# Impacts of Climate Change on Horticulture Across India

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**Abstract**

In India, increase in mean annual maximum temperature was 0.76°C and mean minimum temperature was 0.22°C. Increase in annual mean temperature was 0.49°C during the period, commencing from 1901 to 2003. In terms of increase in temperature, the West Coast of India is warmer, followed by the Northeast India and the Western Himalayas when compared to other regions of the country. The years 2009 and 2010 were recorded as the warmest in the country since 1901. Increase in temperature and rainfall was noticed in the country in tune with the global warming and climate change though spatial and seasonal differences were evident. At the same time, rainfall during the monsoon season was deficit in recent years like 1987, 2002 and 2009 which adversely affected the food grains production in India. In the case of thermo-sensitive crops like tea, coffee, cardamom, cocoa, cashew and black pepper, the projected increase of 2–3°C in temperature may directly affect the cropped area and productivity. The observations on mango and cashew flowering also indicated that increase in night temperature during winter is a concern as seen in 2010. The coconut productivity in Kerala is likely to decline under the projected climate change scenario as the occurrence of floods and summer droughts is likely to affect the crop adversely, and their frequency is likely to increase under the projected climate change scenario. Therefore, proactive technologies need to be developed against the global warming and climate change for sustenance of crop production in horticulture as a part of "climate resilient horticulture".

## 2.1 Introduction

Increase in temperature is likely to impact the atmospheric processes, and the occurrence of weather abnormalities like floods, droughts and cold and heat waves is likely to increase in ensuing

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decades under the projected climate change scenarios. The super cyclone in 1999 across the Orissa Coast adversely affected the cashew plantations to a considerable extent through uprooting of trees in sandy soils. All the fruit crops suffered heavily due to unprecedented cold wave in 2002–2003 across the North Indian states. At the same time, temperate fruit crops such as apple, plum and cherry gave high yield due to extended chilling. In contrast, the heat wave in March 2004 in the same belt adversely affected apple, tea, potato and vegetables. Potato and vegetables matured early, and heavy crop losses were noticed due to abnormal increase in temperature as a result of heat wave (Prasad and Rana 2006). The prolonged droughts during summer adversely affected the crops like cocoa, black pepper, coconut, coffee, tea and cardamom along the West Coast in 1982–1983 and 2003–2004 (Rao et al. 2008). Increase in night temperature in several parts of the country during winter 2010 adversely affected mango flowering. Therefore, there is a need for proactive measures for sustenance of horticulture against the occurrence of cold and heat waves, floods and droughts as well as against sea level rise as a part of "National Climate Resilient Horticulture" under projected climate change scenario as their frequency is likely to increase in the ensuing years. Keeping the above in view, an attempt has been made to understand the impact of climate change on horticultural crops across different regions of the country.

Temperature data (maximum and minimum) for the period from 1901 to 2003 for different zones of the country and for the country as a whole were downloaded from the IITM website *www.tropmet.res.in*. Trends were worked out for maximum, minimum and mean temperatures and temperature range for all the zones. Summer (March to May) maximum temperature and winter (December to February) minimum temperatures were also collected for all the zones, and trends were worked out. The data on warm years during the recent decade/century were also downloaded. Rainfall trends for various periods for different zones were also worked out using the data downloaded from the *www.tropmet.res.in*. Crop data on area, production and productivity of horticultural crops were collected from the published sources. Attempts were made to understand the impact of climate change on the selected horticultural crops across the country through agroclimatic analysis.

## 2.2 Climate Change Scenarios Across India

The increase in annual mean temperature over different zones of the country varied between 0.2°C and 0.73°C with an overall increase of 0.49°C for the country as a whole. The West Coast of India is warmer (0.73°C), followed by the Western Himalayas (0.7°C), the Northeast India (0.63°C) and the East Coast of India (0.52°C) in terms of the mean annual temperature. A least increase (0.2°C) in annual mean temperature was noticed across the Northwest India over a period of 103 years, commencing from 1901 to 2003 (Table 2.1).

The increase in annual maximum temperature in different zones of the country varied between 0.53°C and 1.24°C with an overall increase of 0.76°C for the country as a whole. The West Coast of India is warmer (1.24°C), followed by the North East India (1.04°C), the Western Himalayas of India (0.93°C), the North Central India (0.74°C) and the East Coast of India (0.67°C). In the case of summer maximum temperature, it varied between 0.39°C and 1.02°C with an overall increase of 0.65°C for the country as a whole. The West Coast of India, the Western Himalayas and the Northeast of India recorded a high of 1.02°C, 0.99°C and 0.82°C, respectively (Table 2.2).

In the case of annual minimum temperature, the Western Himalayas of India showed highest increase (0.48°C), followed by the Interior Peninsular India (0.45°C) and the East Coast of India (0.36°C). Interestingly, the Northwest India showed cooling tendency (–0.14°C) rather than warming in terms of minimum temperature. In the case of winter minimum temperature, the Western Himalayas of India showed warming tendency (0.84°C), followed by the Interior Peninsular India (0.70°C) and the East

**Table 2.1** Increase in annual temperature across various zones of India

| | | Increase in temperature (°C) | | |
|---|---|---|---|---|
| Sl. no. | Zone | Max (°C) | MinT (°C) | MeanT (°C) |
| 1 | All India | 0.76°C | 0.22°C | 0.49°C |
| 2 | West Coast of India | 1.24°C | 0.22°C | 0.73°C |
| 3 | East Coast of India | 0.67°C | 0.36°C | 0.52°C |
| 4 | Northeast India | 1.04°C | 0.19°C | 0.63°C |
| 5 | Northwest India | 0.55°C | –0.14°C | 0.20°C |
| 6 | North Central India | 0.74°C | 0.26°C | 0.49°C |
| 7 | Interior Peninsular India | 0.53°C | 0.45°C | 0.49°C |
| 8 | Western Himalayas of India | 0.93°C | 0.48°C | 0.70°C |

**Table 2.2** Increase in summer maximum temperature across various zones of India

| Sl. no. | Zone | Increase in summer maximum temperature (°C) |
|---|---|---|
| 1 | All India | 0.65°C |
| 2 | West Coast of India | 1.02°C |
| 3 | East Coast of India | 0.50°C |
| 4 | Northeast India | 0.82°C |
| 5 | Northwest India | 0.50°C |
| 6 | North Central India | 0.69°C |
| 7 | Interior Peninsular India | 0.39°C |
| 8 | Western Himalayas of India | 0.99°C |

**Table 2.3** Increase in winter minimum temperature across various zones of India

| Sl. no. | Zone | Increase in winter minimum temperature (°C) |
|---|---|---|
| 1 | All India | 0.42°C |
| 2 | West Coast of India | 0.12°C |
| 3 | East Coast of India | 0.65°C |
| 4 | Northeast India | 0.64°C |
| 5 | Northwest India | –0.35°C |
| 6 | North Central India | 0.56°C |
| 7 | Interior Peninsular India | 0.70°C |
| 8 | Western Himalayas of India | 0.84°C |

Coast of India (0.65°C) and the North East India (0.64°C). The night temperature was low (–0.35°C) across the Northwest India, indicating cold nights during winter while warm nights relatively across the remaining parts of the country (Table 2.3). Such trend of cool and warm nights may not be always true across the country under the projected climate change scenario. Interestingly, the minimum temperature was declining during the southwest monsoon if the country is taken as a whole.

The rate of increase in maximum temperature was high (1.0°C) in post monsoon season, followed by winter (0.9°C) when compared to that of other seasons (Fig. 2.1). It is true in the case of minimum temperature also. On an average, the increase in temperature range was 0.54°C. It is a concern in northern states during the *rabi* season as winter crops are adversely affected due to temperature increase. It is more so in the case of temperate fruit crops. Increase in temperature might be one of the reasons for glaciers melt across the

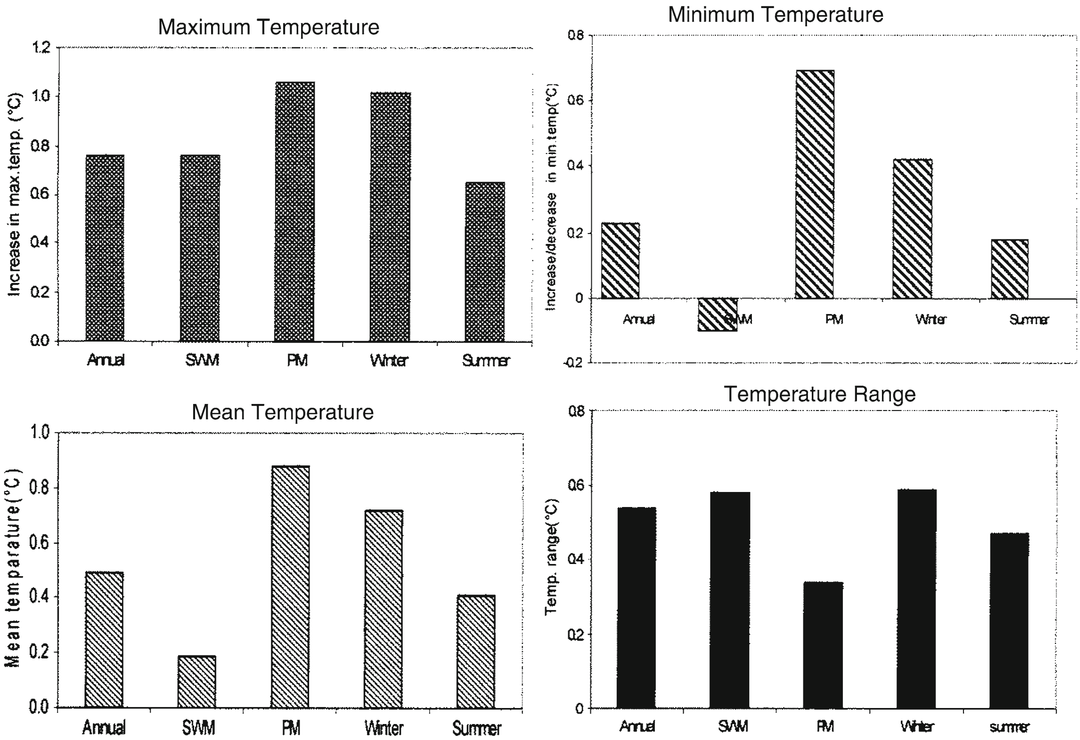


**Fig. 2.1** Annual and seasonal temperature rate of increase in maximum, minimum, mean and range (°C) over India

Himalayas. It is again a concern and threat to the two rich hotspots of biodiversity in the country as the rate of increase in temperature is relatively high across the Western Ghats and Western Himalayas of India.

There was a marginal increase in annual rainfall as well as seasonal rainfall during the southwest monsoon and post monsoon season since last 194 years (1813–2006) for the country as a whole. Similar trend was noticed in all the zones in annual and southwest monsoon rainfall except in Northeast India, where the decline in rain fall was insignificant. Such trend was seen during post monsoon season in the Eastern Peninsular India and the North Central India. Rainfall is likely to increase between 5% and 25% all over the tropics in the next 25–30 years on account of climate change according to climate change projection models.

The study reveals that the West Coast of India is warmer followed by the Northeast India and the Western Himalayas. The warming over the Northwest India is mild, and cooling was noticed rather than warming during winter. Although there had been a distinct rise in temperatures since 1970, the rate of increase in the last 15 years was higher in the country compared to the preceding 15 years. While the rise in temperature was 0.2°C during 1901 to 2000, it was 0.4°C between 2001 and 2010, according to the Indian Meteorological Department. Out of 13 warmest years, 8 years fell during the decade 2001–2010. 2001, 2002, 2003, 2004, 2006, 2007, 2009 and 2010 were the warmest years in the recent decade. The increase in mean temperature during the recent decade (2001–2010) was 0.6°C. The years 2009 and 2010 were recorded as the warmest in the country since 1901. Increase in temperature and rainfall was noticed in the country in tune with the global warming and climate change though spatial and seasonal differences were evident but insignificant in the case of rainfall since last two centuries. At the same time, rainfall during the monsoon season was deficit in recent years like 1987, 2002 and 2009 during which the Indian food grains production was adversely affected. The projected maximum and minimum temperature from the base period of 1961–1990

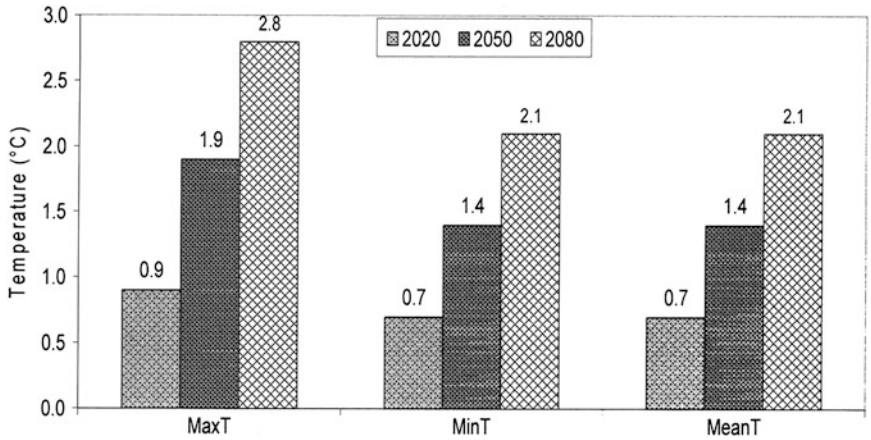


**Fig. 2.2** Projections in rate of increase in temperatures across India by 2020, 2050 and 2080

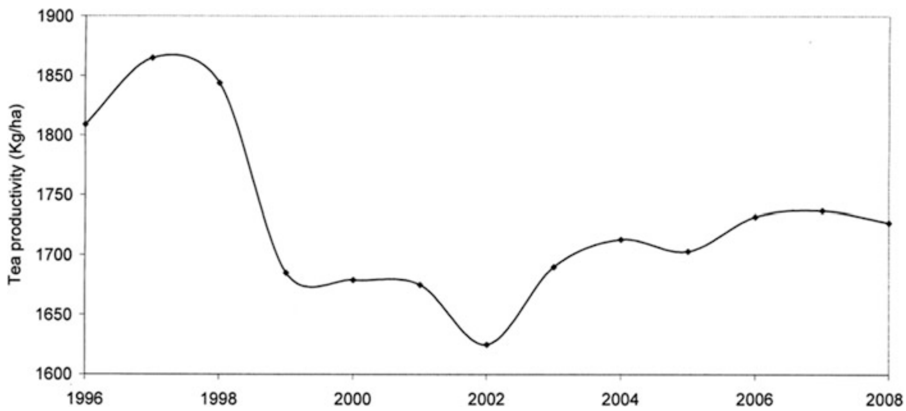


**Fig. 2.3** Tea productivity in India from 1996 to 2007

assuming a linear trend would be 2.8°C and 2.1°C, respectively, by 2080 A.D (Fig. 2.2). Of course, the rate of increase in ensuing decades may vary depending upon the emission of greenhouse gases, in particular the emission of $CO_2$ as it accounts up to 70–75% of increase in atmospheric temperature.

## 2.3 Effect of Climate Change on Tea Productivity

There was a phenomenal increase in the case of tea productivity from 1918 to 2008 with stagnation in 1930s (500–600 Kg/ha in majority of the years) and early 1940s (less than 800 Kg/ha) and reached its peak productivity during 1996, 1997 and 1998 (greater than 1800 Kg/ha). Of course, the annual variations within the phenomenal increase in productivity could be attributed to weather changes under better management and cultural practices. However, the decline in tea productivity since 1999 is a concern (Fig. 2.3). The reasons for decline of tea productivity in recent years could be many, including price fluctuations, senile and neglected plantations and shortage of plantation workers due to low daily wages in addition to warming across the tea-growing regions as the recent decade was the warmest since records are maintained. The studies along the West Coast indicated that the optimum temperature for tea productivity appears to be 26.5°C in terms of maximum temperature while 17.5°C in the case of minimum temperature. Increase in temperature during the last decade appears to be adversely affecting the tea productivity (Gopakumar 2011). Therefore, warming across the tea-growing area is a threat to tea productivity. Similar was the case in coffee productivity also in the absence of blossom and backing showers. Crop growth simulation models outside the country indicated that a rise of 2°C in temperature is likely to affect the area under tea and coffee adversely. However, detail studies need to be carried out on regional scales to establish the impact of global warming and climate change on tea as well as coffee productivity for which various agencies involved in the industry should take initiatives as a part of climate resilient horticulture.

## 2.4 Climate Change and Coconut Productivity

In the case of coconut, it is projected that the coconut productivity on all India basis is likely to go up by up to 4% by 2020, up to 10% by 2050 and up to 20% by 2080 over current yields due to global warming and climate change. Along the West Coast, yields are projected to increase by up to 10% by 2020, up to 16% by 2050 and up to 39% by 2080, while in the East coast yields are projected to decline up to 2% by 2020, 8% by 2050 and 31% by 2080 over current yields (Kumar and Aggarwal 2009). Yields are projected to go up in Kerala, Maharashtra and parts of Tamil Nadu and Karnataka, while they are projected to decline in Andhra Pradesh, Orissa, Gujarat and parts of Tamil Nadu and Karnataka. It reveals that coconut productivity across the state of Kerala is likely to increase due to global warming and climate change. However, the model results cannot be taken into account on real-time basis as the global warming is likely to increase the frequency of occurrence of floods and droughts, which affect coconut production adversely as seen in the past in the state of Kerala. Moreover, any increase in temperature during the second phase of nut development is likely to influence the nut size and thereby the copra outturn and oil content. The second phase of nut development is more sensitive to high temperature. In addition, the inputs like projected $CO_2$ levels used in the model may also not be realistic. In contrast to the Infocrop model output of Kerala, a marginal decline in coconut productivity was noticed under field conditions from one tri-decade to another tri-decade. The coconut productivity in Kerala on tri-decadal basis was high (5762 nuts/ha) during 1951–1980 when compared to that of 1981–2009 (5670 nuts/ha). The percentage decline was 1.6% in 1981–2009 when compared to that of 1951–1980. There was a distinct difference in rainfall distribution, aridity index, number of summer droughts, moisture index and temperature from 1951–1980 to 1981–2009 (Fig. 2.4). Increase in temperature, aridity index, number of severe summer droughts and decline in rainfall and moisture index were the major factors for a marginal decline or stagnation in coconut productivity over a period of time. It is a clear signal of decline in coconut productivity due to global warming and climate change. In view of the above, there is an urgent need for proactive measures as a part of climate change adaptation to sustain coconut productivity in the state of Kerala, which is having a lion share in coconut productivity of the country. Therefore, the coconut productivity is likely to decline under the projected climate change scenario as the occurrence of floods and droughts is likely to affect the crop adversely, and their frequency is also likely to increase under the projected climate change scenario. Similar case studies were also taken up by the authors in several plantation and spice crops, viz. cashew, cocoa, cardamom, tea, coffee, rubber and black pepper across the West Coast of India, where the rate of warming is relatively high.

## 2.5 Conclusion

The impact of climate change on horticulture crop like coconut could be seen indirectly in the form of climate variability rather than directly due to increase in temperature. In the case of thermo-sensitive crops like tea, coffee, cardamom, cocoa, cashew and black pepper the projected increase of 2–3°C in temperature may directly affect the cropped area and productivity.

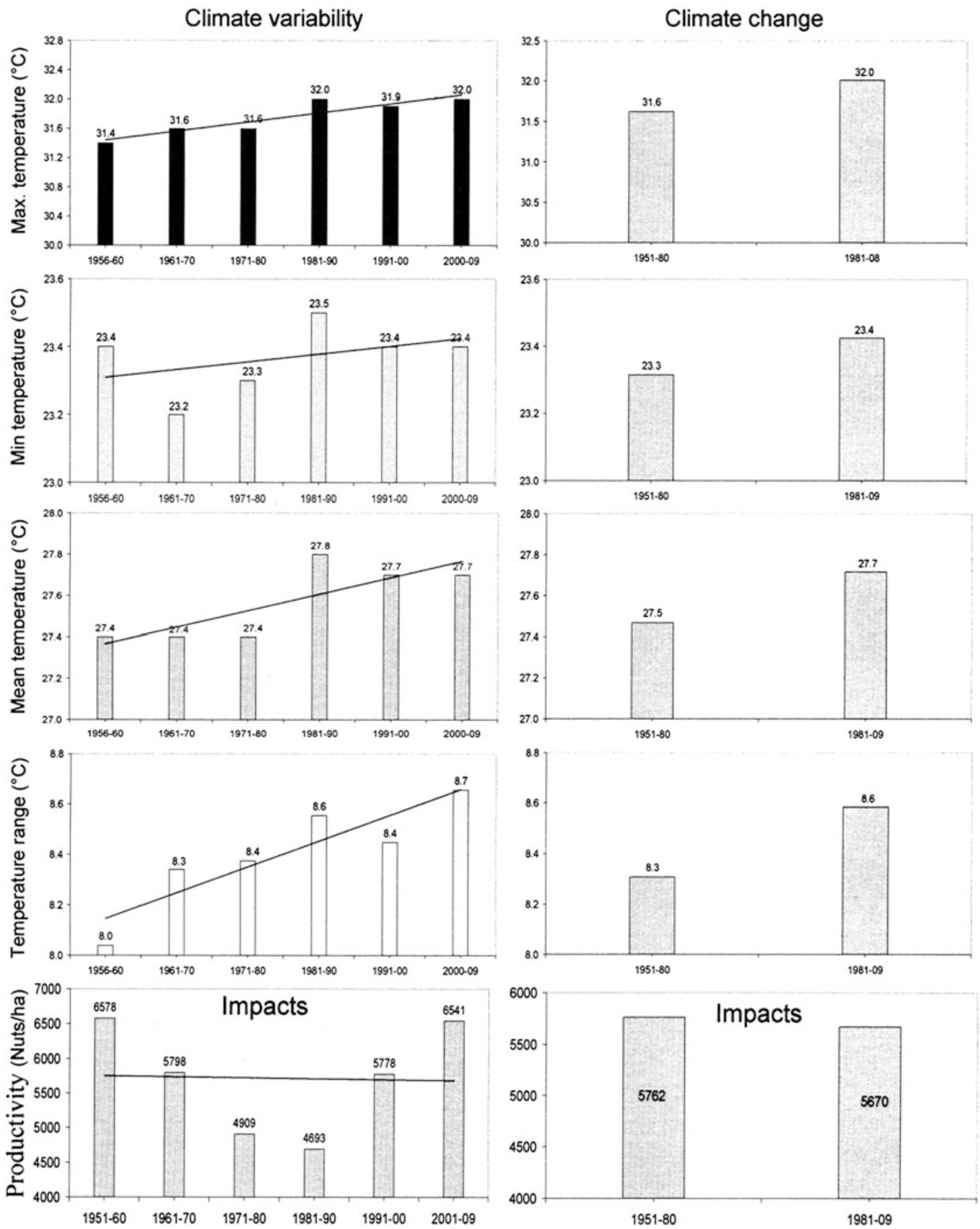


**Fig. 2.4** Decadal and tri-decadal maximum, minimum, mean temperature, temperature range and productivity of coconut

The observations on mango and cashew flowering also indicated that the increase in night temperature during winter is a concern in recent years as seen in 2010. Therefore, proactive technologies need to be developed against the global warming and climate change for sustenance of crop production in horticulture as a part of "climate resilient horticulture".

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