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Rainfall Variability and its Influence on Agricultural GDP in Central Dry Zone of Karnataka: An Econometric Analysis

Sagar, M[1*]., Mahadevaiah, G.S[2]., Shripad Bhat[3] and Harish Kumar H.V[4]

[1]Post-Doctoral Associate, Indian Institute of Management Bangalore, Bengaluru, Karnataka, India
[2]Department of Agricultural Economics, University of Agricultural Sciences, G.K.V.K., Bengaluru, Karnataka, India
[3]Scientist, ICAR-Indian Institute of Pulses Research, Kanpur, Uttar Pradesh, India
[4]Scientist, ICAR-IASRI, New Delhi, India

*Corresponding author: sagarmandya@gmail.com

ABSTRACT

Agriculture is highly dependent on rainfall. Any irregularities impact the production and farm income of the rural households. Hence it is important to estimate the impact of rainfall on farm income in order to understand the extent of dependence and responsiveness of agriculture income on climate parameters. Analysis of the time series data on rainfall for the period 1901 to 2015 of Chitradurga district exposed the existence of breaks in the series. Auto-regressive error correction model revealed a significant influence of rainfall received on agricultural GDP of Chitradurga district of central dry zone.

Keywords: Rainfall, agricultural GDP, Central dry zone, homogeneity tests, auto-regressive error correction model

Farming in India as well as in the world is facing different challenges today. The climate change and variability is one among them. There are various studies related to the climate change and variability at macro level such as international, national and state level (Anonymous, 2007 and Chand *et al.* 2011). It is observed from the literature that climate change is an ongoing process with respect to the temperature, annual rainfall and rainfall distribution. The key findings from the research at macro level may not holds good for micro level such as individual districts, since the agro-climatic conditions, land pattern, cropping systems, cropping pattern and resource availability vary over region (Kumar *et al.* 2011 and Jangra, 2011). The study on climate parameters and its impact on agriculture at regional level is need of the hour.

Agriculture is the major occupation in the rural areas and also generates major revenue in the villages. The normal activities of the farming and allied sectors largely depend on rainfall and number of rainy days in the year. Any deviation in climatic parameters from their normal mean acts as stress to the rural livelihood and rural economy. The agrarian crisis in the state has increased over years due the distress conditions in the rural agriculture. With this background the present study attempted to see the changes in monthly and annual rainfall and its impact on district agricultural income and cropping pattern in Chitradurga District of Karnataka State.

Methodology

Chitradurga district is located at latitude 14° 14′ N and longitude 76° 26′ E in central part of Karnataka State. The annual average rainfall is about 514 mm. The South west monsoon plays the major role in the agriculture and its activities in the district.

The data regarding climate parameters was collected from Karnataka State Natural Disaster Monitoring Cell. The secondary data regarding area, production and productivity, domestic product was taken from Directorate of Economics and Statics.

The present study was undertaken to access the climate variability including drought, floods and any long term variation of climatic parameters from their normal mean level. The study aims to find the cause and effect relationship between climate parameters on the cropping pattern and crop production.

(a) Autoregressive error correction model

To understand the impact of rainfall during south west and north east monsoon season and number of rainy days during monsoon period on the agricultural GDP, autoregressive error model was employed. To remove the effect of inflation on agricultural GDP the series was expressed in 2004-05 prices. In time series regression there will be problem auto-correlated errors, to avoid that autoregressive error terms were also included in the model.

Ln (Agricultural GDP) = f(ln Pre Monsoon, ln SW monsoon, ln NE monsoon, ln T Max, ln T Min)

(b) Homogeneity Tests

Pettitt's test, Standard normal homogeneity test (SNHT) and Buishand's test were used to check the homogeneity with following null and alternate hypothesis.

- H_0: Data are homogeneous
- H_a: There is a date at which there is a change in the data

RESULTS AND DISCUSSION

The Chitradurga district is mainly driven by Agriculture income (19.39 %) which constitutes about ₹ 87,727 lakhs at constant 2004-05 prices. Chitradurga district stands 21st in the State according to the Gross District Domestic Product. The district population is around 1.716 million during 2011.

The temporal variability of key climate parameters was analysed by employing homogeneity test. The homogeneity test was used to find out the shift (increase or decrease) or break point in long term climate parameters such as rainfall and temperature.

With respect to analysis on rainfall, the test was carried out for total annual rainfall, total rainfall during monsoon months (June to September) and total rainfall received during individual months of monsoon period. The number of rainy days was analysed according to total annual rainy days over the years, total rainy days over the monsoon period and total rainy days over individual monsoon months.

Daily minimum and maximum temperature over the years, minimum and maximum temperature over different seasons of monsoon such as pre-monsoon (January to May), south west monsoon (June to September) and north east monsoon (October to December) seasons and monthly minimum and maximum temperature during south west monsoon season (June to September) were analysed. The results which are found to be statistically significant are presented and interpreted.

(a) Total rainfall

The homogeneity test was carried out for the data pertaining to total annual rainfall received over the years, total rainfall received during monsoon months (June to September) and total rainfall received during individual months of monsoon period in Chitradurga district for a period 115 years. The three tests such as Pettitt's test, Standard normal homogeneity test (SNHT) and Buishand test were employed in the homogeneity test analysis. Since the Standard normal homogeneity test takes into account of normal distribution in the analysis, therefore this test was used for explanation in whole manuscript. The tests which are proved to be significant statistically were presented and interpreted in this section.

The results obtained for the respective analysis was found non-significant over all the listed parameters which can be interpreted that there exists no change or shift in long term trend of total annual rainfall over the years, total rainfall received during monsoon months and total rainfall received during individual months of monsoon period in Chitradurga district. These findings are in confirmatory with the results of Patle and Libang (2014) whose findings reported that there is no change in quantity of annual rainfall.

(b) Number of rainy days

The rainfall data pertaining to daily, monthly and different monsoon seasons was analysed by employing homogeneity test for the period 1901 to 2015. The analysis of rainy days for all months in Chitradurga district is presented in Table 1. The results indicated that per day rainfall with less than

Table 1: Homogeneity test to detect the shift in intensity of rainfall in Chitradurga district

	Rainy days < 2.5 mm			Rainy days >= 2.5 mm			Rainy days_ 2.51 to 5.00 mm			Rainy days_ 5.1 to 7.50 mm		
	Pettitt's test	SNHT	Buishand's test	Pettitt's test	SNHT	Buishand's test	Pettitt's test	SNHT	Buishand's test	Pettitt's test	SNHT	Buishand's test
t	1968	2009	1974	1968	2003	1973	1969	1969	1969	1955	1995	1968
p-value (Two-tailed)	< 0.0001	0.000	< 0.0001	0.025	0.009	0.017	0.000	< 0.0001	< 0.0001	0.003	0.002	0.001

Table 2: Homogeneity test to detect the shift in intensity of rainfall during monsoon months (June to September) in Chitradurga district

Particulars	Rainy days < 2.5 mm			Rainy days >= 2.5 mm			Rainy days_2.51 to 5.0 mm			Rainy days_5.1 to 7.5 mm
	Pettitt's test	SNHT	Buishand's test	Pettitt's test	SNHT	Buishand's test	Pettitt's test	SNHT	Buishand's test	Buishand's test
t	1973	2009	1974	1955	2003	1973	1969	1970	1970	1968
p-value (Two-tailed)	< 0.0001	0.000	< 0.0001	0.032	0.040	0.028	< 0.0001	< 0.0001	< 0.0001	0.019

2.5 mm per year found increased from 10.93 days to 65.50 days since 2009. The rainy days more than or equal to 2.5 mm rainfall has increased from 34.84 to 44.33 days since 2003. The rainy days ranging from 2.51 to 5.00 mm rainfall per day also found increased from 7.36 to 11.25 days since 1969. The high intensity rainfall ranging between 5.1 to 7.5 mm per day also found increased from 4.68 to 7.44 days from 1995.

The shift in the total annual rainfall was not found but the shift was observed in the quantity of rainfall received per day. The rainfall received per day with less than 2.5 mm, more than or equal to 2.5 mm, 2.51 to 5.00, 5.1 to 7.5 mm were found increased significantly from the normal long term trend. Since the rainfall received per day with more than 5.0 mm has increased indicating that intensity of the rainfall has increased. Rainfall with high intensity could hinder the crop growth and development. These findings are in line with the results of the Dourte *et al.* (2015).

(c) Number of rainy days during Monsoon months (June to September)

The analysis of rainy days during monsoon for Chitradurga district is presented in Table 2. The results obtained from homogeneity test indicated that rainy days with less than 2.5 mm per day has increased from 8.04 to 38.17 days since 2009; the rainfall interval with more than or equal to 2.5 mm per day rainy days has increased from 34.84 to 42.83 days since 2003. Similarly, the rainy days between 2.51 to 5.00 mm per day also found increased from 4.17 to 7.02 days since 1970 during monsoon season.

The rainy days with rainfall more than or equal to 2.5 mm and 2.51 to 5.00 mm per day found increased by 7 and 3 days significantly. The rainy days with more than 5.00 mm found increased during monsoon months. These findings corroborate with the results of the Dourte *et al.* (2015).

Economic impact of climate variability on agricultural production

Agriculture sector is dependent on prevailing climate and is regional specific. The interaction of climate parameters with the biophysical component of plants results in crop yield. The crop production is directly dependent on climate parameters and other minor variables. The agricultural GDP is calculated by multiplying the individual crop production with the respective product price. The Agricultural Gross Domestic product may vary significantly with the climatic parameters.

The relationship between the climatic parameters and the district agricultural GDP was studied by employing the autoregressive error model and

Table 3: Estimates of autoregressive error model for Chitradurga District

Variable	DF	Estimate	Standard Error	t Value	ApproxPr> |t|
Intercept	1	-2.6209	1.1536	-2.27	0.0382
ln Pre Monsoon	1	-0.0076	0.0107	-0.71	0.4865
ln SW Monsoon	1	0.0273	0.0153	1.78	0.0945
ln NE Monsoon	1	0.0099	0.0148	0.67	0.5129
ln T Max	1	0.5394	0.3173	1.70	0.1098
ln T Min	1	0.2755	0.2575	1.07	0.3015
AR1	1	-0.2406	0.2905	-0.83	0.4204
AR2	1	-0.2458	0.3005	-0.82	0.4262

Note: *R-Square 0.54, MSE 0.001;* ***Source:*** *Economic analysis of climate variability on farming systems in Karnataka, Sagar, M., 2016.*

presented in Table 3. The dependent variable is district Agricultural Gross Domestic Product whereas the independent variables are climatic parameters such as rainfall and temperature which are classified according to various seasons such as pre-monsoon, south west monsoon and north east monsoon over the years. The maximum and minimum temperature over the years for the respective district were included in the model. In each decade, the selected districts such as Chitradurga and Kolar districts were declared drought prone by the revenue department, GOK very frequently in a decade. There is no major irrigation facility available for the cultivation of crops. Therefore, farmers of these districts largely depend on monsoon for crop production. Therefore the district agricultural GDP was regressed with the climatic parameters to find out the impact on respective district agricultural GDP.

Estimates of autoregressive error model for Chitradurga district

The results of the autoregressive error model for Chitradurga district is presented in Table 3.

The results from Table 3 revealed that agricultural GDP of the Chitradurga district is significantly responsive to rainfall received during south-west monsoon. The quantity of south west monsoon rainfall received has a positive impact on Chitradurga district agricultural gross domestic product. Results from the auto-correlated error model indicated that for every one per cent increase in quantity of south-west monsoon rainfall the agricultural GDP increases by 0.028 per cent. These findings are corroborated by the results of the Poudeland Shaw (2016).

CONCLUSION

The long term trend of rainfall was found affected due to climate variability in the Chitradurga district of Karnataka. The district agricultural gross domestic product is more prone to south west monsoon. Diversification strategies towards income, asset and livelihood play a crucial role in ensuring food security under climate change, as they have the potential to address two of the Climate-Smart Agriculture (CSA) pillars by contributing to food security and adaptation to climate change. Providing incentives for adaptation of various diversification activities need to be encouraged as it will help the households to improve the food security and to become resilient to climate shocks.

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