



## Original Research Paper

## Factors Contributing to Horticulture Development in Himachal Pradesh: An Agroclimatic Zone-wise Analysis

Hakam Chand<sup>1\*</sup>, Mudasir Ahmad Dar<sup>2</sup><sup>1</sup>Research Scholar, Department of Economics, Mittal School of Business, Lovely Professional University, Phagwara, Punjab, India.✉ [Chandhakam865@gmail.com](mailto:Chandhakam865@gmail.com)<sup>2</sup>Assistant Professor, Department of Economics, Mittal School of Business, Lovely Professional University, Phagwara, Punjab, India.✉ [Darmudasir74@gmail.com](mailto:Darmudasir74@gmail.com)

## Abstract

Himachal Pradesh has become India's leading fruit-producing state, particularly in apple cultivation, due to favorable climatic conditions and strategic policy interventions. This study analyzes the zone-wise factors that have influenced horticultural development in the state between 1970 and 2025. Using a mixed-method approach combining quantitative trend analysis and qualitative policy assessment, it evaluates the roles of climate, infrastructure, and technology across four agroclimatic zones. Findings reveal that the temperate Zone III accounts for nearly 64% of total horticultural output, driven by government schemes, cold chain infrastructure, and high-density apple planting systems. The analysis also highlights emerging challenges, including rising temperatures, reduced chilling hours, and market volatility. Recommendations emphasize adaptive climate strategies, orchard rejuvenation, and diversification. The study contributes to sustainable horticultural policy formulation in mountain regions.

**Keywords:** Horticulture, Agroclimatic zones, Apple cultivation, Climate adaptation, Agricultural policy, Sustainable development

## 1. Introduction

Himachal Pradesh, located in the Western Himalayas, has witnessed one of India's most successful agricultural transformations. Over five decades, it transitioned from subsistence farming to a horticulture-driven economy. The state's geographical diversity, ranging from subtropical low hills to cold arid mountains, provides distinct agro climatic zones that support various horticultural crops.

## 1.1 Background and Significance

The area under fruit cultivation expanded from 44,329 hectares in 1970–71 to 236,466 hectares in 2022–23, marking an over fivefold increase. Apple cultivation dominates the sector, contributing 82–83% of total fruit production. Horticulture now accounts for a major share of the state's rural income and employment. However, climatic and socio-economic heterogeneity across zones necessitates zone-specific evaluation to inform sustainable development strategies.

## 1.2 Research Objectives

The study aims to:

1. Analyze climatic, policy, and technological factors driving horticultural development across agroclimatic zones.

2. Evaluate infrastructure and market linkages supporting horticultural growth.
3. Identify emerging challenges and propose adaptive policy recommendations.

## 2. Materials and Methods

## 2.1 Study Area

Himachal Pradesh consists of four agroclimatic zones:

| Zone            | Altitude (m)              | District Examples            | Major Crops            |
|-----------------|---------------------------|------------------------------|------------------------|
| I               | –300–<br>Subtropical 1000 | Kangra (low), Una, Bilaspur  | Citrus, Mango, Guava   |
| II – Sub-humid  | Sub-1000–<br>1800         | Solan, Mandi, Hamirpur       | Plum, Peach, Pear      |
| III – Temperate | –1800–<br>2800            | Shimla, Kullu, Mandi (upper) | Apple, Cherry, Walnut  |
| IV – Cold Arid  | >2800                     | Kinnaur, Spiti               | Apple, Apricot, Almond |

## 2.2 Data Sources

Secondary data from 1970–2025 were collected from the Directorate of Horticulture, Government of Himachal Pradesh, World Bank reports, and academic studies. Analytical tools included time series analysis, compound annual growth rate (CAGR), and correlation methods.

## 2.3 Analytical Framework

\*Corresponding Author:

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A mixed-method framework was adopted comprising:

- **Quantitative Analysis:** Trend and CAGR evaluation of area, production, and productivity.
- **Qualitative Analysis:** Policy and institutional impact assessment.
- **Comparative Analysis:** Cross-zone evaluation of enabling and constraining factors.

### 3. Results and Discussion

#### 3.1 Growth in Horticultural Area and Production

**Table 1. Horticultural Area and Production in Himachal Pradesh (1970–2023)**

| Year    | Area (ha) | Production (tonnes) | CAGR (%) |
|---------|-----------|---------------------|----------|
| 1970–71 | 44,329    | 148,580             | –        |
| 1990–91 | 83,420    | 390,000             | 3.1      |
| 2022–23 | 236,466   | 814,611             | 3.4      |

Source: Directorate of Horticulture, Himachal Pradesh (2023)

The data reveal a steady increase in both area and production, with apple cultivation emerging as the predominant driver of growth.

#### 3.2 Zone-wise Performance Analysis

##### Zone I – Subtropical Zone

Favorable for citrus fruits and mango, this zone benefits from proximity to lowland markets and strong processing linkages. However, water scarcity and pest problems persist.

##### Zone II – Sub-humid Zone

Characterized by moderate rainfall and temperature, this zone supports diverse fruit crops like plum and pear. Policy interventions focus on diversification and organic farming.

##### Zone III – Temperate Zone

The core of Himachal's apple industry. It enjoys optimal chilling hours and institutional support, including cold chains and research initiatives. It accounts for 64% of total production.

##### Zone IV – Cold Arid Zone

High-altitude districts such as Kinnaur and Spiti produce premium apple and apricot varieties. Though climatic stress is high, low humidity ensures superior fruit quality and export potential.

#### 3.3 Comparative Zonal Contribution

**Table 2. Contribution of Agroclimatic Zones to Horticultural Output (2022–23)**

| Zone            | Area (%) | Production (%) | Major Crop    |
|-----------------|----------|----------------|---------------|
| I – Subtropical | 18       | 12             | Citrus        |
| II – Sub-humid  | 28       | 18             | Stone fruits  |
| III – Temperate | 45       | 64             | Apple         |
| IV – Cold Arid  | 9        | 6              | Apple/Apricot |

Source: Computed from HP Horticulture Department (2023)

#### 3.4 Facilitating Factors

**Table 3. Ranking of Key Factors Facilitating Development by Zone**

| Zone | Key Factors                                                        | Rank |
|------|--------------------------------------------------------------------|------|
| I    | – Market Access, Water Management, Subtropical Policy Support      | 1    |
| II   | – Sub-Crop Diversification, Infrastructure, humid Organic Farming  | 2    |
| III  | – Technology Adoption, Cold Chain, Temperate Institutional Support | 3    |
| IV   | – Cold Climate Advantage, Altitude, Arid Community Cooperation     | 4    |

##### Technology Adoption

High-density apple orchards (150 trees/bigha) and semi-dwarf rootstocks have tripled yields.

##### Infrastructure

Over 200 cold storage units and all-weather roads enable efficient market access.

##### Institutional Interventions

Schemes like MIDH, RKVY, and the World Bank-supported Horticulture Development Project (2019–2025) have significantly modernized the sector.

#### 3.5 Emerging Challenges

1. **Climate Change:** A 0.9°C temperature rise has reduced chilling hours, shifting apple cultivation 300 m upwards.
2. **Market Volatility:** Price instability affects profitability.
3. **Aging Orchards:** Orchards established in the 1970s–80s require rejuvenation.
4. **Labor Shortages:** Migration to cities has increased dependency on migrant labor.

#### 4. Conclusion and Policy Recommendations

Himachal Pradesh's horticultural growth reflects the synergy of natural advantages, institutional support, and farmer innovation. However, to sustain progress, adaptive and zone-specific strategies are essential.

##### Policy Recommendations:

- **Zone I:** Enhance citrus processing and irrigation.
- **Zone II:** Promote diversification and organic certification.
- **Zone III:** Focus on orchard rejuvenation and climate-resilient varieties.
- **Zone IV:** Develop cold desert horticulture models and premium branding.

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