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Effect of Pre-monsoon Rainfall on Maize Yield in Manipur

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ABSTRACT

The study examines the impact of pre-monsoon rainfall deviation on maize yield in Manipur. Secondary data on rainfall was extracted from high resolution $0.5^0 \times 0.5^0$ daily gridded data obtained from India Meteorological Department for the period of twenty-eight years (1980-2007). The annual yield of maize was regressed on time trend and rainfall (January, February, March, April, May). Different regression models were worked out using different explanatory variables and functional form and the log-lin model turns out to be the best model based on logistic (sign and coefficients), statistical (p-value) and econometric (value of R-square) criteria. The regression model shows that time trend has positive and significant (1% level of significance) impact on yield of maize and March rainfall deviation has negative and significant (5% level of significance) impact on yield of maize. This is because, in Manipur, the tasseling and silking stage (critical stage of maize) falls during March. Hence, 1 per cent increase in March deviation leads to 5.6 unit decrease in yield of maize. The study recommended planting of drought-tolerant maize variety in the study area.

Keywords: Impact, maize, rainfall deviation, Manipur

Maize is an inferior grain and is cultivated both for food and fodder purpose. The crop requires 50-100 cm rainfall and cannot be grown in areas more than 100 cm rainfall. In areas receiving less rainfall, the crop is irrigated as a long dry spell is harmful for crop growth. The grain of maize plant ripens faster in cool and dry weather. Maize plant usually grows well in temperatures varying from 21°C to 27°C, although it can tolerate temperatures as high as 35°C. Frost is injurious to maize and grows well in frost free areas. Fertile well-drained alluvial or red loams free from coarse materials and rich in nitrogen are the best soils for its successful growth. Maize thrives best in well drained plain and also grows in some hilly areas. It is intercropped along with legumes, vegetables and oilseeds in India. The major producing states in the country during 2014-15 are Andhra Pradesh with a total production of 4236 thousand tones followed by, Karnataka (3915 thousand tones), Maharashtra (2203 thousand tones), Bihar (2178 thousand tones) and Madhya Pradesh (2026 thousand tones) (GoI, 2016).

Maize production is greatly affected by price fluctuation, pest and disease, poor storage facilities and insufficient resource utilization. Climatic factors like temperature, rainfall, relative humidity, sunshine (day length) are the important elements that affect crop production (Sowunmi and Akintola, 2010). A 1°C rise in *rabi* temperature and *kharif* temperature reduced the gross value of output per hectare by 4 per cent and 5 per cent, respectively (Brithal *et al.* 2014a). Maximum temperature has negative effect on yield of *kharif* season crop. A 1°C rise in maximum temperature in *kharif* season reduced the yield of rice, sorghum and pigeon pea by 11-12 per cent and maize and groundnut by 9 per cent. But, the marginal effect of rainfall on *kharif* season crop productivity has positive and significant effect except in maize (Birthal *et al.* 2014b). A study shows that drought intensity of 10 per cent will reduce the area under rice by 4.4 per cent, pearl millet by 2.8 per cent, maize by 1.1 per cent, sorghum by 0.9 per cent and groundnut by 0.5 per cent. While, there will be decline in yield of pearl millet by 7.6 per cent, sorghum by 6.8 per cent, rice by 6.3 per cent, pigeon pea by 4.5 per cent, cotton by 4.1 per cent, groundnut by 3.6 per cent and maize by 2.8 per cent (Kumar *et al*. 2014).

Less rainfall (drought) or flood can result in 100 per cent loss in maize production (Chi-chung and Mccarl, 2004). The changing climatic pattern affects crop yield depending on the sowing time (*kharif* or *rabi*), crop water requirement, critical stages of crop growth and the resistant capacity of the crop from water stress. Studies showed that rainfall variation within seasons and variation during the crop growth period has great influence on crop yield (Hu and Buyanovsky, 2003). High or low rainfall during the reproductive stage of maize compared to the vegetative state has more impact on maize yield (Malone *et al.* 2009). Although drought or low rainfall during all the stages affect crop yield, the crop is more sensitive during pollination. Studies in North-East India also showed that climate change is likely to reduce maize yield by 50 per cent. By 2030, the irrigated maize may have yield loss between 15-50 per cent and rain fed maize by about 35 per cent (Kumar *et al.* 2011)

Manipur is located at a longitude of 93°03′ E to 94°78′ E and latitude of 23°56′N to 25°68′N. Manipur has a total geographical area of 22, 327 sq. km., out of which ninety per cent (20, 089 sq. km.) is covered under hill districts and the remaining (2, 238 sq. km.) under valley districts. About 17, 418 sq. km. is under forest area which forms about 78 per cent of the total geographical area. The state experienced a sub-tropical climate and an average annual rainfall of 1657.20 mm in 2015 (GoM, 2016). During 1975-2007, 24.24 per cent of drought weeks were experienced during transplanting stage and panicle initiation stage of rice. About 21.21 per cent and 18.18 per cent of drought weeks coincide with active tillering stage and milking stage of rice, respectively (Laitonjam, 2015). Das *et al*. (2009) in their study in North-East India during 1983-2009 reported a rainfall deficit of 67 per cent in 2009 in Manipur. In 2011, the state has registered the highest rainfall deficit (-52%) among the North-Eastern states (NES). During monsoon season of 2016, Manipur has registered the highest rainfall deficit of 87 per cent (163 mm as against 1262.7 mm) among the NES (www.newsepapers.com).

Maize is the second cereal crop grown in the state with a total area of 5.30 thousand ha and production of 11.32 thousand tones during 2014-15. Maize is grown in all the hill and valley districts of Manipur. The area under the crop was higher in hill region than in valley region with total area of 6.20 thousand ha and 19.99 thousand ha in valley and hill region, respectively (GoM, 2016). With this drawback the present study analyses the trend in annual rainfall, the drought scenario during pre-monsoon season (maize growing season) and impact of pre-monsoon rainfall on maize yield.

Data Base and Methodology

Secondary data on daily rainfall for the last thirty-three years (1975-2007) were extracted from high resolution $0.5^0 \times 0.5^0$ daily gridded data obtained from India Meteorological Department to analyse the meteorological drought in Manipur. The available secondary data for the period of 1980-2007 on area, production and yield of maize were collected from the Department of Agriculture, Government of Manipur to estimate the impact of drought on maize yield.

The intensity of drought was based on the percentage departure of rainfall from normal and was calculated using the following equation (Eq. 1):

$$\mathrm{Di} = \frac{Pi - \mu}{\mu} \times 100 \qquad \text{....(1)}$$

where,

Di = percentage deviation from long term mean

Pi = annual rainfall (mm)

μ = long term mean of annual rainfall

The intensity of drought was categorized into five different categories *viz.*, no drought (M_0), mild drought (M_1), moderate drought (M_2), severe drought (M_3) and extreme drought (M_4), as per IMD Protocol (IMD, 1971).

Table 1: Drought codification based on percentage deviation of rainfall from normal value

Percentage departure of rainfall from normal	Drought intensity	Code
0.0 or above	No drought	M_0
0.0 to -25.0	Mild drought	M_1
-25.0 to - 50.0	Moderate drought	M_2
-50.0 to -75.0	Severe drought	M_3
-75.0 to less	Extreme drought	M_4

To study the impact of drought on maize yield, the annual yield of maize for the period of twenty-eight years (1980-2007) was regressed on time trend and pre-monsoon rainfall deviation (January, February, March, April and May). Time trend was included in the model as an alternative to represent the technological change that occurs during the study period. Different regression models were run using different combinations of explanatory variables (irrigation, time trend, annual rainfall, maximum and minimum temperature, *etc*) and different functional specifications (linear, lin-log, log lin, quadratic, *etc*). Log-lin model turns out to be the best model based on the logic (sign and values of coefficients), statistical criteria (value of t-ratios) and econometric criteria (value of R square).

The regression model applied in this study is given below:

$$\log Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + b_7 x_7 + \mu$$

Where, Y= annual yield of maize (MT/ha), x_1= January rainfall deviation (%), x_2= February rainfall deviation (%), x_3= March rainfall deviation (%), x_4= April rainfall deviation (%), x_5= May rainfall deviation (%), μ= error term. Dummy variables indicating 0 = no drought, 1 = mild drought, 2 = moderate drought, 3 = severe drought and 4 = extreme drought were assigned for rainfall deviations.

RESULTS AND DISCUSSION

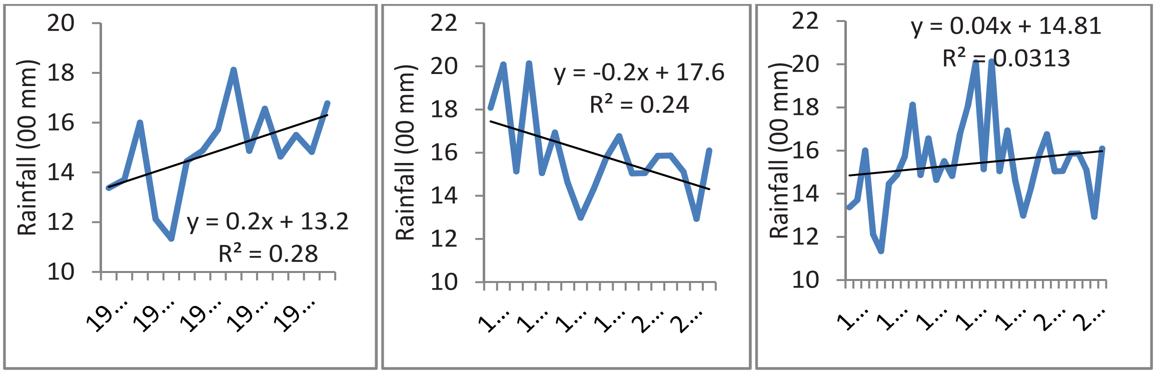
The trend in annual rainfall during the period 1975-2007 showed an increasing but insignificant trend (β=3.52) for the annual rainfall (Table 1). When the overall period was sub-divided into two sub-groups, there was increasing and significant trend (β =20.66) during the first sub-period (1975-1989) whereas it exhibited negative and significant trend (β = -18.49) at 5 per cent level of significance during the second sub-period (1990-2007).

Table 2: Linear trend coefficients for annual rainfall in Manipur

Season	Trend	p-value
1975-1989	20.66**	0.045
1990-2007	-18.49**	0.036
1975-2007	3.52	0.325

*** 5% level of significance.*

In Manipur, during the study period there was occurrence of mild, moderate, severe and extreme drought during all the pre-monsoon months (Fig. 2). Tasseling and silking stage which fall during March in Manipur are the most critical stages of maize production. Even during these critical stages, Manipur registered 24.24 per cent severe drought, 12.12 per cent extreme drought and 9.09 per cent mild and moderate drought. Mid January and mid February is the planting time of maize in Manipur and during this planting stage, the study area experienced 30.30 per cent and 12.12 per cent of extreme drought, 15.15 per cent and 12.12 per cent of severe drought, 18.18 per cent and 30.30 per cent of moderate drought and 3.03 per cent and 15.15 per cent of mild drought. During April and May, there was 21.21 per cent and 24.24 per cent of mild drought, 24.24 per cent and 15.15 per cent of moderate and 6.06 per cent and 9.09 per cent of severe drought in the study area.



During 1975-1989 (b) During 1990-2007 (c) During 1975-2007

Fig. 1: Trend in annual rainfall during 1975-1989, 1990-2007 and 1975-2007

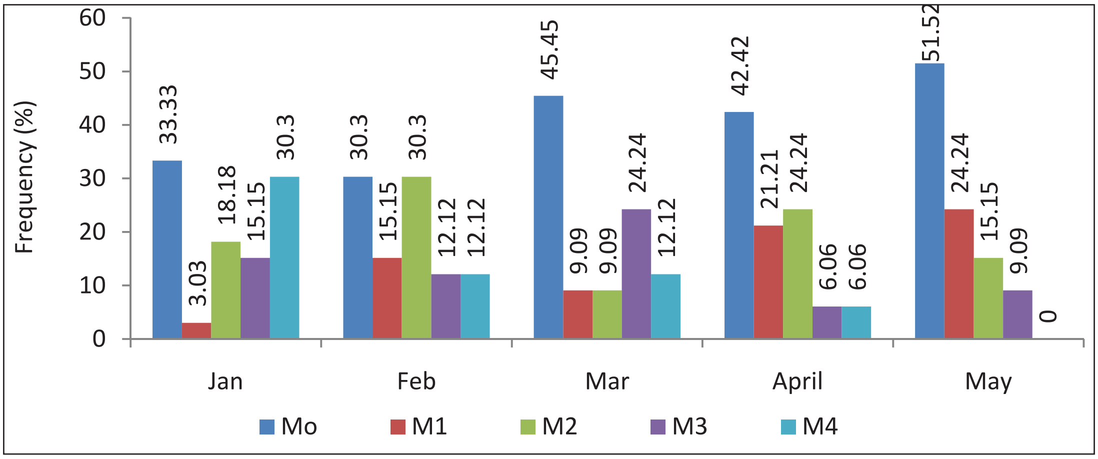


Fig. 2: Pre-monsoon drought scenario in Manipur

Table 3: Descriptive statistics for the variables used in the regression model

Variables	Mean	Maximum	Minimum	CV (%)
Dependent Variable				
Yield (MT/ha)	2572.11	3669.28	1546.25	21.12
Independent variables				
January rainfall (mm)	10.49	48.25	0.00	115.77
February rainfall (mm)	40.08	179.00	0.20	104.88
March rainfall (mm)	70.13	179.63	2.15	73.11
April rainfall (mm)	124.48	331.28	0.00	55.70
May rainfall (mm)	177.18	314.80	53.55	36.81

Source: *Authors' calculation.*

The average annual yield of maize in Manipur was 2572.11 MT/ha during 1975-2007 with a maximum of 3669.28 MT/ha and a minimum of 1546.25 MT/ha (Table 3). During pre-monsoon months, the average rainfall was highest during May (177.18 mm) and lowest during January (10.49 mm). The CV for all the independent variables was also high, with highest in January (115.77%) and lowest in May (36.81%).

The slope coefficients were estimated using the Ordinary Least Squares (OLS) technique. The model showed that time trend have positive and significant (at 1% level of significance) impact on yield of maize (Table 4). Time trend represents change in technology hence, a 1 per cent increase in technology leads to 1.70 unit increase in yield of maize. The result also showed that March rainfall deviation has negative and significant (at 5% level of significance) impact of maize yield. A 1 per cent increase in March rainfall deviation leads to 5.60 unit decrease in maize yield.

Table 4: Slope coefficients and p-value of log-lin model

Variables	β-coefficient	Standard error	p-value
Intercept	7.573	0.10	6E-27
Time	0.017***	0.01	0.004
January deviation	0.012	0.03	0.638
February deviation	0.002	0.03	0.925
March deviation	-0.056**	0.03	0.051
April deviation	0.024	0.04	0.532
May deviation	-0.004	0.04	0.92
R-square	0.46		
Adjusted R-square	0.30		

Source: Authors' calculation.

As tasseling and silking stage of maize falls during the month of March in Manipur, hence it is a cause of concerned for maize farmers. Studies also showed that moisture stress during tasseling cause lag between pollen shed and silk development and largest yield reduction will occur from this stress. Drought or moisture stress during tasseling and silking stage cause 4 per cent and 7 per cent yield loss per day, respectively. During this critical period irrigation should be given if rainfall is less. There might be grain loss of 30-40 per cent if there is single irrigation omission during the sensitive stages and a higher grain loss of 66-93 per cent due to prolong water stress and irrigation omission (Cakir, 2004). The R-square value of 0.46 showed that 46 per cent of the variation in yield of maize was explained by the explanatory variables.

CONCLUSION

In Manipur, there was significant declined in annual rainfall from 1990 onwards. The monthly drought scenario showed that there was occurrence of drought in all the months in the study area. Moreover, there was occurrence of mild, moderate, severe and extreme drought during all the pre-monsoon months which is a cause of concern for the maize farmers. The impact of pre-monsoon rainfall deviation on maize yield showed that March rainfall deviation has negative and significant impact on yield of maize plant. Hence, an increase in rainfall deviation during the critical stages of maize plant leads to decline in yield of maize plant. Also, time trend which represents change in technology has a positive impact on yield of maize in the study area. Hence, the study recommended planting of drought tolerant maize varieties in the study area.

REFERENCES

Birthal, P.S., Digvijay, S.N., Kumar, S., Aggarwal, S., Suresh, A. and Khan, M.T. 2014a. How sensitivity is Indian agriculture to climate change? *Indian Journal of Agricultural Economics*, **69**(4): 474-487.

Birthal, P.S., Khan, M.T., Negi, D.S. and Agarwal, S. 2014b. Impact of climate change on yield of major crops in India: Implications for food security. *Agricultural Economics Research Review*, **27**(2): 145-155.

Cakir, R. 2004. Effect of water stress at different development stages on vegetative and reproductive growth of corn. *Field Crops Research*, **89**: 1-16.

Chi-chung, C. and McCarl, B.A. 2004. Yield Variability as influenced by climate; A statistical investigation. *Journal of Climate change*, **66**: 239-261.

Das, A., Ghosh, P.K., Choudhury, B.U., Patel, D.P., Munda, G.C., Ngachan S.V. and Chowdhury, P. 2009b. Climate change in North-East India: Recent facts and events–worry for agricultural management. *Impact Climate Change on Agriculture*, **38**(8): 32-37.

GoI. 2016. Statistical Year Book India 2016. Directorate of Economics and Statistics, Government of India, India.

GoM. 2016. Statistical year book-Manipur 2013, Manipur, Directorate of Economics and Statistics. Government of Manipur, Imphal.

Hu, Q. and Buyanovsky, G. 2003. Climate effects on corn yield in Missouri. *Journal of Applied Meteorology*, **42**: 1626–1635.

IMD. 1971. Climate diagnostic bulletin of Indian - June, July, August 1971; Rep. No. 88, 89 and 90, National Climate Centre. India Meteorological Department, Pune.

Kumar, P., Joshi, P.K. and Aggarwal, P. 2014. Projected effect of droughts on supply, demand and price of crops in India. *Economics and Political Weekly*, **49**(52): 54-63.

Kumar, S.N., Aggarwal, P.K., Rani, S., Jain, S., Saxena, R. and Chauhan, N. 2011. Impact of climate change on crop productivity in Western Ghat, Coastal and North Eastern region in India. *Current Science*, **101**(3): 332-341.

Laitonjam, N. 2015. Drought and Rice Productivity in Manipur: A Socio-Economic Analysis. M.Sc. Thesis, Submitted to Central Agricultural University, Imphal, Manipur, India.

Malone, R.W. and Ma, L.N. 2009. Uptake Affects Model (RZWQM). In *New Advances in Understanding and Quantification of Plant N Uptake*; Ma, L., Bruulsema, T., Ahuja, L., Eds.; CRC Press: Boca Raton, FL, USA, 2009; pp: 259–275.

Sowunmi, F.A. and Akintola, J.O. 2010. Effect of climate variability on maize production in Nigeria. *Research Journal of Environmental and Earth Science*, **2**(1): 19-30.

www.newsepapers.com/india/english/shillong-times. CM seeks action plan as State records rain deficit. Accessed 18 September 2016.