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Statistical Analysis of Impact of Meteorological Parameters on Rice Production in Thrissur District of Kerala

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Abstract: ***This study is based on secondary data of weather parameters such as rainfall, relative humidity, maximum temperature and minimum temperature and their effect on rice crop yield in Thrissur district of Kerala by using the data from 2004-2005 to 2018-2019. The main aim of this study is to analyze the climatic variability and its effect of rice productivity in different weather seasons. The result obtained from analysis of relationship of rice production with weather parameters shows non-significant and negatively correlated for rainfall. The rice production was positively correlated and non-significant with maximum and minimum temperature, Relative humidity was highly significant and negatively correlated with rice production. In case of multiple regression analysis, relative humidity shows significant and negatively influence on rice production. In prediction of rice production, among different linear and non-linear models, cubic model was found to be the best for Thrissur district rice production (highest R^2 value)with respect to all weather parameters (viz, rainfall, relative humidity, maximum temperature and minimum temperature)***

Keywords: Rice Production, Climatic factors, Correlation, Nonlinear Models, Multiple Linear Regression and Seasonal variation

1. Introduction

Agriculture is demographically extensive economic sector and plays a significant role in the nationwide socio-economic fabric of India. Rice plays a vital role in the national food security and would continue to remain, because of its wider adaptability to grow under diverse ecosystems. Rice is the most important crop to millions of small farmers who grow it on millions of hectares throughout the region, and to the many landless workers who derive income from working on the farms. Rice production in India is an important part of the national economy. India is one of the world's largest producers of rice, including white rice and brown rice, grown mostly in the eastern and southern parts of the country.

India is one of the world's largest producers of rice, including white rice and brown rice, grown mostly in the eastern and southern parts of the country. Production increased from 53.6 million tons to 74.6 million tons, a 39 percent increase over the decade. Since 1950 the increase has been more than 350 percent. Most of this increase was the result of an increase in yields; the number of hectares did not increase during this period. Yields increased from 1,336 kilograms per hectare in1980 to 1,751 kilograms per hectare in 1990. The per-hectare yield increased more than 262 percent between 1950 and 1992.Rice is the most important food crop grown in Kerala. It occupies 7.46 percent of the total cropped area of the state. However, the area under rice has been falling at an alarming rate ever since the 1980s. From 8.82 lakh hectare in 1974-75, the paddy area has come down to 1.96 lakh hectare in 2015-16.

Paddy cultivation in Kerala has witnessed a steady decline since the 1980s. The sharp fall in the area under paddy cultivation as well as in the quantity of rice produced in the State has had important implications for Kerala's economic, ecological and social development. Over the last five years, however, there have been commendable signs of a revival in rice production in Kerala. A new sense of purpose and enthusiasm is visible now among paddy cultivators in Palakkad, a region that is referred to as the "rice bowl" of Kerala. This field report, which is based partly on interviews with farmers, government officials and leaders of mass organizations in Palakkad, is an account of some of the long-term challenges facing paddy cultivation in Kerala. It also attempts to review the policy initiatives of the State and local Governments over the last few years that have helped revive rice cultivation in Kerala.

In 2012, rice production for Thrissur District was 62,316 tonnes. Though Thrissur District rice production fluctuated substantially in recent years, it tended to decrease through the 2003 - 2012 period ending at 62,316 tonnes in 2012.

Paddy cultivation is by far the largest agricultural practice pursued by a major section of the people. The low-lying lands are cultivated with paddy and are fit only for this purpose. The major irrigation works in the district are the Peechi, Vazhani, Chalakudy and Cheerakuzhy Projects. The ayacut of Peechi project which is the largest consists of 46,000 acres of cultivable land. In addition, the project supplies 46,000,000 gallons of drinking water per day to Thrissur town. The project also effectively controls the peak flows in the Manali river minimizing flood havocs, and ensures sufficient draft for the maintenance of navigation between Thrissur town and the backwaters along the coast. The Peechi Dam site is a popular holiday resort as well. The most important crop of the district is paddy. Next to paddy, tapioca farms the chief food crop. The coconut palm dominates the garden crops of a large variety of fruit trees are also grown in the district. Paddy is cultivated in three seasons in all the districts of Kerala except Wayanad district. In Wayanad there is no autumn paddy cultivation. The area under paddy cultivation in the state is decreasing year by year. Thrissuris in second position of paddy cultivation in winter and summer seasons. But in autumn paddy cultivation Thrissur is in fifth position.

2. Methodology

This study is based on secondary data. The data set for present study is covering 15 years at Thrissur district level panel data during 2004 to 2018.The data for agriculture and climatic variables are taken from reputed Institutions.

2.1 Correlation Analysis

The correlation analysis was carried out to determine the degree of association between two variables. In the present study, the degree of relationships between rice production and each of the weather parameters viz., rainfall, relative humidity, minimum temperature and maximum temperature were determined by using Karl Pearson's correlation coefficient.

2.2 Significance of the correlation coefficient

To test the significance of the correlation coefficient 't' test was used. Here null hypotheses was set as, $H_0: \rho = 0$ against the alternative hypothesis $H_1: \rho \neq 0$.
This was tested by using test statistic

$$t_{(n-2)} = \frac{|r|\sqrt{(n-2)}}{\sqrt{(1-r^2)}}$$

Where, n is the number of pairs of observation and r is the correlation coefficient.

2.3 Linear and Non -Linear Model

The simplest way of representing any relation is by fitting a linear equation using the variables under study. But, in all the cases it may not follow. In the present study, taking rice production as dependent variable and weather parameters as independent variables, Linear and various non-linear models (Table 1) were tried to fit to the data. Among the below several model the best model were selected based on R^2 Value.

Table 1: Linear and non-linear models

S. No	Model	Equation	Description
1	Linear	$Y_t = a + bt$	Y and t are yield and weather parameter respectively. A and b are constants to be estimated
2	Logarithmic	$Y_t = a + b \ln(t)$	Y and ti 's are yield and weather parameter respectively. A and b_i's are constants to be estimated and ln is Natural Log
3	Quadratic	$Y_t = b_0 + b_1 t_i + b_2 t_i^2$	Y and ti 's are yield and weather parameter respectively.b_0 and b_i 's are constants to be estimated. The quadratic model can be used to model a series that "takes off" or a series that dampens
4	Cubic	$Y_t = b_0 + b_1 t_i + b_2 t_i^2 + b_3 t_i^3$	Y and t_i's are yield and weather parameter respectively.b_0 and b_i's are constants to be estimated
5	Power	$\ln(Y) = \ln(a) + b \ln(t)$ or $Y = a t^b$	Y and t_i's are yield and weather parameter respectively.b_0 and b_i 's are constants to be estimated and ln is Natural Log
6	Exponential	$Y_t = ab^t$	Y and t_i 's are yield and weather parameter respectively.b_0 and b_i 's are constants to be estimated.

2.4 Multiple Linear Regression Analysis:

To study the influence of weather parameters on rice production, multiple regression analysis was used. The multiple linear regression equation is, $Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta p X p + \varepsilon$, Where, Y is the dependent variable and Xi's are the independent variables with β as the partial regression coefficients of Y on Xi's where i=1, 2,.....p. In the present study, Y was taken as crop yield and Xi's were weather parameters viz,area, rainfall, relative humidity, maximum temperature, minimum temperature.

3. Results and Discussions

3.1 Correlation Analysis

Correlation coefficient between rice production and weather parameters in Thrissur District were calculated by using data from period2004-2005 to 2018-2019 and the results are presented in Table 2.

Table 2: Correlation coefficient between rice production and weather parameters in Thrissur District

Rice crop	Rainfall	Maximum temperature	Minimum temperature	Relative humidity
Rice production	-0.049NS (0.863)	0.123NS (0.662)	0.036NS (0.900)	-0.565**(0.028)

Figures in the parenthesis indicates P value
** significant at 5% NS- not significant

The results revealed that the production level of rice in Thrissur district was negatively correlated and non-significant with rainfall. The rice production of Thrissur district was positively correlated and non-significant with maximum temperature and minimum temperature. And relative humidity was negatively correlated and significant with rice production. Result concludes that there is a reduction in rice production with increase in rainfall and relative humidity. Even though the rainfall received above the rice crop requirement for growth it experiences reduction in yield as rainfall increases became of uneven distribution of rainfall during growing period.

3.2 Prediction Model for Rice Production in Thrissur District, Kerala:

The linear and various non-linear models were used to predict rice production level with the help of different weather parameters are given in table 3.2.1.The best model was selected based on the highest R^2 value. For predicting rice production level with the help of rainfall, relative humidity, maximum temperature and minimum temperature, cubic model was found to be best with highest $\mathbf{R^2}$ values **(0.28, (0.55), (0.063) &(0.258)** respectively.

Table 3: Comparison of models for predicting rice production with the help of weather parameters in Thrissur district, Kerala

Model	*Rainfall*		*Maximum Temperature*		*Minimum Temperature*		*Relative Humidity*	
	Coefficient	*R^2*	*Coefficient*	*R^2*	*Coefficient*	*R^2*	*Coefficient*	*R^2*
Linear	-0.655	0.002	189.7	0.015	20.52	0.001	-323.29	0.318
Logarithmic	26.19	0.000069	6172.73	0.015	402.63	0.0009	-23736.658	0.32
Quadratic	-0.066	0.116	-971.34	0.06	206.3	0.067	44.616	0.335
	32.07		62838.5		-9109.41		-6859.48	
Cubic	0.0016	**0.28**	-485.54	**0.063**	313.66	**0.258**	-107.29	**0.55**
	-1.278		45951.3		-20536.43		23605.8	
	319.46		-1448529		447486.45		-1730971.27	
Power	5483.899	7.60E-05	78.78	0.02	3969.0625	0.0025	2.9497E+11	0.318
Exponential	-0.00011	0.0022	0.037	0.019	0.0055	0.0029	-0.0564	0.317

3.3 Multiple Linear Regressions

Multiple linear regression fitted by using rice production as dependent variable and rainfall, relative humidity, maximum temperature and minimum temperature as independent variables and the results are given in Table 3.The fitted model was found to be significant (5%) with $\mathbf{R^2}$value of **0.453** and out of four independent variables selected for the study only relative humidity was found to be significant to the yield.

Table 4: Regression output

Variables	B (coefficients)	Standard Error	t	P value
Constant	49741.575	23914.617	2.080	.064
Rainfall	-1.320	3.371	-.392	.704
Minimum temperature	350.320	249.451	1.404	.191
Maximum temperature	-523.891	618.154	-.848	.417
Relativehumidity	-474.717	169.217	-2.805	**0.02**

(Significance at 5%)

Model Summary[b]

Model	R	R Square	Adjusted R Square	S.E of the Estimate
1	0.673[a]	0.453	0.234	638.504

a. Predictors (Constant), Relative humidity, Maximum temperature C, Rainfall mm, Minimum temperature C
b. Dependent Variable: Production in tonnes

Here the fitted model is $Y= 49741.575-1.320X_1+350.320X_2-523.891X_3-474.717X_4$

The table 3 provides data that relate to the goodness of fit of the regression equation. The R^2 of 0.453 indicates that 45% of the variation in rice production is explained by the regression variables X_1,X_2,X_3 and X_4.

Table 5: Regression results

Year	Regression model values	Error
2004	6553.575	735.008
2005	5849.125	230.125
2006	5537.271	-117.604
2007	5625.241	-676.825
2008	5868.699	123.718
2009	5065.506	255.661
2010	4396.468	26.782
2011	5847.525	-654.525
2012	5268.324	362.426
2013	5799.778	-245.361
2014	6073.593	261.074
2015	5584.292	989.541
2016	5903.234	-1113.400
2017	5910.568	-151.068
2018	5811.737	-24.071
2004	6553.575	735.008

3.4 Seasonal Variation

Seasonal Variation of Rainfall

Seasonal variation of the rainfall with their linear regression are estimated and displayed in figure 1. From the scatter diagram with their linear regression the trend during autumn and summer season is found to be decreasing whereas during the winter season it is slightly increasing.

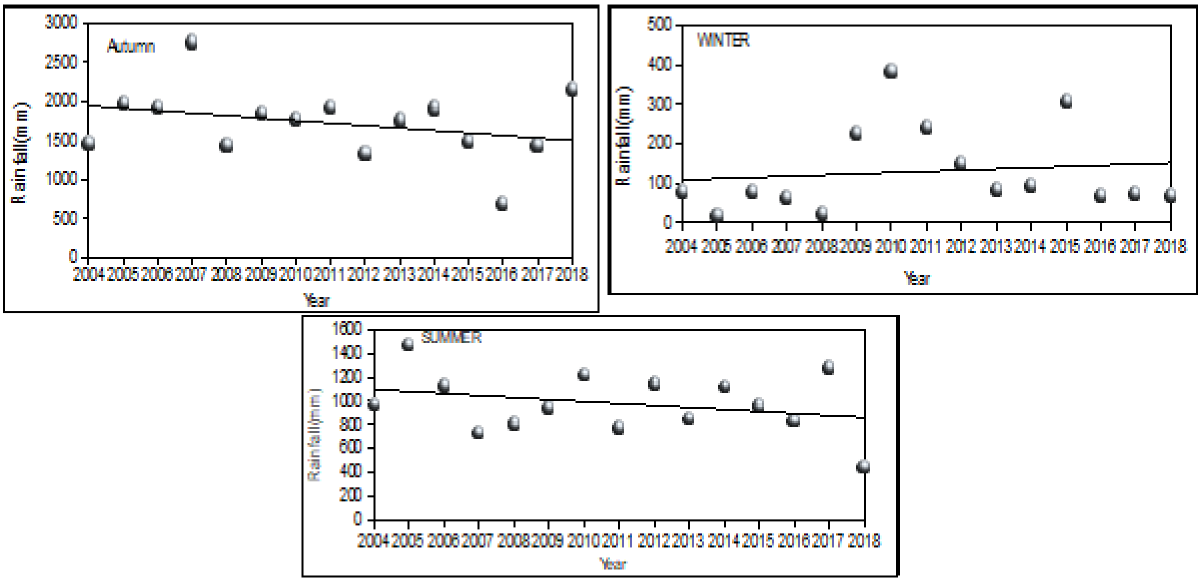


Figure 1: Seasonal Variations of Rainfall with their Linear Regression

Seasonal Variation Of Maximum Temperature

Seasonal variations of the maximum temperature with their linear regression are estimated and displayed in figure 2. From the scatter diagram with linear regression, the trend during autumn, winter and summer seasons are found to be increasing.

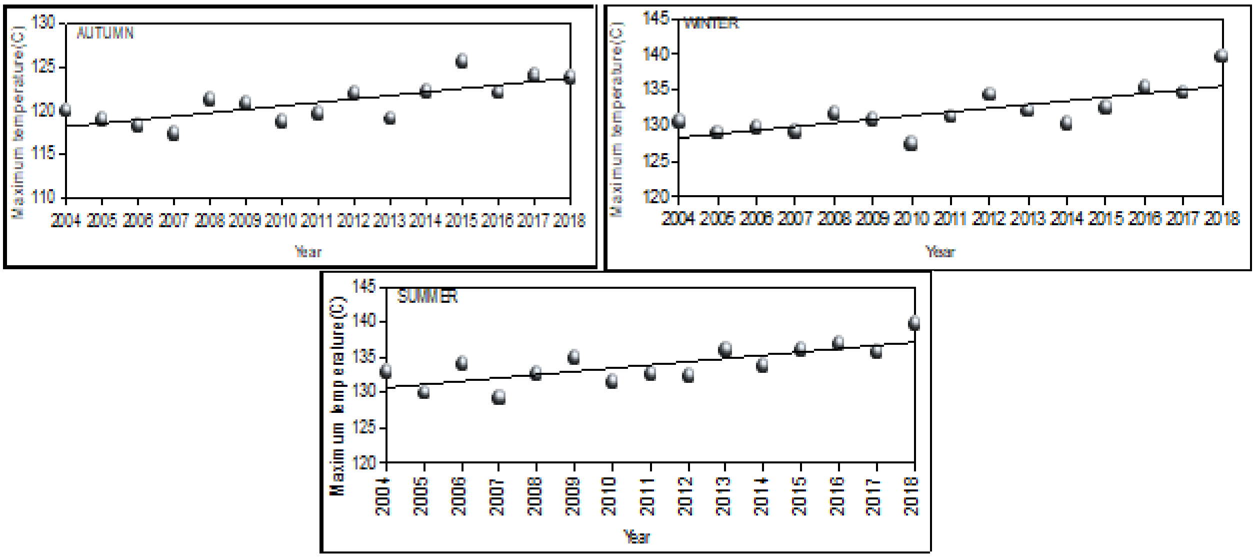
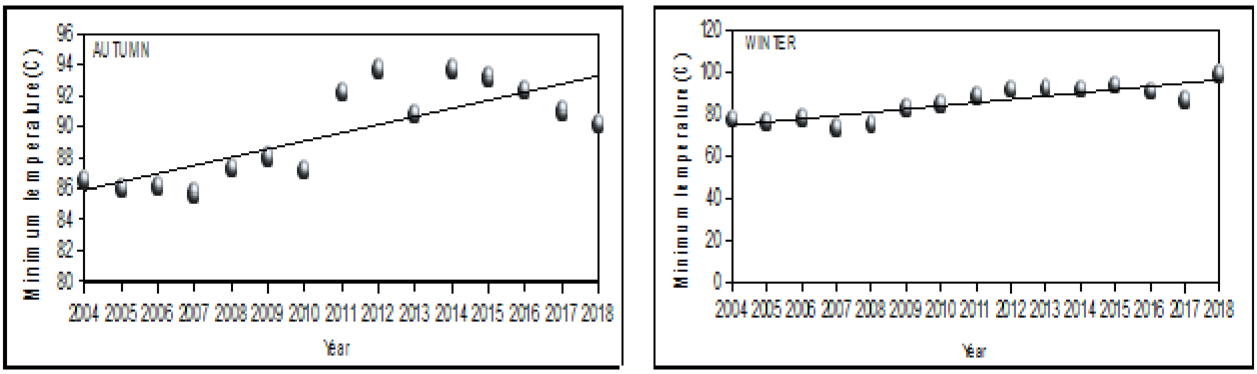


Figure 2: Seasonal Variations of Maximum temperature with their Linear regression

Seasonal Variation of Minimum Temperature

Seasonal variations of the minimum temperature with their linear regression are estimated and displayed in figure 3.From the scatter diagram with the linear regression, the trend during autumn and summer seasons are found to be increasing rapidly where in winter season it is increasing slowly.



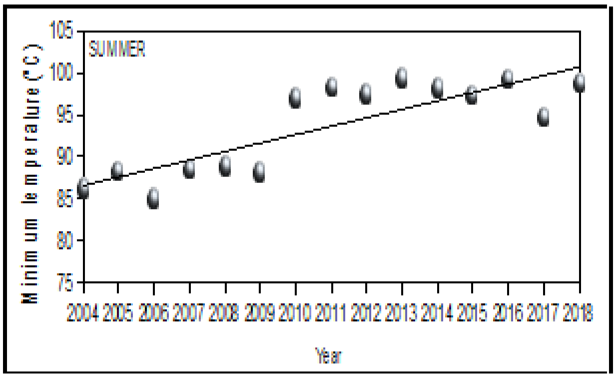


Figure 3: Seasonal Variation of Minimum temperature with their Linear Regression

Seasonal Variation of Relative Humidity

Seasonal variations of the relative humidity with their linear regression are estimated and displayed in figure 4.From the scatter diagram with linear regression, the trend during autumn season is found to be increasing slightly whereas during the summer season it is found to be decreasing. And during the winter season it is found be moderately same even there is a slight increase.

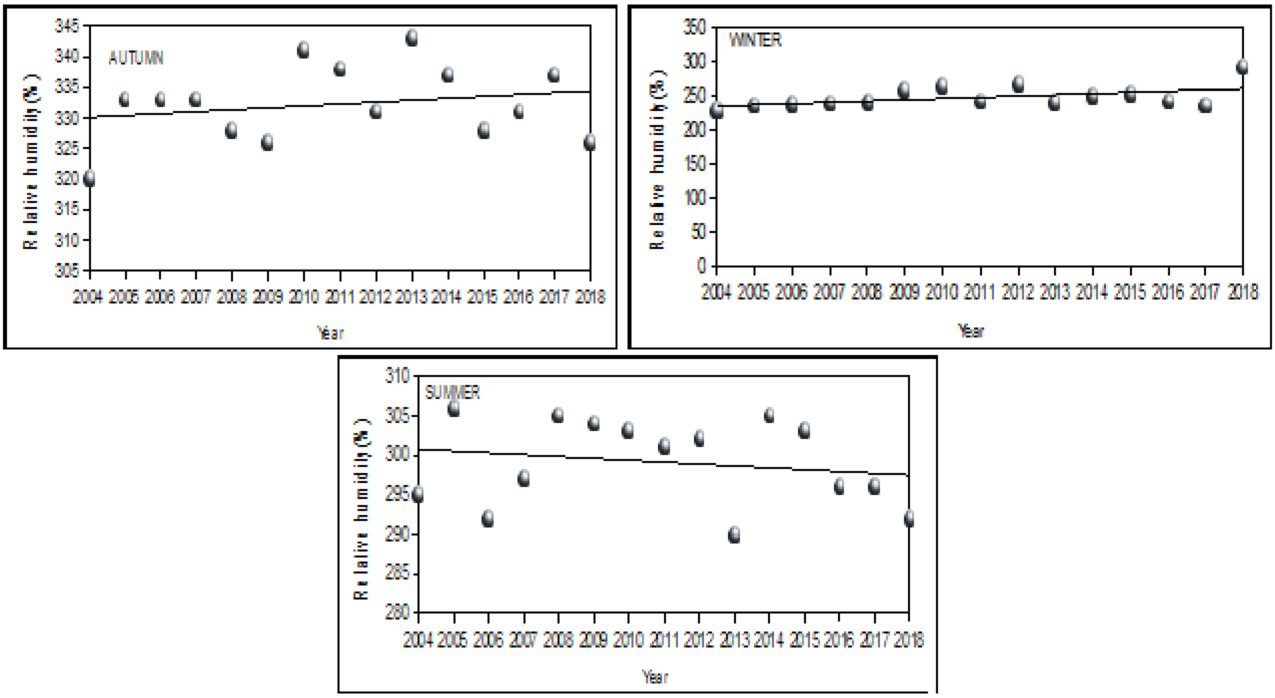


Figure 4: Seasonal Variations of Relative humidity with their Linear Regression

4. Conclusions

Climate change is a global environmental threat to all economic sectors, specifically the agricultural sector. Weather parameters play an important and unique role in the growth and development of crops and affect the crops differently during different stages of development. There is a need to educate the farmers to consider weather parameters during cropping period and selection of crops in order to mitigate food security

The main aim of this study is to analyze the climatic variability and its effect of rice productivity in different weather seasons. Rice production as dependent variables and other climatic factors as explanatory variables are compiled a panel data set for Thrissur district of Kerala during 2004 to 2018.

The result obtained from analysis of relationship of rice production with weather parameters shows non-significant and negatively correlated for rainfall. The rice production was positively correlated and non-significant with maximum and minimum temperature. Relative humidity was highly significant and negatively correlated with rice production. In case of multiple regression analysis, relative humidity shows significant and negatively influence on rice production. In prediction of rice production, among different linear and non-linear models, cubic model was found to be the best for Thrissur district rice production (highest R^2value) with respect to all weather parameters (viz, rainfall, relative humidity, maximum temperature and minimum temperature)

Therefore, it is observed that climatic factors have a non-linear relationship with rice production. When we consider Multiple Linear Regression model, Value of R^2 is 0.453 indicates that 45% variation in rice production is explained by climatic parameter.

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