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Impact of Climate Variability on Cropping Pattern in Chitradurga District, Karnataka: An Economic Analysis

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Abstract

Agriculture is highly dependent on rainfall. Any irregularities in climate variables impact the production, cropping pattern and farm income of the rural households. Analysis of rainfall data from 1900 to 2015, temperature data from 1971 to 2014 of Chitradurga district showed that there were break points in annual rainfall, pre-monsoon rainfall, monsoon rainfall and minimum and maximum temperature. Results of Markov chain analysis revealed that rice, arecanut, groundnut, maize and *ragi*were the stable crops in the districts as more than 75 per cent of their previous share in area of these crops were retained.

The climate variability is one of the serious challenges faced by Indian agriculture. It is observed from the literature that climate change is an ongoing process with respect to the temperature, annual rainfall, rainfall distribution and number of rainy days. The key findings from the research at macro level may not hold good for micro level such as individual districts, since the agro-climatic conditions, land pattern, cropping systems, cropping pattern and resource availability vary over space (Chand *et al.*, 2011 and Jangra, 2011). Therefore, there is a need to carry out studies on climate parameters and their impact on agriculture at regional level.

The normal agricultural and allied activities 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 to the distress conditions in agriculture. With this background, the present study attempted to analyse the changes in monthly rainfall, annual rainfall and temperature and their impact on cropping pattern in Chitradurga District, Karnataka State.

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 economy of Chitradurga district was mainly driven by agriculture as it contributed 19.39 percent to the district's GDP which was about ₹ 87,727 lakhs at constant prices of 2004-05. Chitradurga district stood 21st in the State according to the Gross District Domestic Product criterion.The study aims to find out the influence of climate variables on cropping pattern changes in Chitradurga district.

The data regarding climate parameters (rainfall and temperature) were collected from India Meteorological Department and Karnataka State Natural Disaster Monitoring Cell. The secondary data regarding area, production and productivity were collected from Directorate of Economics and Statistics, Bengaluru.

a. Identification of structural break in the time series: Homogeneity testwas carried out to examine the exact shift or break in the time series data.Pettitt's test, Standard normal homogeneity test (SNHT) and Buishand's test were used to check the homogeneity with null and alternate hypothesis given below.

H_0: Data are homogeneous

H_a: There is a break in the series of data related to rainfall and temperature

b. Markov Chain Analysis: The Markov Chain Analysis was carried out to examine shifts in cropping pattern as influenced by climate variables for the period 1956-57 to 2011-12.The current study aims to identify the changes in cropping pattern due to climate parameters for the study period.

The results of homogeneis1ty testfor climate parameters is indicated below.

a) Rainfall : The rainfall data for the Chitradurga district was analysed for the period 1900 to 2015. The

TABLE I

Homogeneity tests for climate parameters (rainfall & temperature) in Chitradurga district

Pettitt's test		Standard normal homogeneity test		Buishand's test	
Annual rainfall					
K	940.00	T0	33.80	Q	18.28
t	1985	t	2005	t	2004
p-value (Two-tailed)	0.047	p-value (Two-tailed)	0.021	p-value (Two-tailed)	0.001
Pre-Monsoon rainfall					
K	1020.00	T0	27.42	Q	17.24
t	2003	t	2003	t	2003
p-value (Two-tailed)	0.025	p-value (Two-tailed)	0.001	p-value (Two-tailed)	0.005
Monsoon rainfall					
K	1244.00	T0	31.12	Q	17.35
t	1973	t	2005	t	2004
p-value (Two-tailed)	0.002	p-value (Two-tailed)	0.022	p-value (Two-tailed)	0.002
Annual Maximum temperature					
K	8574082.00	T0	255.47	Q	779.85
t	02/02/1995	t	10/02/2010	t	21/01/2002
p-value (Two-tailed)	< 0.0001	p-value (Two-tailed)	< 0.0001	p-value (Two-tailed)	< 0.0001
Annual Minimum temperature					
K	9863383.00	T0	465.19	Q	1037.92
t	13/03/1997	t	16/02/2011	t	12/03/1997
p-value (Two-tailed)	< 0.0001	p-value (Two-tailed)	< 0.0001	p-value (Two-tailed)	< 0.0001
		Minimum temperature			
August					
K	253.00	T0	10.47	Q	8.59
t	1997	t	2011	t	1997
p-value (Two-tailed)	0.011	p-value (Two-tailed)	0.015	p-value (Two-tailed)	0.036
September					
K	249.00	T0	21.98	Q	10.07
t	1997	t	2010	t	1997
p-value (Two-tailed)	0.013	p-value (Two-tailed)	0.000	p-value (Two-tailed)	0.006
		Maximum temperature			
June					
K	240.00	T0	13.64	Q	9.92
t	1994	t	2008	t	1994
p-value (Two-tailed)	0.019	p-value (Two-tailed)	0.001	p-value (Two-tailed)	0.011
July					
K	279.00	T0	19.24	Q	11.49
t	1995	t	2009	t	2001
p-value (Two-tailed)	0.004	p-value (Two-tailed)	0.000	p-value (Two-tailed)	0.001
August					
K	328.00	T0	23.75	Q	12.32
t	1992	t	2008	t	1994
p-value (Two-tailed)	0.000	p-value (Two-tailed)	< 0.0001	p-value (Two-tailed)	0.000

total rainfall was analysed according to year, months and different rainfall seasons. Significant structural breaksoccurredin the total annual rainfallseries from 524.49 mm to 764.60 mm, 528.36 mm to 1204.00 mm and 525.65 mm to 1168.00 mm during the years 1985, 2005 and 2004, respectively (Table I).In the case of pre-monsoon rainfall, shift was observed from 98.98 mm to 193.26 mm during 2003 (Table I). The monsoon rainfall was analysed for the study period which revealed that significant breaks in terms of increase in rainfall from 257.08 mm to 424.08 mm, 269.14 mm to 831.92 mm and 267.43 mm to 796.87 mm2 during the years 1973, 2005 and 2004, respectively (Table I).

b) Temperature: The temperature was analysed for the period 1971 to 2014 by employing homogeneity test to identify the shift. The results revealed that temperature (maximum & minimum) was increased during the study period (Table I). The maximum temperature was increased from 30.19°C to 30.79°C, 30.33°C to 31.57°C and 30.25°C to 30.97°C during 02.02.1995, 10.02.2010 and 21.01.2002, respectively whereas the minimum temperature was also increased from 18.80°C to 19.45°C, 18.93°C to 20.39°C and 18.80°C to 19.45°C during 13.03.1997, 16.02.2011 and 12.03.1997, respectively. Temperature was analysed for monsoon season (June to September) and the results revealed that the minimum temperature for August month increased from 19.84°C to 20.23°C, 19.93°C to 20.84°C and 19.84°C to 20.22°Cduring 1997, 2011and 1997. The minimum temperature for September month was increased from 19.65°C to 20.21°C, 19.73°C to 21.19°C and 19.65°C to 20.21°C during 1997, 2010 and 1997 (Table I).

The results of the structural break analysis for maximum temperature in the monsoon season revealed that June month recorded significant shift (increase) in temperature from 29.35°C to 30.40°C, 29.57°C to 31.46°C and 29.35°C to 30.40°C during 1994, 2008 and 1994, respectively whereas in July month there was a significant shift (increase) from 27.60°C to 28.55°C, 27.79°C to 29.77°C and 27.67°C to 28.85°C during 1995, 2001 and 2009, respectively. Shift in maximum temperature was recorded during August month from 27.22°C to 28.17°C, 27.44°C to 29.32°C and 27.25°C to 28.23°Cin the years 1992, 1994 and 2008, respectively (Table I).

Markov Chain analysis: The dynamics of change in area under different crops in Chitradurga district were analyzed using the Markov transitional probability matrix (Table II). The row elements in the transitional probability matrix indicate the extent of loss (decrease) in the area on account of competing crops. The column elements indicate the probability gains in previous share of area from other competing crops and the diagonal elements indicate probability of retention of the previous share in area by the respective crop in the current year. The study revealed that the maize, groundnut, arecanut, *ragi* and rice are the stable crops cultivated in the district as they retained more than 75 per cent of their previous share in area.

Rice gained its previous share in area from cotton (3.6%) and ragi (3.7%), whereas, it lost its previous share in area to coconut (2.5 %), ragi (2.4%) and *aware* (1.0%), respectively. While maize gained its previous share in area from sunflower (7.0%) and ground nut (4.0%) whereas maize lost its previous share in area to ragi (5.0%), coconut (2.9%), ground nut (2.4%), sunflower (2.4%) and arecanut (2.0%), respectively. Groundnut gained its previous share in area from green gram (30.7%), onion (29.6%), sunflower (22.2%), coconut (9.7%), maize (2.4%) and ragi (2.4%). Groundnut lost its previous share in area to coconut (4.1%), maize (4.0%) and sunflower (3.2%) respectively. Arecanut gained its previous share in area from maize (2.0%) while it lost its previous share to bengal gram (6.3%) and *save* (5.1%). Ragi gained its previous share in area from sesamum (99.4%), *aware* (22.3%), greengram (14.0%), safflower (12.2%), onion (6.8%), maize (5.0%), rice (2.4%) and horesegram (2.03%) respectively. Ragi lost its previous share in area to sesamum (7.2%), jowar (6.6%), rice (3.6%), groundnut (2.4%) and horsegram (2.4%), respectively.

The study found significant structural breaks (increase) were found in annual rainfall, pre-monsoon rainfall and monsoon rainfall with respect to rainfall analysis. Significant structural breaks (increase) were

TABLE II

Transition Probability Matrix of the crops cultivated in Chitradurga district (1956-57 to 2011-12)

Crops	Rice	Jowar	Maize	Bengalgram	Ground nut	Sunflower	Cotton	Sugarcane	Arecanut	Coconut	Ragi	Avare Navane	Others Tar
Rice	0.929	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.024	0.000	0.000
Jowar	0.000	0.558	0.000	0.000	0.000	0.000	0.123	0.000	0.000	0.000	0.000	0.037	0.068
Maize	0.000	0.000	0.837	0.000	0.024	0.025	0.000	0.000	0.021	0.029	0.051	0.000	0.000
Bengalgram	0.000	0.000	0.000	0.693	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ground nut	0.000	0.000	0.041	0.005	0.858	0.032	0.000	0.000	0.005	0.041	0.000	0.000	0.000
Sunflower	0.000	0.000	0.070	0.000	0.223	0.703	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Cotton	0.036	0.246	0.000	0.000	0.000	0.000	0.641	0.000	0.000	0.000	0.000	0.000	0.047
Sugarcane	0.000	0.000	0.000	0.000	0.000	0.261	0.000	0.740	0.000	0.000	0.000	0.000	0.000
Arecanut	0.000	0.000	0.000	0.064	0.000	0.000	0.000	0.000	0.885	0.000	0.000	0.000	0.000
Coconut	0.000	0.000	0.000	0.011	0.097	0.000	0.000	0.000	0.000	0.706	0.000	0.000	0.000
Ragi	0.037	0.066	0.000	0.000	0.024	0.000	0.000	0.000	0.000	0.006	0.765	0.000	0.000
Navane	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.623	0.000
Tur	0.000	0.537	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.292
Bajra	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.115	0.000
Onion	0.000	0.000	0.000	0.000	0.296	0.000	0.000	0.000	0.000	0.195	0.068	0.000	0.000
Save	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.404	0.000
Haraka	0.000	0.673	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Horse gram	0.000	0.388	0.000	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.204	0.045	0.000
Green gram	0.000	0.000	0.000	0.014	0.307	0.000	0.000	0.000	0.000	0.000	0.140	0.000	0.032
Sesamum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.994	0.000	0.000
Castor	0.000	0.251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.228
Nigerseed	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Safflower	0.000	0.000	0.000	0.000	0.000	0.103	0.000	0.000	0.000	0.263	0.122	0.000	0.157
Tobacco	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.746	0.000
Dry chillies	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.052	0.000	0.000	0.000
Avare	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.223	0.000	0.000
Others	0.000	0.000	0.000	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.259

Table II contd.

TABLE II Contd.

Transition Probability Matrix of the crops cultivated in Chitradurga district (1956-57 to 2011-12)

Crops	Bajra	Onion	Save	Marka	Horsegram	Greengram	Sesamum	Castor	Nigerseed	Safflower	Tobacco	Dry chillies		
Rice	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.008	0.010	0.000
Jowar	0.000	0.077	0.002	0.016	0.000	0.089	0.005	0.000	0.004	0.000	0.000	0.001	0.021	0.000
Maize	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.007
Bengalgram	0.000	0.000	0.000	0.000	0.000	0.040	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.253
Ground nut	0.000	0.002	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000
Sunflower	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
Cotton	0.000	0.000	0.000	0.000	0.022	0.000	0.000	0.002	0.000	0.000	0.000	0.006	0.000	0.000
Sugarcane	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Arecanut	0.000	0.000	0.052	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coconut	0.000	0.164	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000
Ragi	0.000	0.001	0.000	0.000	0.024	0.000	0.072	0.000	0.001	0.000	0.004	0.000	0.001	0.000
Navane	0.176	0.000	0.000	0.071	0.130	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Tur	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.000	0.000	0.000	0.000	0.000	0.116
Bajra	0.431	0.000	0.000	0.059	0.377	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Onion	0.000	0.441	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Save	0.062	0.000	0.180	0.000	0.328	0.000	0.000	0.008	0.000	0.000	0.019	0.000	0.000	0.000
Haraka	0.000	0.000	0.000	0.327	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Horse gram	0.000	0.000	0.048	0.000	0.244	0.000	0.029	0.005	0.000	0.000	0.011	0.010	0.000	0.000
Green gram	0.000	0.000	0.000	0.000	0.081	0.265	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.147
Sesamum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000
Castor	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.521	0.000	0.000	0.000	0.000	0.000	0.000
Nigerseed	0.000	0.000	0.000	0.000	0.000	0.000	0.372	0.000	0.628	0.000	0.000	0.000	0.000	0.000
Safflower	0.000	0.033	0.000	0.000	0.000	0.099	0.000	0.000	0.000	0.217	0.000	0.000	0.006	0.000
Tobacco	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.254	0.000	0.000	0.000	0.000	0.000
Dry chillies	0.000	0.105	0.299	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.544	0.000	0.000
Avare	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.044	0.000	0.000	0.728	0.000
Others	0.000	0.000	0.042	0.000	0.000	0.089	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.577
Bajra	0.431	0.000	0.000	0.059	0.377	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Onion	0.000	0.441	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Save	0.062	0.000	0.180	0.000	0.328	0.000	0.000	0.008	0.000	0.000	0.019	0.000	0.000	0.000
Haraka	0.000	0.000	0.000	0.327	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Horse gram	0.000	0.000	0.048	0.000	0.244	0.000	0.029	0.005	0.000	0.000	0.011	0.010	0.000	0.000
Green gram	0.000	0.000	0.000	0.000	0.081	0.265	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.147
Sesamum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000
Castor	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.521	0.000	0.000	0.000	0.000	0.000	0.000
Nigerseed	0.000	0.000	0.000	0.000	0.000	0.000	0.372	0.000	0.628	0.000	0.000	0.000	0.000	0.000
Safflower	0.000	0.033	0.000	0.000	0.000	0.099	0.000	0.000	0.000	0.217	0.000	0.000	0.006	0.000
Tobacco	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.254	0.000	0.000	0.000	0.000	0.000
Dry chillies	0.000	0.105	0.299	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.544	0.000	0.000
Avare	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.044	0.000	0.000	0.728	0.000
Others	0.000	0.000	0.042	0.000	0.000	0.089	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.577

observed in annual maximum and minimum temperature, August and September months for minimum temperature, whereas, June, July and August for maximum temperature, respectively. The Markov chain analysis revealed that rice, arecanut, groundnut, maize and *ragi* were the stable crops in the districtsas more than 75 per cent of their previous share in area of these crops were retainedin Chitradurga.

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