

## **IMPACT OF CLIMATE CHANGE ON FOOD AND PLANTATION CROPS IN THE HUMID TROPICS OF INDIA**

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### **ABSTRACT:**

Long series of climatological data for 140 years over Kerala in the humid tropics of India indicate cyclic pattern in rainfall with a declining trend in annual and southwest monsoon rainfall during the past 60 years. In contrast, there was an increasing trend in post monsoon rainfall, indicating likely shifts in rainfall patterns. Onset of monsoon over Kerala, the Gateway of monsoon, appears to be little early. If the onset of monsoon is early that is on or before 25th May, the monsoon rainfall is below normal or normal over Kerala. Rise in maximum and minimum temperatures was also noticed since last 49 years over Kerala. The day maxima increase was  $0.64^{\circ}\text{C}$  while the night minimum  $0.23^{\circ}\text{C}$ . Increase in mean annual surface air temperature over Kerala was  $0.44^{\circ}\text{C}$ . Such warming was noticed in the entire West Coast. The difference in maximum and minimum temperatures (temperature range) was widening where thermo-sensitive crops like cardamom, tea, black pepper and cocoa are grown along the high ranges. These changes in thermal and moisture regimes have resulted in climate shifts from B4-B3 to B2-B1, moving Kerala from wetness to dryness within the humid climates. The impact of climate change in the form of climate variability like floods and droughts adversely affected food and plantation crops to a large extent and thus there is an urgent need to adapt crop management, crop improvement and crop protection strategies in tune with projected climate change scenarios so as to mitigate the ill effects of weather aberrations and sustain agricultural production in ensuing decades.

### **1. INTRODUCTION**

Climate change is real. Polar ice is melting. Rise in temperature and sea level are likely. Global temperature rise is likely to be  $1.5 - 5.5^{\circ}\text{C}$  under varied Co2 levels. The projected atmospheric Co2 will be around 550 ppm by 2100 A.D. if carbon cuts are not implemented on war footing by various political Governments. Uncertainties in rainfall patterns are expected. Crop seasons in temperate and tropical regions are likely to shorten. Land and ocean biodiversity are likely to be under threat. Underdeveloped and developing countries suffer much more under projected climate change scenario.

Agricultural land is declining year after year across the country and Indian foodgrains production is stagnated mostly due to weather aberrations. Increase in temperature is likely to be around  $3^{\circ}\text{C}$  by 2100 A.D. in India. 1972, 1979, 1987, 2002 and 2009 were the severe drought years during which the kharif foodgrains production was adversely affected to a considerable extent. Crop simulation models indicate that area under rice and wheat across the Country is likely to decline in ensuing decades and total foodgrains production is under threat as a result of increase in temperature and rainfall uncertainties. Changes in temperature and rainfall will lead to frequent occurrence of floods and droughts and heat and cold waves. Rise in current food prices, as a result of increase in global prices, inadequate monsoon and severe droughts in addition to increase in support prices, is a crisis at present. Therefore, it is high time to project climate change at the site/local/region level and its impact on crops as the agriculture is the main sector which suffers to a great extent and the Indian economy is agrarian based. Such studies in the humid

tropics of India are of more relevant where plantation crops are predominant though rice is a staple food. Unlike in seasonal crops, the impact of weather aberrations will be having long standing ill effects as the crops are perennial in nature and as a result the State's economy is adversely affected. Hence an attempt is made to understand the impact of climate change or climate variability on major crops of Kerala based on long series of climatological data on temperature and rainfall.

### **2. MATERIAL AND METHODS**

Rainfall data for the IMD stations of the State of Kerala for the period from 1871 to 2008 were utilized for the study. Temperature data for seven IMD stations were collected from National Data Centre of IMD, Pune from 1956 to 2004. The past climatological data for 33 selected stations in Kerala have also been collected over a period of 104 years (1901 to 2004). Three stations having dataset for 89 years (1916 to 2004), 59 years (1946-2004) and 55 years (1951 – 2004) were also selected for the study. Temperature data from three KAU stations (Pattambi -1950-2008), Pampadumpara (1978-2005) and Ambalavayal (1984-2005) were also utilized. Trend analysis was carried out to find out long period changes in temperature and rainfall. Climate shifts were also worked out using the moisture index. The moisture index is a ratio between water surplus and water need and expressed in percentage, was worked out using the standard book-keeping water balance procedure as suggested by Subrahmanyam (1982). Simultaneously, area under major crops was also collected to understand the shifts in cropping systems in relation to climate change or climate variability over Kerala.

### 3. RESULTS AND DISCUSSION

The average annual maximum temperature varies from 30.4 °C at Trivandrum to 32.9 °C at Punalur. Second high maximum temperature (32.4°C) was noticed at Palakkad in Kerala. On an average, the annual maximum temperature varied between 28.8°C during southwest monsoon while 32.8°C during summer (Table 1). Occasionally, the day maxima crosses beyond 40° C over the Palakkad region in plains as noticed during summer 2004. The ever highest maximum temperature of 41° C was recorded on April 26, 1950 at Palakkad.

Station	Maximum Temperature (°C)				
	SWM	PM	Winter	Summer	Annual
Trivandrum	29.6	29.6	30.8	31.9	30.4
Punalur	30.8	31.9	34.0	35.2	32.9
Alappuzha	30.0	30.2	32.2	32.9	31.2
Kottayam	30.8	31.0	32.8	33.8	31.9
Cochin	29.5	30.8	31.7	32.4	31.0
Palakkad	30.2	30.7	33.4	35.9	32.4
Kozhikode	28.9	30.8	31.6	32.7	30.8
Pattambi	29.7	31.7	33.8	35.2	32.4
Ambalavayal	25.1	26.4	28.0	30.1	27.3
Pampadumpara	23.3	24.3	24.6	28.3	24.9
Average	28.8	29.7	31.3	32.8	30.5
Minimum temperature (°C)					
Trivandrum	23.6	23.4	22.7	25.0	23.7
Punalur	22.7	22.1	20.7	23.3	22.3
Alappuzha	23.7	23.9	23.0	25.4	24.0
Kottayam	22.9	23.1	22.5	23.9	23.1
Cochin	23.9	23.9	23.1	25.5	24.1
Palakkad	22.9	23.0	22.2	24.7	23.2
Kozhikode	23.7	23.7	22.5	25.5	23.8
Pattambi	22.8	22.4	20.8	24.0	22.5
Ambalavayal	18.2	17.8	17.8	19.0	17.3
Pampadumpara	17.7	17.5	15.7	18.7	17.4
Average	22.2	22.1	21.1	23.5	22.1

Table 1. Season-wise Surface Air Temperature (°C) at Different Locations Over Kerala

In the case of minimum temperature, it varies between 22 and 24°C across Kerala in plains and the mid-land regions. Across the highranges, where thermo-sensitive crops like cardamom, coffee, tea, black pepper and cocoa are grown, the annual maximum temperature revolves around 24-28°C while the night temperature around 17°C. The minimum temperature during winter varies between 15 and 18°C across the highranges while summer maximum temperature between 35 and 37°C in plains. There was an increase in maximum temperature over Kerala by 0.64°C during the period of 49 years, commencing from 1956 to 2004 while increase in minimum temperature was 0.23°C. Overall increase in annual average temperature was 0.44°C. A clear upward trend was noticed in surface air temperature in Kerala (Figure. 1). The warmest (28.3°C) year over Kerala was in 1987,

followed by 1983 (28.2°C). The highest annual maximum temperature over Kerala was recorded in 1987 (32.8°C) followed by 1983 (32.4°C) while lowest minimum temperature was recorded in 1974 (22.8°C) followed by 1968 (22.9°C).

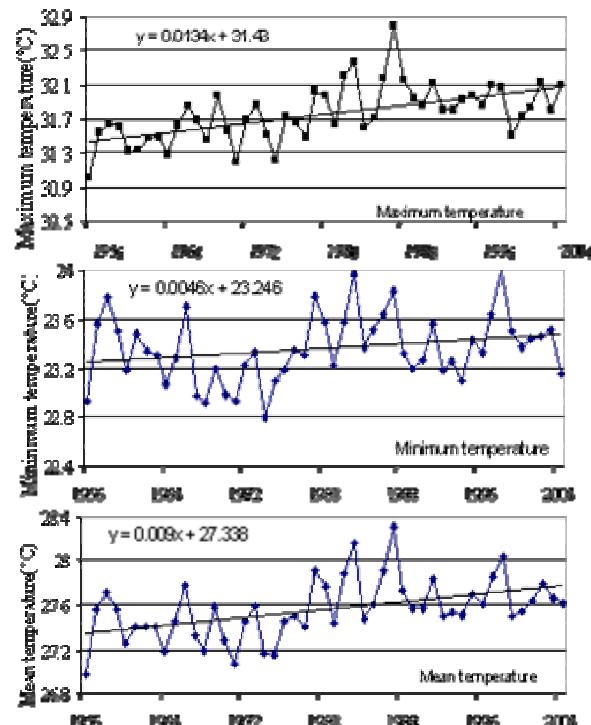


Figure 1. Trend in Maximum, Minimum and Mean Surface Air Temperatures Over Kerala

Similar trend was noticed in the case of annual maximum temperature at Trivandrum, Kottayam, Punalur, Pampadumpara, Kochi, Alapuzha, Palakkad, Kozhikode, Ambalavayal and Kannur. Such trend was noticed not only in annual maximum temperature but also during all the seasons viz., southwest monsoon, post monsoon, winter and summer. Interestingly, the maximum temperature during winter at Palakkad was marginally in decreasing trend. Such trend was noticed in post monsoon season and summer at Ambalavayal also. In the case of minimum temperature, Trivandrum and Pampadumpara showed decreasing trend though overall increase was noticed across the State. The study revealed that the difference in maximum and minimum temperatures (temperature range) was increasing at some locations as the day maxima was increasing while decreasing night minimum temperature. It was more so where cardamom, tea and black pepper are commonly grown across the high ranges of Kerala in addition to warming Kerala as a whole. This trend was similar across the West Coast too, where warming is taking place.

The onset of monsoon over Kerala, the Gateway of monsoon, appeared to be little early with an average commencement of 1<sup>st</sup> June with plus or minus 7 days. The monsoon rainfall is likely to be below normal or normal if the monsoon set in on or before 25<sup>th</sup> May. It was tested in 2001, 2004, 2006 and 2009 and found correct. Such trend was not seen if the monsoon is delayed that is

on or after 8<sup>th</sup> June. In the case of rice, suitable varieties and crop calendars can be suggested during kharif under varied monsoon patterns through crop simulation models. Such studies are the need of the hour to enhance rice yields under monsoon rainfall uncertainties.

Long series of climatological data for 140 years over Kerala in the humid tropics of India indicate cyclic trend in annual rainfall with a declining trend in annual and southwest monsoon rainfall during the past 60 years. In contrast, there was an increasing trend in post monsoon rainfall, indicating likely shifts in rainfall patterns (Figure. 2). Though decreasing trend was noticed over Kerala as a whole, Haripad and Kasaragod showed increasing trend in annual and southwest monsoon rainfall. Similarly, Quilandi, Munnar, Hosdurg and Ponnani also showed increasing trend in annual rainfall. Unlike in temperature trends, rainfall trends are uncertain at several locations (Kumar et al 2002; Krishnakumar et al., 2008 &2009; Rao et al., 2008). Hence, there is a need to take up these studies location wise. Long term changes in thermal and moisture regimes have resulted in climate shifts over Kerala from B<sub>4</sub>-B<sub>3</sub> to B<sub>2</sub>-B<sub>1</sub>, moving from wetness to dryness within the humid type of climate. It was significant since last three decades.

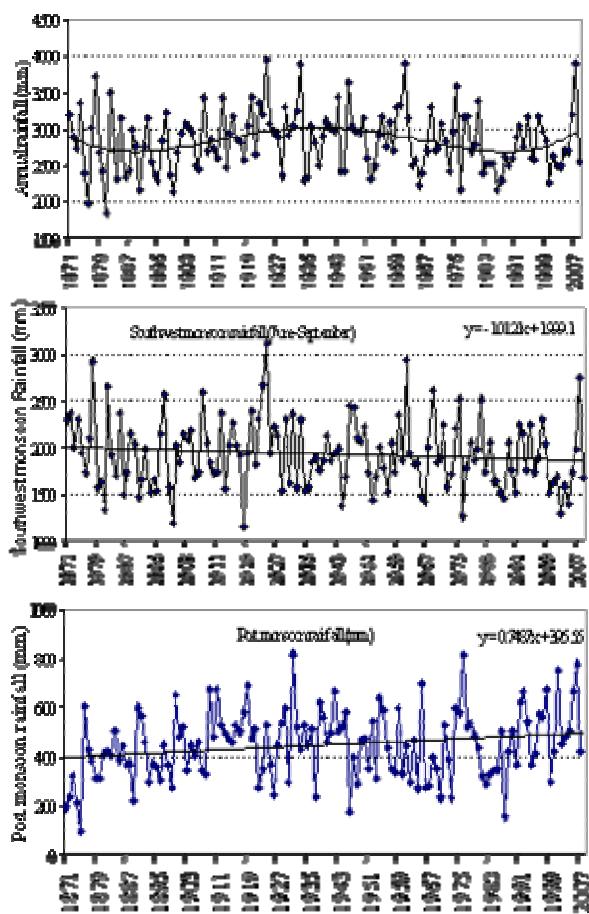


Figure 2. Trends in Rainfall Over Kerala from 1871 to 2008

A clear shift was noticed from foodgrain crops to non-foodgrain crops in Kerala over a period of time due to various reasons.

Increase in area under coconut, arecanut, banana, black pepper and rubber was noticed at the cost of phenomenal decline in rice area. It resulted in wide difference between production and demand of rice in addition to frequent floods in monsoon season and droughts during summer season. The prolonged wet spell in kharif 2007 and unusual rains in 2008 devastated the paddy production to a large extent (Figure. 3).

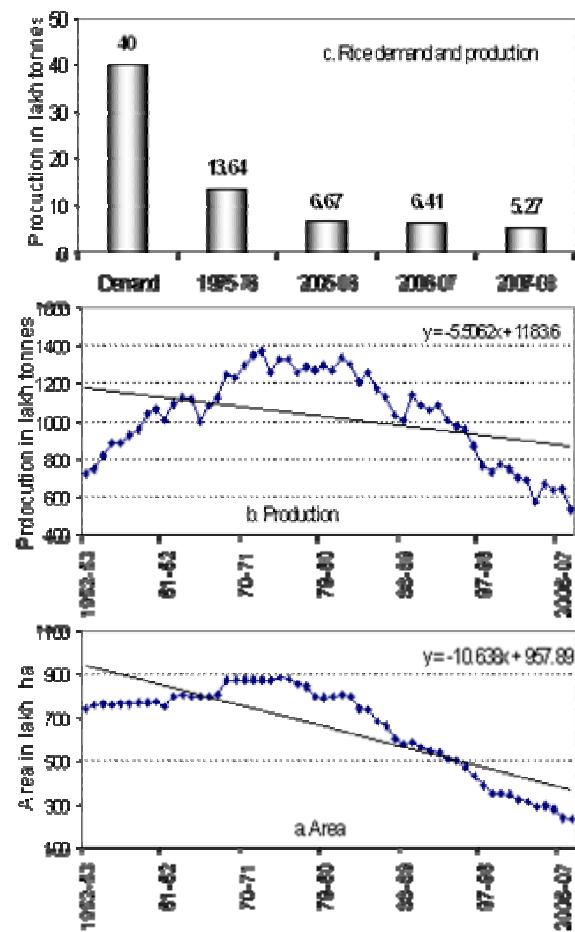


Figure 3. Trend in area and production of paddy over Kerala from 1952-53 to 2007-08

Though Kerala stood first in cashew production a decade ago, at present it occupies only fourth position and likely to go down further. It was due to steady decline in cashew area and also occurrence of weather aberrations during the reproductive phase of cashew. Area under tea was also declining along the high ranges. Crop projection models outside India indicate that a rise of 2° C in temperature is likely to affect the area under tea and coffee adversely. Aberrations in blossom and backing showers adversely affect coffee production to a great extent. Lack of backing showers during summer 2009 over Wayanad district is likely to reduce considerably crop output in coffee. Almost all the plantation crops suffered to a great extent in 1983 and 2004 due to disastrous summer droughts. Increase in maximum temperature of 1-3° C during summer 2004 adversely affected thermo-sensitive crops like black pepper and cocoa (Rao et al.,2008). Deforestation and

decline in wetlands along with the high intensity of rainfall may lead to frequent occurrence of floods and droughts and their ill effects on all the crops will be manifested much more in addition to human and property losses. Therefore, it is high time to have climate change adaptation strategies to mitigate ill effects of weather aberrations and sustain crop production under projected climate change scenario. Special attention is to be given in this direction to the thermo-sensitive crops like black pepper, cardamom, tea, coffee and cocoa as temperature range (the difference between maximum and minimum temperatures) is likely to increase and rainfall is likely to decline along with deforestation as these crops grow under the influence of typical forest-agro-ecosystems.

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