quadir et al. (2003) showed that the monsoon rainfall up to certain optimum level is favorable for Aman rice yield and harmful for rainfall beyond that optimum level. The impact of climate variables on Aman rice yield has been studied by Sarker et al. (2012), Amin et al. (2015), Chowdhury and Khan (2015) and Mamun et al. (2015), which provide important relationship of rainfall, humidity and temperature with rice yield. All these studies have shown adverse impacts of the increase of maximum and minimum temperature and rainfall beyond the optimum requirement. Kabir (2015) found contradictory result, which depicts that the maximum temperature has positive impact and minimum temperature has negative impact on Aman rice production. Choudhury and Khan (2015) showed that the Aman rice yield has gradually increased by almost 3 fold from 1972 to 2014. Increasing temperature and variable rainfall levels along with severe and frequent floods, droughts and cyclones adversely affect agricultural production and place Bangladesh's food security at risk (Ara et al, 2016; Karim, 2012; Zakaria et al, 2014). The aim of this paper is to assess the impact of climatic parameters on Aman rice production in Rangpur District, a district from north-western region of Bangladesh.

Aman growth phases:-

Rice plants take around 3–6 months to grow from seeds to mature plants, depending on the variety and environmental conditions. They undergo three general growth phases: vegetative, reproductive and ripening. Rice varieties can be categorized into two groups: the short-duration varieties which mature in 105–120 days and the long-duration varieties which mature in 150 days. A 120-day variety, when planted in a tropical environment, spends about 60 days in the vegetative phase, 30 days in the reproductive phase, and 30 days in the ripening phase.

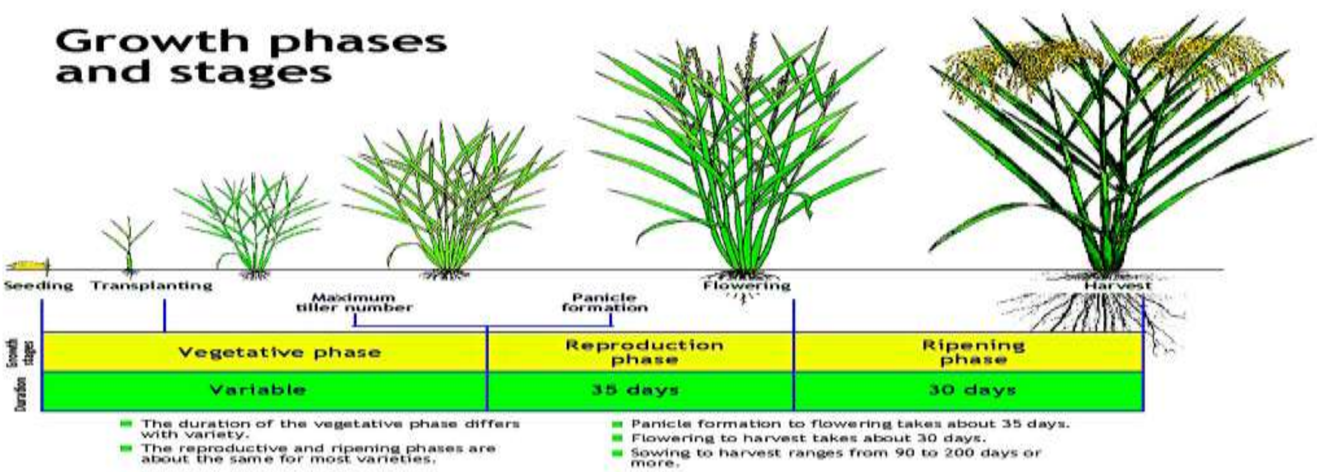


Figure 1:-Growing Phases and Stages

(**Source:**https://www.flickr.com/photos/ricephotos/6811396464?ytcheck=1&new_session=1)

Methodology:-

Data source and study area:-

We consider the study area is Rangpur. It’s area 2367.84 sq km, located in between 15°03' and 26^{o}00' north latitudes and in between 88°57' and 89°32' east longitudes. It is bounded by Lalmonirhat district on the north, Kurigram district on the east, Gaibandha on the south-east, Dinajpur on the south-west, Nilphamari on the north-west. Teesta river divided Rangpur from Lalmonirhat and Kurigram in its north and north-east boarder accordingly. The study was conducted in a purposely-selected district, Rangpur. The study was limited to some climatic factors and non-climatic factors. The selected climatic variables were maximum temperature, minimum temperature, average temperature, total rainfall, sunshine hours and humidity. Time and dummy variable (DMY) are the non-climatic variables. Estimation of the model required two sets of data:

1. Historical crop yield data from period 1987 to 2015 and
2. Historical data on a number of agro-climatic variables from period 1987 to 2015.

Data relating to these agro-climatic variables were obtained from the Bangladesh Meteorological Department (BMD), Bangladesh Bureau of Statistics (BBS) and the Department of Agricultural Extension (DAE). Rice production data will also be collected from the Yearbook of Agricultural Statistics of Bangladesh of BBS.

Data processing:-
Data has been entered and processed in the computer by using MS-Excel program. All data were converted into standard units such as yield is converted into Ton/hectare, rainfall into mm, temperature into ^oC, sunshine into hours and humidity into percentage.

From all the data set at first the dataset from 1987 to 2015 has been deducted. After that from this year, the data of the months August to December has been deducted. Then the data of the month has been classified as the pre-assumed stages. Next we have calculated some features of the data. The feature calculated from different data has been given bellow:

1. Rainfall: Total rainfall in the three stages, average rainfall, number of consecutive days, total rainfall in consecutive days, average rainfall of consecutive days.
2. Maximum temperature: maximum temperature of the stage, average maximum temperature accordingly.
3. Minimum temperature: minimum temperature of the three stage, average minimum temperature accordingly.
4. Sunshine: maximum, minimum and average sunshine of calculated each stages.
5. Humidity: maximum, minimum and average humidity of the three stages accordingly.

After processing this features data analysis has been performed by statistical package SPSS and stepwise regression had been applied on the features as well as variables.

Multiple Regression Model:-
The yield forecasting model has been used in this study was specified as:

$$y_i = \beta_0 + \sum_i^n \sum_j^k \beta_j w_{ij} + \varepsilon_i \quad ; i = 1,2,3,...,n \quad ; j = 1,2,3...,k$$

where, y_i is the yield of the Aman rice crop, w_{ij} is the agro-climatic variables, β_j are the coefficients of the relevant variables, β_0 is the constant and ε_i is the disturbance term. The explicit formulation of the models was:

For model 1:	$y_1 = \beta_0 + \beta_1 DMY + \varepsilon_1$
For model 2:	$y_2 = \beta_0 + \beta_1 DMY + \beta_2 S3HA + \varepsilon_2$
For model 3:	$y_3 = \beta_0 + \beta_1 DMY + \beta_2 S3HA + \beta_3 S1SM + \varepsilon_3$
For model 4:	$y_4 = \beta_0 + \beta_1 DMY + \beta_2 S3HA + \beta_3 S1SM + \varepsilon_4$

where,
$y_i (i = 1,2,3,4) =$ yield of Aman rice, production/area (Mt/ha)
DMY = Dummy variable [0 = Unfavorable climate condition
1 = Favorable climate condition]
S3HA = Stage 3 Humidity Average, S1SM = Stage 1 Sunshine Maximum, S1RCA = Stage 1 Average Rainfall of Consecutive Days.
β_0 = Intercept term, β_1 = Coefficient of DMY, β_2 = Coefficient of S3HA, β_3 = Coefficient of S1SM
β_4 = Coefficient of S1RCA, $\varepsilon_i (i = 1,2,3,4) =$ Error term.
The models for least square were used to estimate the regression coefficients in equation (1) by SPSS Software. The model was estimated for all the stages of Aman rice crop growth.
Stepwise regression can utilize several different algorithms, and models can be judged to be better or worse by several different criteria. In general, these methods often do a decent job of the following:

1. Detecting and dropping variables that aren't associated with the outcome, either in univariate or multiple regression.

2. Detecting and dropping *redundant variables* (predictors that are strongly associated with even better predictors of the outcome).
3. Detecting and including variables that may not have been significant in univariate regression but that are significant when you adjust for the effects of other variables.

Most stepwise regression software also lets you “force” certain variables into the model, if you know (from physiological evidence) that these variables are important predictors of the outcome.

Model accuracy:-
A way to test for errors in models created by step-wise regression is to not rely on the model's *F*-statistic, significance, or multiple R, but instead assess the model against a set of data that was not used to create the model (Karim et. al., 1996). This is often done by building a model based on a sample of the dataset available (e.g., 70%) – the “training set” – and use the remainder of the dataset (e.g., 30%) as a validation set to assess the accuracy of the model. Accuracy is then often measured as the actual standard error (SE), MAPE, or mean error between the predicted value and the actual value in the hold-out sample. This method is particularly valuable when data are collected in different settings (e.g., different times, social vs. solitary situations) or when models are assumed to be generalizable.

Results and Discussions:-

To obtain the prevailing condition of rice production and the climatic variables, exploratory data analysis method was adopted and the following results were obtained. Stepwise regression model for predicted variables is given in Table 1.

Table 1:-Model summary statistics

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.840[a]	.706	.695	.1840673	
2	.902[b]	.814	.800	.1490585	
3	.926[c]	.858	.841	.1328621	
4	.939[d]	.882	.863	.1234375	2.446
a. Predictors: (Constant), Dummy					
b. Predictors: (Constant), Dummy, S3_Humi_Avg					
c. Predictors: (Constant), Dummy, S3_Humi_Avg, S1_Sun_Max					
d. Predictors: (Constant), Dummy, S3_Humi_Avg, S1_Sun_Max, S1_Rain_Con_Avg					
e. Dependent Variable: Yield					

Adding each predictor in our stepwise procedure results in a better predictive accuracy.

1. **R** is simply the Pearson correlation between the actual and predicted values for the impact of climatic parameters on Aman rice production. The values of R for the model 1, 2, 3 and 4 are 0.84, 0.902, 0.926 and 0.939 respectively. All the values of R show that there exists a strongly positive correlation between the actual and predicted values for each model.
2. **R square** -the squared correlation- is the proportion of variance in yield accounted for by the predicted values.

R-square for the 1st model is 70.6%, which means that the predictor dummy variable is account for 70.6% of the variance in overall yield.

R-square for the 2nd model is 81.4%, which means that the predictor variables (Dummy and S3_Humi_Avg) are account for 81.4% of the variance in overall yield which also indicates that S3_Humi_Avg is account for (81.4%-70.6%) = 0.8% change in variance proportion in this model.
R-square for the 3rd model is 85.8%, which means that the predictor variables (Dummy, S3_Humi_Avg and S1_Sun_Max) are account for 85.8% of the variance in overall yield which also indicates that S1_Sun_Max is account for (85.8%-81.4%) = 4.4% change in variance proportion in this model.

R-square for the 4th model is 88.2%, which means that the predictor variables (Dummy, S3_Humi_Avg, S1_Sun_Max and S1_Rain_Con_Avg) are account for 88.2% of the variance in overall yield which also indicates that S1_Rain_Con_Avg is account for (88.2%-85.8%) = 2.4% change in variance proportion in this model.

Adjusted R Square- It is typically seen that the regression equation performs better when more variables is associated. The regression equation tries to estimate the predictive accuracy and is slightly lower than R square. Adjusted R squared is a corrected goodness-of-fit (model accuracy) measure for linear models. It identifies the percentage of variance in the target field that is explained by the input or inputs. The models 1, 2, 3 and 4 identifies 69.5%, 80%, 84.1% and 86.3% of variance in the target field respectively that is explained by the inputs. Depending on adjusted R^2 among all the models the 4th model fit the data more accurately. The Durbin-Watson statistic is 2.446 which is between 1.5 and 2.5 and therefore the data is not autocorrelated. ANOVA table for these four model is given below in Table 2.

Table 2:-Goodness of fit for the regression model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.194	1	2.194	64.767	.000[b]
	Residual	.915	27	.034		
	Total	3.109	28			
2	Regression	2.531	2	1.266	56.968	.000[c]
	Residual	.578	26	.022		
	Total	3.109	28			
3	Regression	2.668	3	.889	50.377	.000[d]
	Residual	.441	25	.018		
	Total	3.109	28			
4	Regression	2.743	4	.686	45.014	.000[e]
	Residual	.366	24	.015		
	Total	3.109	28			
a. Dependent Variable: Yield,						
b. Predictors: (Constant), Dummy						
c. Predictors: (Constant), Dummy, S3_Humi_Avg						
d. Predictors: (Constant), Dummy, S3_Humi_Avg, S1_Sun_Max						
e. Predictors: (Constant), Dummy, S3_Humi_Avg, S1_Sun_Max, S1_Rain_Con_Avg						

Table 2 shows that all the regression models are highly significant. The result shows that the independent variables are statistically significantly predicted better result as $F(4,24) = 45.014$ i.e. the 4th regression model are good fit to the data. Diagnostic of crop climate regression model is given in Table 3.
This coefficient table indicates that SPSS performed 4 steps, adding one predictor in each. We usually report all the models. Existence of multicollinearity in the data has been checked by two ways which had been described below:

A rule of thumb is that Tolerance < 0.10 indicates multicollinearity. As the value of tolerance for each case is >0.10, so we can conclude that there exists no multicollinearity.

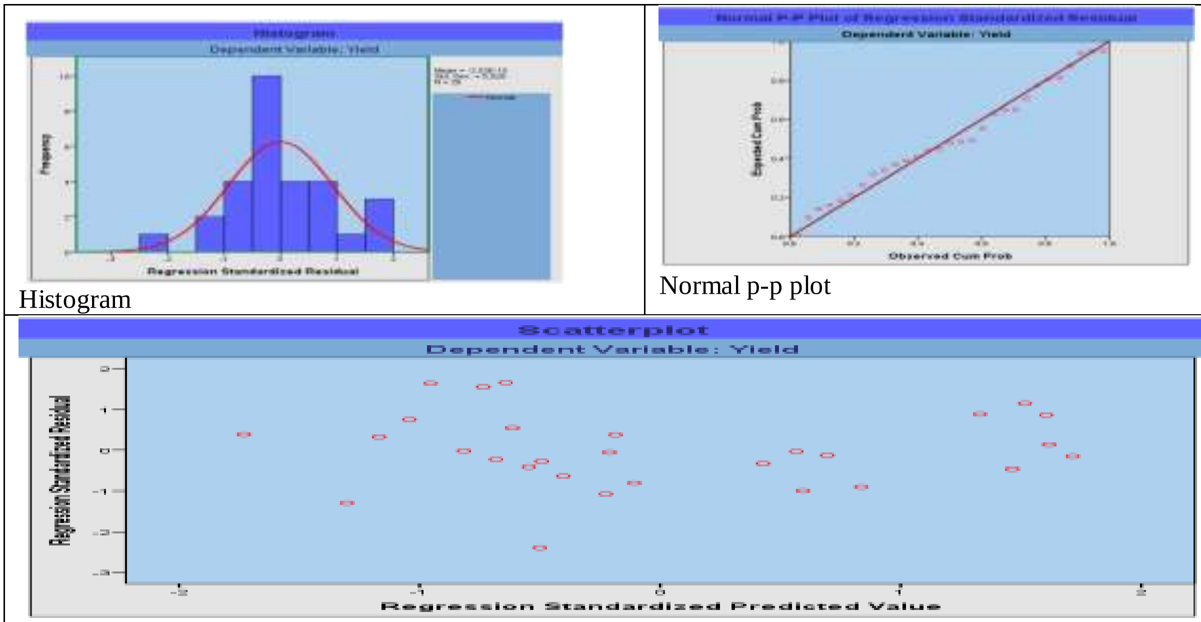
The analysis reveals the value of variance inflation factors (VIF) of the explanatory variables in the final models of equations are less than, so it can be said that the data have no evidence of collinearity problems. Variance inflation factor (VIF) is nothing only a multicollinearity measurement technique of a regression model.

Table 3:- Diagnostic of crop climate regression model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	1.831	.043		42.209	.000	1.742	1.920		
	Dummy	.567	.070	.840	8.048	.000	.422	.711	1.000	1.000
2	(Constant)	5.800	1.020		5.689	.000	3.704	7.896		
	Dummy	.529	.058	.784	9.137	.000	.410	.648	.971	1.029
	S3_Humi_Avg	-.049	.013	-.334	-3.895	.001	-.075	-.023	.971	1.029
3	(Constant)	6.697	.964		6.945	.000	4.711	8.683		
	Dummy	.431	.063	.638	6.887	.000	.302	.559	.661	1.512
	S3_Humi_Avg	-.044	.011	-.296	-3.815	.001	-.067	-.020	.942	1.062
	S1_Sun_Max	-.116	.042	-.261	-2.779	.010	-.202	-.030	.642	1.558
4	(Constant)	6.687	.896		7.464	.000	4.838	8.536		

	Dummy	.467	.060	.691	7.739	.000	.342	.591	.614	1.629
	S3_Humi_Avg	-.048	.011	-.326	-4.443	.000	-.070	-.026	.910	1.099
	S1_Sun_Max	-.100	.039	-.226	-2.544	.018	-.182	-.019	.621	1.610
	S1_Rain_Con_Avg	.006	.003	.165	2.228	.036	.000	.012	.896	1.116
a. Dependent Variable: Yield										

Histogram, normal p-p plot from regression standardized residual, scatterplot are given in figure 2. The histogram is seemed to be normal that is our data is normally distributed with mean -2.52E-15 and standard deviation 0.926. Here N= 29 indicates our total number of study year. For checking the normality assumption the following plot plays a pivotal role. The above plot is a check on normality; the plotted points should follow the straight line. Serious departure would suggest that normality assumption is not met. Here we have no major cause for concern. Scatterplot is a useful feature to determine the present or absence of heteroscedasticity in the data. The scatterplot shows that the plotted points creates some homogeneous blocks i.e., the associated random variables have a homogeneity in their variances. There is a low leverage point in the plot but that doesn't affect the yield in a large or significant proportion. So, we may conclude that the data set is free of heteroscedasticity. Displays scatterplot of residual of each independent variable and the residual of the dependent variable when both variables are regressed separately on the rest of the independent variable. At least two independent variables must be in the equation for a partial plot to be produced. Four partial regression plots are given in figure 3.



Histogram

Normal p-p plot

Scatter plot of ZPRED and ZRESID

Figure 2:-Histogram, normal probability plot and scatter plot

Partial plot for the residual of dummy and the residual of Yield:-

The following scatterplot shows how the residual of dummy variable is associated with the residual of yield is presented at figure 3. The above plot shows that the dummy variable has a positive linear trend i.e., the dummy variable is positively associated with the yield which means that due to any increment or decrement in the variable there should be a corresponding increment or decrement in the yield.

Partial plot of the residual of S1_Rain_Con_Avg and the residual of Yield:-

The Partial plot of the residual of S1_Rain_Con_Avg and the residual of Yield (listed in figure 3) shows that there exists a positive linear trend between the residual of S1_Rain_Con_Avg and the residual of yield which signifies that there exists a positive or negative change in the yield for positive or negative change in S1_Rain_Con_Avg respectively.

Partial regression plot of the residual of S1_Sun_Max (Stage 1: Sunshine Maximum) and the residual of Yield:-

From figure 3, the Partial regression plot of the residual of S1_Sun_Max (Stage 1: Sunshine Maximum) and the residual of Yield shows that there exists a negative linear trend between the residual of S1_Sun_Max and the residual of yield which signifies that there exists a positive or negative change in the yield for negative or positive change in S1_Sun_Max respectively.

Partial regression plot of the residual of S3_Humi_Avg (Stage 1: Sunshine Maximum) and the residual of Yield:-

The above Partial regression plot of the residual of S3_Humi_Avg (Stage 1: Sunshine Maximum) and the residual of Yield plot from figure 3 presents that there exists a negative linear trend between the residual of S3_Humi_Avg and the residual of yield which signifies that there exists a positive or negative change in the yield for negative or positive change in S3_Humi_Avg respectively.

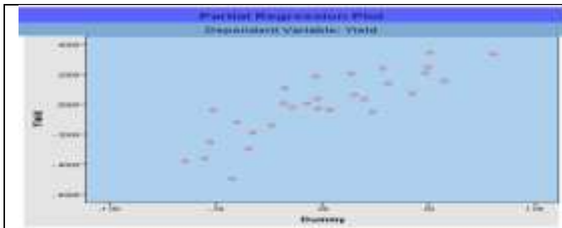
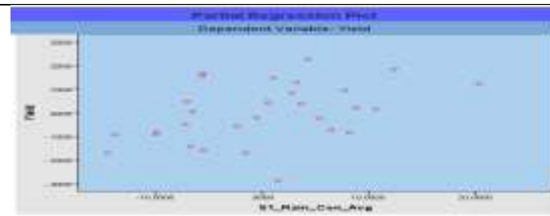
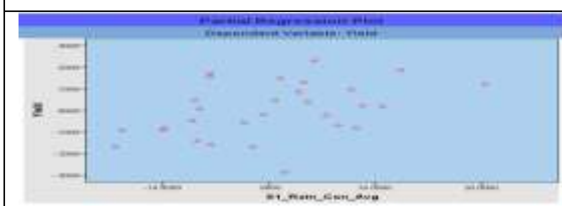
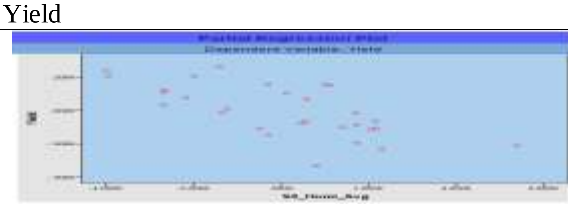
 Partial plot for the residual of dummy and the residual of Yield	 Partial regression plot of the residual of S1_Rain_Con_Avg (Stage 1: Continuous days rainfall average) and the residual of Yield
 Partial regression plot of the residual of S1_Sun_Max (Stage 1: Sunshine Maximum) and the residual of Yield	 Partial regression plot of the residual of S3_Humi_Avg (Stage 1: Sunshine Maximum) and the residual of Yie**ld**

Figure 3:-Partial plot for the residual of dummy, S1_Rain_Con_Avg, S1_Rain_Con_Avg (Stage 1: Continuous days rainfall average), S3_Humi_Avg (Stage 1: Sunshine Maximum) and the residual of Yield

Trend line for Aman Rice Production:-

The trend line for Aman rice production is given in figure 4. This line plot shows that the mean yield of Aman rice is increasing day by day. In the year of 1998-99 and 2007-08 the regular production of aman rice has been fallen because of extreme flood.

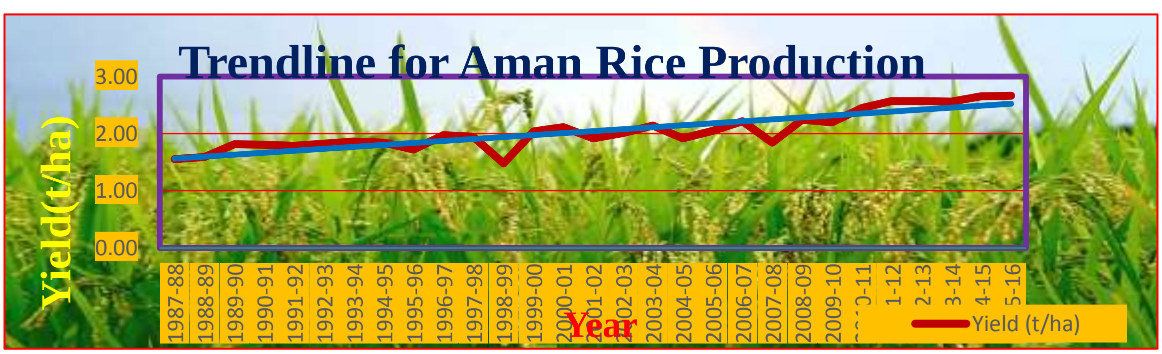


Figure 4:-Line plot for Mean Yield against Year

Conclusion:-

This study provides an in-depth analysis of variables associated with vulnerability and spatial patterns of indicators for climatic circumstances which would help to achieve sustainable development goals such as sustainable water and combat climate change and its impact.

This study was designed to list the impact of climatic parameters on Aman rice production in Rangpur district. Three stages namely vegetative, reproductive and ripening stage has been considered for this research. Variations in average humidity over the growing stage 3 (ripening stage) and maximum sunshine over the growing stage 1 (vegetative stage) have been found to have adverse effect on rice yield. Increasing average rate of continuous day's rainfall has been found to have a positive impact on the yield. It implies that average rate of continuous day's rainfall for vegetative stage is the dominant factor in this district which increases the Aman rice production significantly. So, effect of average rate of continuous day's rainfall is becoming the dominant variable continuously in the Aman rice production of Rangpur district in last 3 decades. This study shows the present condition of the impact of climatic parameters on Aman rice production and the recommendations would help the government and other related local and global organizations to make precisions about how to tackle the situation of present and upcoming climate change to increase Aman rice production.

Reference:-

1. Ahmed, A. and Ryosuke, S. (2000): Climate change and agricultural food production of Bangladesh: an impact assessment using GIS-based biophysical crop simulation model, Center for Spatial Information Science. University of Tokyo. 4-6-1 Komaba. Japan.
2. Amin, M. R., Zhang, J. and Yang, M. (2015): Effects of Climate Change on the Yield andCropping Area of Major Food Crops: A Case of Bangladesh, Sustainability, doi:10.3390/su7010898, ISSN 2071-1050.
3. Ara, I, Megan, L. and Ostendorf, B.(2016): Spatio-temporal analysis of the impact of climate, cropping intensity and means of irrigation: an assessment on rice yield determinants in Bangladesh. Agriculture & Food Security 5.1 (2016): 12.
4. Basak, J. K., (2010): Climate Change Impacts on Rice Production in Bangladesh: Results from a Model. Unnayan Onneshan-The Innovators, Dhanmondi, Dhaka-1209, Bangladesh.
5. Climate Change Cell (2008c): Economic Modelling of Climate Change Adaptation Needs for Physical Infrastructures in Bangladesh Department of Environment, Ministry of Environment and Forests. Component 4b, Comprehensive Disaster Management Programme, Ministry of Food and Disaster Management, Bangladesh
6. Chowdhury, I. U.A, and Khan, M. A. E.(2015): The impact of climate change on rice yield in Bangladesh: A time series analysis. RJOAS 4.40 (2015): 12-28.
7. Hasan, M.M., Islam, M.T. and Sultana, N. (2017): Effects of Climate Change on Rice Production in Bangladesh: A Comparative Study between Time Series and Stochastic Models. BUP JOURNAL, Volume -5, Issue -1, May 2017, 15-28.
8. Kabir, M.H. (2015): Impacts of climate change on rice Yield and variability; an analysis of disaggregate level in the southwestern part of Bangladesh especially Jessore and Sathkhira districts. Scholarly Journal of Agricultural Science Vol. 5(8), pp. 283-295
9. Karim, Mohammed R., et al. (2012): Climate change model predicts 33% rice yield decrease in 2100 in Bangladesh. Agronomy for sustainable development 32.4, 821-830.
10. McCarthy, J. J. (2001): Climate change 2001: Impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge Univ Press, Cambridge.
11. Mamun, AHM Monzurul, Ghosh, B.C. and Islam S.M. R.(2015): Climate Change and Rice Yield in Bangladesh: A Micro Regional Analysis of Time Series Data. International Journal of Scientific and Research Publications 5.2,1.
12. Quadir, D. A., Khan, T. M. A., Hossain, M. A.and Iqbal, A., (2003): Study of Climate variability and its impact on rice yield in Bangladesh. SAARC Journal of Agriculture, 1, 69-83.
13. Sarker, M. A.R., Alam, K. and Gow, J. (2012): Exploring the relationship between climate change and rice yield in Bangladesh: An analysis of time series data. Agricultural Systems 112, 11-16.
14. Shahid, S. (2011): Impact of climate change on irrigation water demand of dry season Boro rice in northwest Bangladesh. Climatic change 105.3-4, 433-453.
15. Zakaria, M., Abdullah M.A., Hossain, M. I. and Rahman, N.M.F. (2014): Effects Of Rainfall And Maximum Temperature On Aman Rice Production Of Bangladesh: A Case Study For Last Decade. International journal of scientific & technology research volume 3, issue 2, February 2014.
16.