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Temperature and Rainfall Variability in South Costal Districts of Andhra Pradesh

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ABSTRACT
Temperature and rainfall gridded data of Guntur, Prakasam and Nellore districts of Andhra Pradesh for the period of 1951-2010 were collected from AICRPAM, CRIDA, Hyderabad and analysed using Weather Cock software for its variability considering 1951-1980 as base period. Mean annual rainfall and seasonal rainfall were increased from base period during the study period in all seasons. Coefficient of variability for South West monsoon period and winter period was increased and rest of the period it was decreased. Mean rainy days and coefficient of variability was decreased from base period, except in Guntur district during 2001-2010. Coefficient of variability of South West monsoon rainfall over Nellore district had shown higher variability. During North East monsoon season and summer season there is no particular trend in rainy days and coefficient of variability in all the three districts. Winter season rainy days were increased but particular trend was not recorded in coefficient of variability.After thorough analysis of data, the cooler & warmer decades are 1991-2000 and 2001-2010 respectively and temperature maximum and minimum were higher than base period. Maximum temperature increase was higher in Rabi season (0.8^{o}C) than in Kharif season (0.5^{o}C).Maximum temperature increase was 0.6^{o}C in Prakasam district and 0.5^{o}C in Guntur and Nellore districts respectively.During Kharifminimum temperature was higherin Nellore and Prakasam districts(0.4^{o}C). Whereas,in Guntur district Kharif and Rabi increase in minimum temperatures was 0.3^{o}C.
Key words: Temperature, rainfall, rainy days, variability

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INTRODUCTION

Earth's climate is not constant from its origin. Its climate is continuously changed with time due to natural forces. Post industrialization era climate change is un-precedent due to anthropogenic causes along with natural causes. Human-driven climate change willcontinue for decades and longer (IPCC, 2001).The changes in climate are likely to impactdeveloping countries significantly, where natural-resource dependency is high (Thomas and Twyman, 2005). Rupa Kumar*et al*.,(2003) analysed meteorological data of India compiled over the past century reports that the earth is warming, but there are significant differences at regional level. Accordingto the World Meteorological Organization, the decade of 1998-2007 is thewarmest on record. The global mean surface temperature for 2007 is currentlyestimated at 0.4 °C above the 1961-1990 annual average of 14 °C. Surface air temperature data over the country has been documented for about a century and reported that asymmetry in the temperature trends in terms of daytime and night time temperatures over India particularly for the last two decades (Hinganee*t al*., 1985; Rupa Kumar *et al*., 1994).

Most of the studies during the last four decades have clearly pointed out that the monsoon rainfall is trend less, particularly on an all India Scale (Parthasarthy, 1984) with a prominent epochal nature of variability. Contrasting to that,Rupa Kumar *et al.,* (1992) have shown regional monsoon rainfall trends in the past century. Ashok and Chandranath (2009) analysed gridded rainfall data (1951-2004) of West Midnapore district and concluded that, mean annual rain days varies from 83 to 86 days and during South West monsoon period and mean rainy days were 60 to 66 days, which accounts for nearly 75% of annual rain days and annual rainfall of 80%.Accurate analysis and interpretation of climatological data often helps to formulate plans as well as to prioritize the intended interventions so that the limited available resources can be utilized very rationally to tackle the menace of climate extremes. Hence, to strengthen and supplement the existing data of information an attempt has been made to study the variability of

maximum temperature, minimum temperature, seasonal rainfall and rainy days over south coastal districts of Andhra Pradesh

MATERIAL AND METHODS

Gridded daily temperature maximum, temperature minimum and rainfall data of India Meteorological Department, Pune were collected for a period of 60 years (1951-2010) from All India Coordinated Research Project on Agrometeorology, CRIDA, Hyderabad and was used to analyze variability of temperatures in *Kharif* and *Rabi* seasons and variability of rainfall seasons in South Coastal districts (Guntur, Prakasam and Nellore) of Andhra Pradesh.

Data Analysis

In order to understand the long term temperature and rainfall variability during agricultural season's daily data was analysed using Weather cock software over the region. For rainfall analysis coefficient of variation, mean and standard deviation are taken into account. A lower standard deviation shows less variation in rainfall occurrence, however, it does not say anything about quantitative rainfall. To realize the distribution quantitatively with its quality (distribution variation) coefficient of variation helps as a lowest coefficient of variation shows a consistent rainfall indicating good regularity of rains. At the same time, higher coefficient of variation indicates irregularity in rainfall occurrence. As a base period for normal values 1951-1980 was taken for analysis. Daily data was analyzed for annual, seasonal and monthly temperature, rainfall andrain days in considered time period.

RESULTS AND DISCUSSION:

Rainfall variability:

Seasonal rainfall over Guntur district was observed that standard deviation and coefficient of variation was increased as compared to base period but decadal variation existed in four seasons (Table-1). Highest deviation from mean and coefficient of variation was observed during 1981-1990 decade. Out of the four

Table-1: Seasonal rainfall variability over Guntur district

Season		1951-1980	1981-1990	1991-2000	2001-2010
Winter (Jan-Feb)	Mean	6.4	18.2	19.5	13.8
	SD	7.8	26.9	16.6	17.3
	CV (%)	121.3	148.5	85.1	125.1
Summer (Mar-May)	Mean	66.6	74.3	65.7	87.6
	SD	61.9	109.5	39.1	56.8
	CV	92.9	147.4	59.5	64.8
South West (Jun-Sep)	Mean	577.1	576.0	571.7	610.2
	SD	165.7	178.7	157.5	170.5
	CV	28.7	31.0	27.5	27.9
North East (Oct-Dec)	Mean	233.7	200.0	255.0	238.6
	SD	119.9	121.4	118.2	107.8
	CV	51.3	60.7	46.4	45.2

seasons winter season rainfall was recorded highest variability followed by summer, North East and South West monsoon seasonal rainfall. Highest mean seasonal rainfall was observed during South West monsoon period. Decadal annual rainfall was increased from base period except in 1981-1990. Similar study was conducted by Tripathi *et al*., (2007) for Roorke district of Uttarakhand and concluded that, a rise in the total annual rainfall by 5.8 mm per year was reported.

Table-2: Seasonal rainy days variability over Guntur district

Seasons		1951-1980	1981-1990	1991-2000	2001-2010
Winter (Jan-Feb)	Mean	0.8	1.2	2	1.7
	SD	1.0	2.1	1.5	1.8
	CV	135.6	174.8	74.5	103.9
Summer (Mar-May)	Mean	5.9	4.8	5.8	5.8
	SD	4.0	3.3	2.5	3.1
	CV	67.1	69.3	42.8	53.8
South West (Jun-Sep)	Mean	50.9	50.1	47	47.9
	SD	11.1	9.6	8.2	10.5
	CV	21.7	19.2	17.5	21.9
North East (Oct-Dec)	Mean	17.7	15.7	19.0	17.8
	SD	6.9	6.1	5.2	4.7
	CV	38.7	38.7	27.2	26.6

Mean rainy days were decreased as compared to base period during summer and South West monsoon seasons, while winter season rainy days increased and North East monsoon period was increased except 1981-1990 decade. Coefficient of variation was higher in winter season followed by summer, North East and South West seasons. Standard deviation is highest in rainy days occurred in South West monsoon and lowest in winter season (Table-2).

Table-3: Seasonal rainfall variability over Prakasam district

Seasons		1951-1980	1981-1990	1991-2000	2001-2010
Winter (Jan-Feb)	Mean	8.3	24.1	33.3	28.0
	SD	12.1	28.3	29.1	44.7
	CV	145.2	117.1	87.3	159.4
Summer (Mar-May)	Mean	72.0	71.0	75.9	107.3
	SD	59.4	81.6	62.8	67.0
	CV	82.5	114.9	82.7	62.4
South West (Jun-Sep)	Mean	391.0	416.6	444.3	438.3
	SD	112.8	139.5	145.6	137.0
	CV	28.8	33.5	32.8	31.3
North East (Oct-Dec)	Mean	314.1	320.1	396.6	377.1
	SD	136.5	130.3	162.5	113.1
	CV	43.4	40.7	41.0	30.0

Seasonal rainfall over Prakasam district was observed that, mean annual rainfall was gradually increased from based period and highest increase was observed in North East monsoon period followed by South West monsoon, summer and winter seasons (Table-3). Similar results were observed by Upadhyay *et al*., (2015). Rainfall during

South West Monsoon period was highly stable with low CV values. Upadhyay *et al*., 2015 studied climatic data of Ranichauri district of Uttarakhand and concluded that there is increase in south west monsoon rainfallat rate of 11.09mm per year was also observed during the study period (1951-2013).Mean annual rainfall increased marginally in all seasons except summer season during 1981-1990. Coefficient of variability was highest during winter seasons and lowest during South West monsoon season. Standard deviation and coefficient of variation was increased from base period for South West monsoon period and decreased during North East monsoon periods remaining periods.

Table-4: Seasonal rainy days variability over Prakasam district

Seasons		1951-1980	1981-1990	1991-2000	2001-2010
Winter (Jan-Feb)	Mean	1.1	1.9	2.8	1.5
	SD	1.6	2.0	1.9	2.0
	CV	145.9	106.6	69.0	134.3
Summer (Mar-May)	Mean	6.2	5.6	6.3	6.8
	SD	4.1	4.4	2.3	2.2
	CV	66.7	78.6	35.9	33.1
South West (Jun-Sep)	Mean	40.6	42.7	39.6	39.6
	SD	10.6	11	7.6	6.5
	CV	26.0	25.7	19.2	16.5
North East (Oct-Dec)	Mean	22.9	19.9	24.9	23.9
	SD	7.5	7.5	7.0	4.9
	CV	32.7	37.6	28.0	20.7

Mean rainy days was recorded high decadal variability. Highest rainy days recoded in South west monsoon, followed by North East, summer and winter seasons (Table-4). Coefficient of variability was decreased at decreasing rate during south west monsoon period, whereas North East monsoon and summer season rainy days decreased in last two decades only. Deviation of rainy days from mean was increased from base period in 1981-1990 thereafter decreased gradually during summer, South West and

North East seasons whereas for winter season rainy days were higher than base period with decadal variability.

Table-5: Seasonal rainfall variability over Nellore district

Season		Rainfall (mm)			
		1951-1980	1981-1990	1991-2000	2001-2010
Winter (Jan-Feb)	Mean	10.7	56.2	43.3	29.5
	SD	13.6	90.7	47.1	53.3
	CV	127.5	161.3	108.7	180.6
Summer (Mar-May)	Mean	66.0	50.5	68.6	79.1
	SD	74.3	74.8	81.6	54.9
	CV	112.6	148.0	118.9	69.4
South West (Jun-Sep)	Mean	321.3	344.5	368.6	333.1
	SD	90.4	133.1	126.4	121.2
	CV	28.1	38.6	34.3	36.4
North East (Oct-Dec)	Mean	580.7	577.3	687.8	701.9
	SD	209.3	147.7	285.5	196.4
	CV	36.1	25.6	41.5	28.0

Cumulative mean rainfall is higher than base periods all the three decades during South West, winter and summer seasons (table-5). In North East monsoon season rainfall was decreased in 1981-1990 decade there after increased as compare to base period. Consistency of south west monsoon rainfall decreased in all the three.

Table-6: Seasonal rainy days variability over Nellore district

Season		1951-1980	1981-1990	1991-2000	2001-2010
Winter (Jan-Feb)	Mean	1.0	3.0	3.7	1.6
	SD	1.3	3.6	2.7	2.5
	CV	131.3	119.7	74.3	156.5
Summer (Mar-May)	Mean	4.8	4.4	4.2	5.9
	SD	3.6	4.81	1.7	3.1
	CV	75.3	109.4	41.7	52.1
South West (Jun-Sep)	Mean	33.4	33.9	33.3	33.7
	SD	9.0	12.3	9.9	8.5
	CV	27.01	36.3	29.8	25.3
North East (Oct-Dec)	Mean	29.5	28.6	34.7	29.4
	SD	7.1	8.6	9.4	7.2
	CV	24.2	29.9	27.2	24.5

decades as compare to base period. In North East monsoon consistency of receiving rainfall has recorded fluctuations but is highest among the all seasons. Among the seasons Standard deviation was highest in North East followed by South West, winter and summer seasons and coefficient of variation was vice-versa.

Mean seasonal rainy days were higher during South West monsoon season followed by north east, summer and winter seasons respectively (Table-6). Cumulative mean rainy days were highly fluctuating except in south west monsoon season where slight fluctuations existed. Rainy day consistency is higher in North East monsoon season and lowest is in winter season.

Table-7: Temperature variability over south coastal districts of Andhra Pradesh

Maximum temperature (°C)				Minimum temperature (°C)			
Parameters	Summer	*Kharif*	*Rabi*	Parameters	Summer	*Kharif*	*Rabi*
Guntur district							
1951-1980	36.7	33.5	30.5	1951-1980	24.9	25.1	19.6
1981-1990*	0.2	0.3	0.2	1981-1990*	0.2	0.2	0.3
1991-2000*	0.1	0.3	0.0	1991-2000*	0.1	0.2	0.4
2000-2010*	0.6	0.6	0.8	2000-2010*	0.4	0.3	0.3
Prakasam district							
1951-1980	36.8	33.5	30.6	1951-1980	24.9	25.0	19.6
1981-1990*	0.3	0.3	0.2	1981-1990*	0.2	0.2	0.3

1991-2000*	0.2	0.4	0.0	1991-2000*	0.1	0.2	0.3
2000-2010*	0.7	0.6	0.8	2000-2010*	0.3	0.4	0.3
Nellore district							
1951-1980	36.2	34.2	30.0	1951-1980	24.7	25.0	20.2
1981-1990*	0.6	0.5	0.4	1981-1990*	0.3	0.2	0.2
1991-2000*	0.4	0.2	0.3	1991-2000*	0.0	0.1	0.3
2000-2010*	0.7	0.5	0.8	2000-2010*	0.3	0.2	0.4

* Mean Temperature (^{0}C) deviation values from e period of 1951-1980.

Temperature variability:

Increase of maximum and minimum temperatures during the period study was ranged from 0.1 to 0.7^{0}C and 0.2 to 0.4^{0}C respectively (Table-7). In similar to the above finding Srivastava *et al*. (1992) reported that, decadal trends of temperature over India shown increasing temperature trends in India. Out of the period of study 2000-2010 was warmest decade and 1991-2000 was coolest decade. Variability of maximu temperature is observed as compare to base period in three agricultural seasons in Guntur, Prakasam and Nellore districts except for *Rabi* season is 1991-2000 decade. Out of the three decades, 2000-2010 recorded highest maximum temperatures in all the three districts and in particular Prakasam district recorded highest over other two districts. Out of the three districts, Guntur and Prakasam districts recorded mean higher temperatures during *Kharif* season. In the study area *Rabi* season temperatures were recorded highest (0.8 **^{o}C**) during 2000-2010 decade as compared to base period. This might be due to 2000-2010 decade is warmest decade of earths.

In similar to maximum temperature, minimum temperate also recorded highest during 2000-2010 decade during the period of study in all the three districts. Similar finding was reported by Kamaljit Ray *et al*., (2009) over Gujarat. Highest increase in minimum temperature during summer, *Kharif* and *Rabi* seasons was recorded at Guntur, Prakasam and Nellore districts respectively. Increase in *Rabi* minimum temperatures is alarming in all the districts and this might be due to less rainfall in North East and winter seasons. In case of Nellore district North East monsoon and winter season rainfall was more due to which lowest *Rabi* temperatures recorded in entire study period.

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