Climate- Fruit Crop Correlation

The statistical analysis showed that temperature and rainfall variations had the greatest impact on horticultural productivity during the pre-flowering phenological stage. During this stage, there was a notable statistical correlation observed in climatic parameters for four fruit crops i.e. Apple (with maximum temperature, diurnal temperature and rainfall), Pear (with maximum temperature, diurnal temperature and rainfall), Cherry (with minimum temperature), and Almond (with maximum temperature and rainfall). However, fewer statistically significant correlations were found during the flowering and fruit setting stages. Furthermore, rainy days variations did not show a statistically significant relationship with productivity for any of the fruit crops.

The research examined the sensitivity of all crops towards climatic parameters for pre- flowering, flowering and fruit setting stages. The sensitivity values expressed as percentages, were as follows: Apple (31%, 19%, 21%), Pear (35%, 9%, 10%), Almond (20%, 13%, 27%), Plum (19%, 18%, 1%), Pomegranate (6%, 8%, 24%), Apricot (3%, 14%, 29%), Cherry (13%, 16%, 8%), Peach (5%, 3%, 8%) and Walnut (2%, 3%, 15%).

Farm level perception based vulnerability assessment

- Interviews with 210 farming households from the five blocks in district Kullu indicated a significant increase in total fruits acreage per household over the past three decades, rising from 1.96 bigha to 6.12 bigha.
- The apple acreage increased in all five blocks, with maximum increase in Nirmand block, nearly eightfold. Acreage under stone fruits such as plum, apricot and peaches also increased but only in Anni and Banjar blocks.
- These shifts in crop cultivation were primarily influenced by a combination of factors such as changing climatic conditions, pest infestation, economic incentives and access to better farm practices. Furthermore, the vulnerability index, designed to assess exposure and sensitivity to climate change in relation to adaptive capacities (human, natural, financial and physical), positioned district Kullu at the lower end of vulnerability and risk spectrum.

Conclusion

The status report aimed to explain statistical and perceptible impact of climate change in district Kullu of Himachal Pradesh. From 1990 to 2016, temperature and rainfall showed greater variability during flowering period compared to the pre flowering and fruit setting stages. During the flowering period mean minimum and maximum temperature increased by 0.04°C and 0.12°C per year respectively while rainfall decreased by 6.17 mm per year. Meanwhile, the mean maximum temperature increased by 0.04°C per year during the pre-flowering period. Higher anomalies in maximum and minimum temperature were reported during all three phenological stages indicating an overall warming trend. Furthermore, variations in rainy days showed significant increase of 0.17 during fruit setting and development stage, from May to August. Amongst all studied crops, Apple productivity showed maximum sensitivity, while Walnut productivity was the least affected by climatic variations throughout all three stages .

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Impact of Climatic Variations on Horticultural Crops in Kullu District of Himachal Pradesh

State Centre on Climate Change
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H.P. Council for Science, Technology & Environment
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Introduction

Horticulture is a vibrant sister sector of agriculture, distinguished by scale of production and commercialization, and assumes a pivotal role in fostering food, economic, and nutritional security globally. India is the second-largest horticultural producer, accounting for a record 341.6 MT of production in 2022. Nonetheless, this high-contributing sector is more exposed to climate change compared to its close-associated agriculture sector, but with a relatively smaller carbon footprint. In 2013, 8.71 percent of India's carbon emissions came from agriculture, food, and land use. However, the carbon sequestration quotient from a mixture of perennial horti-culture crops such as tree fruits, tree nuts, vine fruits, seasonal vegetables and herbs offers carbon storage above the ground offsetting the sector's carbon foot-print.

The Himalayan ecosystem is positioned at high vulnerability with respect to the pressing perils of looming climate change. While recent research and discussions have primarily focused on glacial retreat and its impact on downstream water discharge, there is also growing evidence of the potential cascading impact of climate change in the Himalayas on all connected and satellite regions. The fragile Himalayan ecosystem, owing to its geological history and structural rock set-up, is fast approaching a state of disequilibrium with apparent changes in its resources and environment.

A status study was conducted to ascertain the impact of climate change on fruit crops in the district of Kullu in Himachal Pradesh. Seasonal trends in climatic variables such as minimum and maximum temperatures, diurnal temperature variations and rainfall patterns were analyzed with a standardized anomaly index. A multivariate regression analysis was then conducted to establish the relationship between climate and crop yield during the phenological stages of pre-flowering, flowering, fruit setting and development.

Methodology

To understand the impact of climate change variables such as temperature and precipitation (rainfall) vis-à-vis parameters of horticultural productivity, the following statistical measures were employed:

- Trend Analysis
- Standardized Anomaly Index (SAI)
- Multivariate Linear Regression Model

Table 1: Climate Change Impact and Phenological Stages

Phenological Stage	Climate Change Impact
Pre-flowering	•Flower bud initiation is extremely sensitive to temperature variations from extreme highs to lows during the growing season. •High temperatures can lead to the underdevelopment of plant reproductive organs.
Flowering	•Soil moisture variations driven by changing temperatures also influence flowering time and seed germination. •Temperature rise leads to early bud sprouting (2–3 weeks earlier in Apple and Almond) and increases susceptibility to frost damage. •Moderate winds during the flowering stage enable better fruit setting but harsh winds accompanied by heavy rains at low temperatures hinder appropriate flowering. •Hailstorms anytime during the flowering stage are catastrophic for fruit crops.
Fruit Setting	• Orchards situated deep in the valleys typically experience better fruit setting as compared to plantations on wind-ward sides. • Spring frost can either destroy flower sexual organs or completely damage blossoms, affecting fruit set. •Frequent incidents of pests and diseases occur under high-temperatures.
Fruit Development	• Hailstorms at any stage during the fruit development stage are catastrophic for fruit crops. •Excessive rains and fog near maturity lead to poor fruit quality with improper color development and fungal spots. • Extreme and sudden hailstorms result in spotting and fruit dropping, especially in case of temperate fruits. • High temperatures decrease anthocyanin accumulation in fruit trees, resulting in fruit discoloration. • High temperatures are known to alter fruit taste, flavor, sugar content, firmness and antioxidant activity.

Climate Trends

Climatic trends in the Kullu district were calculated using the Mann-Kendall test. The following observations were made during the analysis:

- As per the analysis, both the average maximum and minimum tempera-tures registered an inclining trend progressing at a rate of 0.12°C and 0.04° C per year between 1990 and 2016 (as exhibited by Sen's slope), while the rainfall quantity exhibited a significant decline of 6.17 mm per year during the flowering season, i.e., between March and April.
- During the pre-flowering season, i.e., November to February, the mean maximum temperature increased by 0.04°C per year.
- Furthermore, to better understand precipitation variations, changes in rainy days were analyzed. It was observed that statistically significant variations occurred only during the fruit setting stage between May and August, showing an increase by a factor of 0.17 days. The remaining climatic variables did not exhibit any significant variations during pre-flowering and fruit setting, and development stages.

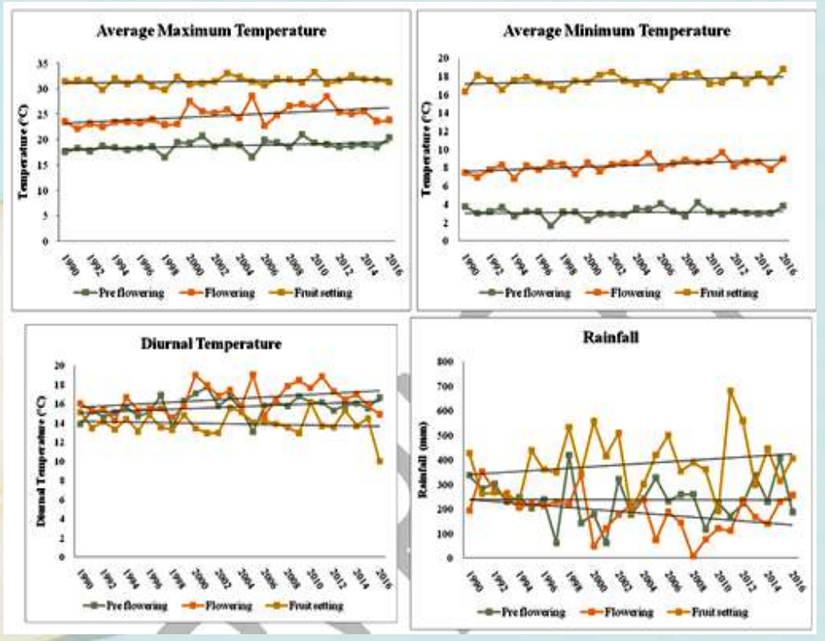

Figure 1. Variations in Climatic Parameters- Minimum T, Maximum T, Diurnal T & Rainfall during pre-flowering, flowering and fruit setting stages (1990-2016), District Kullu, HP

Fruit Crop productivity– District Kullu

An overall increasing productivity trend is recorded for Pear, Peach, and Apricot, with statistically significant p-values at a 95 percent confidence interval. However statisti-cally significant observations weren't registered for the productivity of Apple, Plum, Cherry, Pomegranate, and Walnut. The highest increase was observed in case of Pear (1.09 t $ha^{-1}yr^{-1}$) followed by Peach (0.04 t $ha^{-1}yr^{-1}$) and Apricot (0.01 t ha^{-1} yr^{-1}), while the Almond crop recorded a net decrease in productivity by 0.005 t $ha^{-1}yr^{-1}$.

Table 2. Mann Kendall Test Results – Crop Yields of Fruit Crops (1990-2016), District Kullu, HP

Fruits Productivity	Mean	Sen's slope	p-value	Confidence interval
Apple	4.03	0.06	0.38	0.036,0.077
Pear	16.78	**1.09**	**0.00**	0.911,1.273
Plum	3.69	0.04	0.28	0.022,0.050
Peach	**1.05**	**0.04**	**0.00**	0.024,0.049
Apricot	**0.30**	**0.01**	**0.00**	0.009,0.011
Cherry	0.51	-0.006	0.18	-0.008,-0.004
Pomegranate	1.06	.0005	0.95	-0.005,0.013
Walnut	0.60	0.00	0.65	-0.001,0.00
Almond	**0.12**	**-0.005**	**0.00**	-0.006,-0.004