Residual Mapping Of Value Of Winter Paddy Productivity On Monsoon Rainfall In Assam

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Abstract:
Rainfall has direct impact on agricultural productivity. It controls the growth of crops in different seasons. south west and north east monsoon is the main natural determinant of Indian agriculture. In state of Assam, Paddy cultivation is the major agricultural activity which is controlled by the south west monsoon. Winter paddy cultivation is highly reliant upon the monsoon rainfall. It is therefore assumed that a good relationship exists between these two. Apart from this, value of paddy production depends on many factors, where monsoon rainfall is also one of them. In this paper, interdependency of monsoon rainfall and the value of winter paddy production are examined. A linear positive relation is found between the two. Data are collected from Statistical Handbook of Assam for the period of 2014. IBM-SPSS24 and MS-Excel are used to compile and analyze the data. Geo-spatial mapping is done to show the linear positive relations of the variables for the districts of Assam.

***Index Terms* –** Monsoon rainfall, Winter Paddy productivity, Geo-spatial mapping**.**

INTRODUCTION :

Assam is situated in the north Eastern Region of India between 24°7'0" and 28°00'0" North latitude and between 89°42'0" and 96°02'0" East longitude. Arunachal Pradesh in the North, Mizoram in the South, Nagaland and Manipur in the East and Meghalaya, West Bengal and Bangladesh in the West bound the state. It has river valleys, Plateaus and mountains. The state occupies a total area of 78,438 sq. km. representing about 2.39 % of the total geographical area of India. The total population of the state is 26.66 million (2001 census). Rural population is 87.10% and urban population is 12.90%. The scheduled tribe population constitutes 12.4 % mainly distributed over 8 districts. The population density is 339 persons per kilometer square. The rivers Brahmaputra and Barak, and their tributaries, receive high rainfall almost round the year, which creates large- scale flood plains in this region. The river Brahmaputra originates in Tibet and flows down through China, India, and Bangladesh. In India, it enters Arunachal Pradesh draining nearly 226 km to reach the Assam plains. The river flows its waters for 700 km in length and finally enters Bangladesh to confluence into the Bay of Bengal. The channel length varies in the Assam valley and ranges between 1 and 18.5 km with an annual discharge of 19,820 cumecs[1]. The river Brahmaputra is known as the flooded river of Assam because of catastrophic events in 1954, 1962, 1966, 1972, 1973, 1977, 1978, 1983, 1984, 1987, 1988, 1991, 1993, 1995, 1996, 1998, 2016, and 2017 that devastated nearly 50% of the total geographical region of Assam in 2014[2]. The climate is characterized by a tropical monsoon humid climate with temperatures varying from 6°C in December to 38°C in May, and the average annual rainfall is about 1140 cm, most of which receives from the southwest monsoon. In 2012-13, Assam cultivates winter paddy in 1857 thousand hectares of land. Under these circumstances, an attempt has been made to establish a relationship between the value of winter paddy productivity and the Monsoon rainfall in the districts of Assam for the year 2014.

METHODS AND DATABASE:

I) Secondary data of Monsoon rainfall and winter paddy production for the year 2014 has been collected from the Statistical Handbook of Assam, 2014. The value of winter paddy productivity is calculated as,

Value of winter rice = $\frac{\text{Total value of winter rice in rs.}}{\text{Area under winter rice in hactare}}$

II) Method(s) used to compile and analyze data are,

Simple Linear Regression:

It is used for bi-variate data, of which one is independent (X) and the other is dependent (Y). The regression equation is Y= a ± bX, where 'a' is intercept and 'b' is determinant or slope or regression coefficient. Symbolically, $a = \bar{y}\text{-}b\bar{x}$ and $b = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}}$

't' test : For smaller number of observations, student 't' test is conducted.

$$t = \frac{b-0}{S.E(b)} \text{ , where S.E. (b)} = \frac{\delta^2 \mu}{\sqrt{\sum x^2 - \frac{(\sum x)^2}{n}}} \quad \text{and} \quad \delta^2 \mu = \frac{\sum y^2 \frac{(\sum y)^2}{n} - b\left\{\sum xy - \frac{\sum x^2 - y}{n}\right\}}{n-2}$$

III) Coefficient of Determination (R^2) :

To see how good the assumption of linearity in the relationship is, R^2 is worked out.

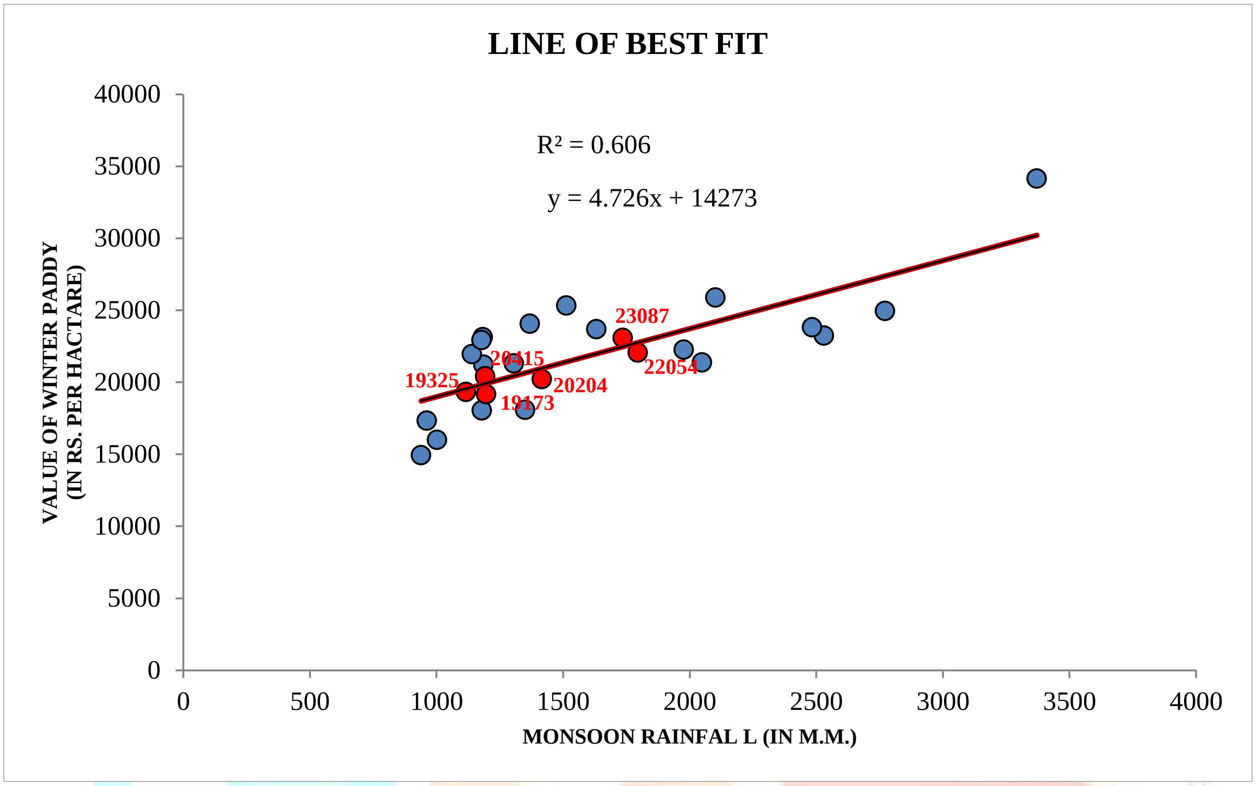
$R^2 = \frac{\textit{Explained Sum of Squares}}{\textit{Total Sum of Squares}}$, where Total sum of squares = $\sum y - \frac{(\sum y)^2}{n}$

Explained sum of squares = $b\left\{\sum xy - \frac{\sum x \sum y}{n}\right\}$

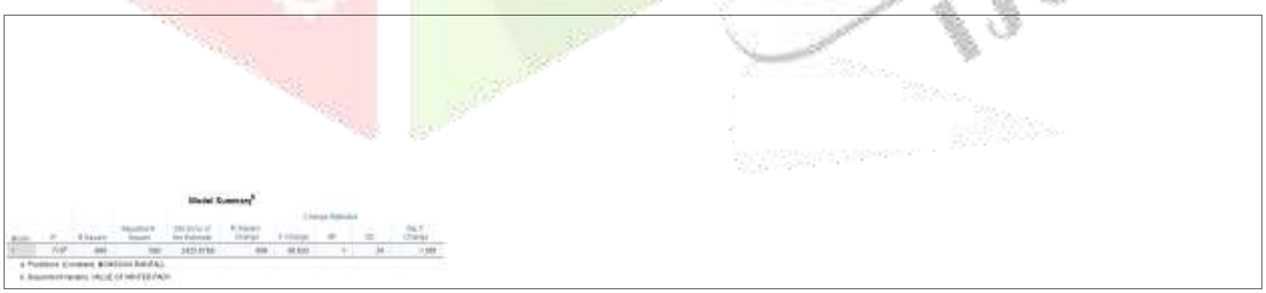
IV) **Tools used :**

IBM-SPSS24 is used to calculate various tables of Regression, Correlation, ANOVA and Residuals. MS-Excel is also used to draw basic statistical diagrams and scatter plots.

RESULTS AND ANALYSIS:



The regression equation of Y on X is Y= 14273 + 4.726X (Y= a ± bx), where the Slope or the Regression Coefficient 'b' shows the average estimated change in Y with respect to unit change in X . It implies to the fact that a millimeter change in monsoon rainfall by and large causes an increase of Rs. 4.726 per hectare in the value of winter paddy productivity. The regression equation also shows that a great deal of value of winter paddy cultivation in the districts of Assam depends on monsoon rainfall. It is observed that very high interdendence of monsoon rainfall on value of winter paddy productivity in the districts of Nagaon (Y=19325), Kamrup



(Y=20415),Morigaon (Y=19713), Baksa (Y=20204), Dhubri (Y=23087), and Hailakandi (Y=22054), as these scatter points lie on and around the line of best fit. It can be inferred that independent variables other than monsoon rainfall determines the value of winter paddy productivity in the remaining districts of Assam. While testing the significance of regression coefficient (b), the t-value stands at 6.077 (table-1). It is significant at 1%

level of significance for (26-2) degrees of freedom, as the calculated t-value is greater than the tabulated t-value at 1% level of significance. Hence, the relationship between monsoon rainfall and value of winter paddy productivity is highly significant (H_0 is accepted).

The value of R^2 (0.606) shows the assumption of linearity in the relationship. It indicates that 60.6% of the total variation in the value of winter paddy productivity is being explained by the monsoon rainfall. It is a good explanation and the remaining 39.40% of variations in dependent variable are yet to be explained. In other words, the value of winter paddy productivity also depends on other independent variables. R^2 change statistics also shows the F-value significant at 1% level of significance.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	[illegible]	1	[illegible]	[illegible]	[illegible][b]
	Residual	[illegible]	24	[illegible]		
	Total	[illegible]	25			

a. Dependent Variable: VALUE OF WINTER PADY

b. Predictors: (Constant), MONSOON RAINFALL

RESIDUAL MAPPING

Residual mapping is used as an effective tool for geographers to identify and regionalize the areas having negative and positive impact over dependent variable (here, Y= value of winter paddy in rs. per hectare) , when the effect of independent variable (here, X = Monsoon rainfall in m.m.) is removed.

When the effect of monsoon rainfall is removed,			
Negative Residuals	Following are districts having positive impact over the value of winter paddy productivity	Positive Residuals	Following are districts having negative impact over the value of winter paddy productivity
High	Barpeta, Bongaigaon, Cachar, Darrang, Golaghat,Karbi Anglong, Karimganj, Kokrajhar, Nalbari, Udalguri	High	Chirang, Dhemaji, Dibrugarh,Goalpara, Jorhat, Lakhimpur, N. C. Hills, Shonitpur Sibsagar, Tinsukia
Medium	Nagaon, Morigaon, Hailakandi, Baksa	Medium	Kamrup, Dhubri

Observation:

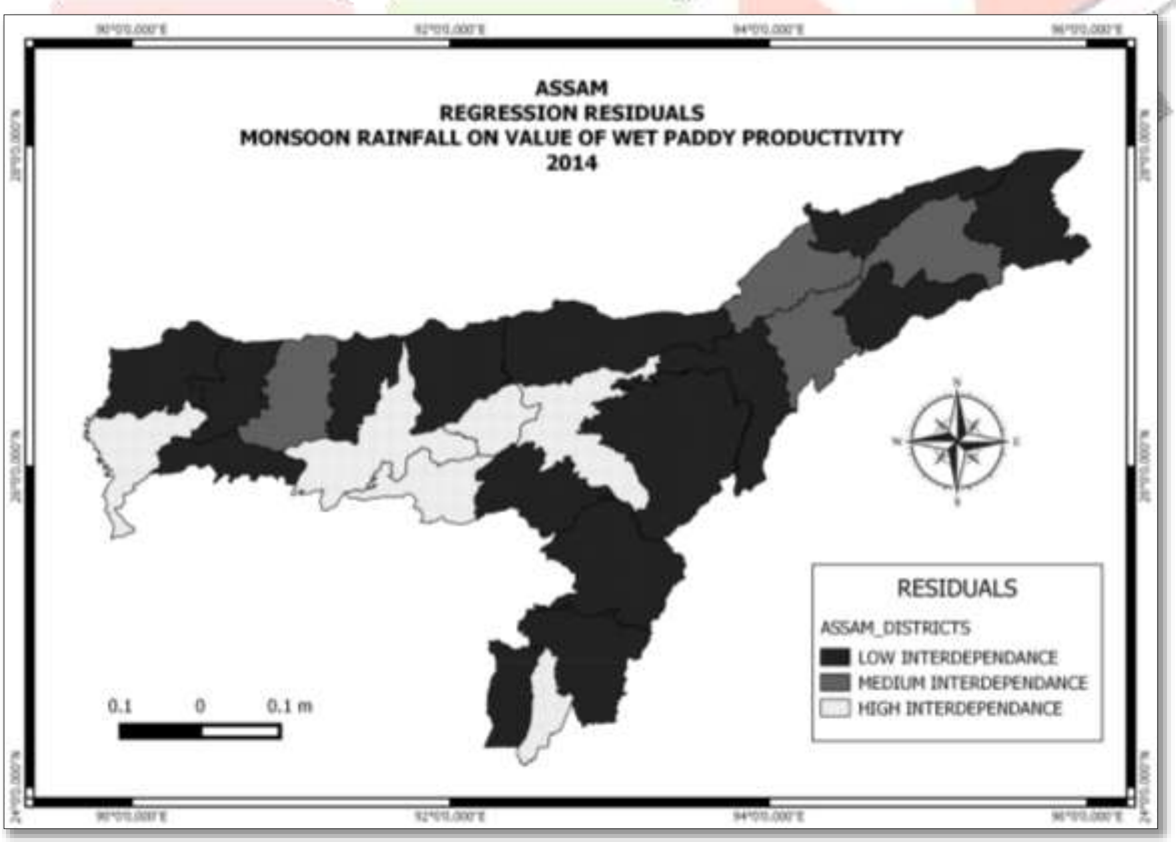
Medium negative values of residuals represented by Nagaon, Morigaon, Hailakandi and Baksa districts indicates that negative impact on the value of winter paddy productivity in the absence of monsoon is very low. Similarly, Medium positive values of residuals represented by Kamrup and Dhubri districts indicates that positive impact on the value of winter paddy productivity in the absence of monsoon is also very low. Districts having values of residuals ranging from -3 to +3 show very low residual. However, the regression equation shows that the value of winter paddy productivity of these districts is highly depended upon the monsoon rainfall.

In contrary, high negative values of residuals represented by Barpeta, Bongaigaon, Cachar, Darrang, Golaghat,Karbi Anglong, Karimganj, Kokrajhar, Nalbari and Udalguri districts indicates that negative impact on the value of winter paddy productivity in the absence of monsoon is very high. Similarly, high positive values of residuals represented by Chirang, Dhemaji, Dibrugarh,Goalpara, Jorhat, Lakhimpur, N. C. Hills, Sonitpur, Sibsagar, Tinsukia and districts indicates that positive impact on the value of winter paddy productivity in the absence of monsoon is also very high. Districts having values of residuals ranging from >-9 and >+9 show very high residual. The regression equation also indicates that the value of winter paddy productivity of these districts is less dependent upon the monsoon rainfall.

In fact, the basic postulate of the regression residual is that **'lower the residual, more is the interdependence and the higher the residual, lower is the interdependence'**.

Geo-spatial Mapping

High interdependent (low negative and low positive) districts shows very low residuals, thereby meaning- even if the effect of rainfall is removed, the positive or negative impact over value of winter paddy productivity would be vey negligible. These districts are Nagaon, Morigaon, Hailakandi, Baksa, Kamrup and Dhubri. But the medium (medium negative and medium positive) to high (high negative and high positive) interdependent districts would witness significant positive or negative impact over value of winter paddy productivity, when the effects of monsoon rainfall would be removed. Regionalization of this kind would be very helpful for regional planners of both agriculture and economics.



CONCLUSION

Effective and desired relationship can be achieved if independent and dependent variables are selected on basis of ground reality check. Theoretical or arbitrary selection of variables very often is unable to draw any concrete inferences. The problem stated here is a universal one. In this paper, there is a scope of adding more independent variables to predict the dependent variable, or identifying principal component(s) from sets of variables selected for the purpose.

NO CONFLICT OF INTEREST : There is no conflict of interest in terms of funding and collected data.

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DATA SOURCE : STATISTICAL HANDBOOK OF ASSAM-2014

	DISTRICT	VALUE OF WINTER PADDY IN RS. PER HACTARE	MONSOON RAINFALL (IN MM)
1	BAKSA	20204	1415.5
2	BARPETA	22278	1976.6
3	BONGAIGAON	23247	2529.6
4	CACHAR	21387	2048.8
5	CHIRANG	34153	3371.1
6	DARRANG	17331	962
7	DHEMAJI	23687	1632
8	DHUBRI	23087	1736.2
9	DIBRUGARH	21307	1305.3
10	GOALPARA	25327	1512.9
11	GOLAGHAT	16000	1001.8
12	HAILAKANDI	22054	1794.7
13	JORHAT	21224	1185.8
14	KAMRUP	20415	1192.3
15	KARBI ANGLONG	14932	938.8
16	KARIMGANJ	23831	2483.2
17	KOKRAJHAR	24962	2772.1
18	LAKHIMPUR	25888	2101.7

19	MORIGAON	19173	1196
20	N. C. HILLS	23143	1182.9
21	NAGAON	19325	1116.4
22	NALBARI	18088	1350.6
23	SHONITPUR	21966	1139.9
24	SIBSAGAR	22928	1178.1
25	TINSUKIA	24057	1369.1
26	UDALGURI	18043	1179

$$\text{VALUE OF WINTER RICE} = \frac{\text{TOTAL VALUE OF WINTER RICE IN RS.}}{\text{AREA UNDER WINTER RICE IN HACTARE}}$$

REGRESSION RESIDUALS

	DISTRICT	VALUE OF WINTER PADDY IN RS. PER HACTARE (Y)	PREDICTED VALUE ($\hat{Y}$)	RESIDUALS (Y-$\hat{Y}$)/Y*100	CATEGORY OF RESIDUALS
1	BAKSA	20204	20962.433283	-3.753876871	Low Negative
2	BARPETA	22278	23614.301379	-5.998300471	Medium Negative
3	BONGAIGAON	23247	26227.887293	-12.82267515	High Negative
4	CACHAR	21387	23955.532668	-12.00978477	High Negative
5	CHIRANG	34153	30204.980507	11.55980293	High positive
6	DARRANG	17331	18819.103786	-8.586370008	High Negative
7	DHEMAJI	23687	21985.654532	7.182612691	High Positive
8	DHUBRI	23087	22478.124066	2.637310755	Low Positive
9	DIBRUGARH	21307	20441.606578	4.061545135	Medium Positive
10	GOALPARA	25327	21422.764690	15.415309	High Positive
11	GOLAGHAT	16000	19007.206352	-18.7950397	High Negative
12	HAILAKANDI	22054	22754.606482	-3.176777374	Medium Negative
13	JORHAT	21224	19876.826259	6.347407374	High Positive
14	KAMRUP	20415	19907.546527	2.485689312	Low Positive
15	KARBI ANGLONG	14932	18709.456058	-25.2977234	High Negative
16	KARIMGANJ	23831	26008.591838	-9.137643565	High Negative

17	KOKRAJHAR	24962	27373.989615	-9.662645681	High Negative
18	LAKHIMPUR	25888	24205.548391	6.498963261	High Positive
19	MORIGAON	19173	19925.033449	-3.922356694	Medium Negative
20	N. C. HILLS	23143	19863.120293	14.17223224	High Positive
21	NAGAON	19325	19548.828316	-1.158231907	Low Negative
22	NALBARI	18088	20655.703218	-14.19561708	High Negative
23	SHONITPUR	21966	19659.893902	10.49852544	High Positive
24	SIBSAGAR	22928	19840.434556	13.46635312	High Positive
25	TINSUKIA	24057	20743.137829	13.77504332	High Positive
26	UDALGURI	18043	19844.688132	-9.985524203	High Negative