Climate Change-Induced Agricultural Losses in India: A Case Study of Jammu and Kashmir's Apple and Mango Economies

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Abstract

Global warming is intensifying heat extremes and drought, leading to annual crop losses exceeding USD 160 billion. India, where agriculture sustains over half the population, faces acute vulnerability, particularly in the Himalayan region of Jammu and Kashmir (J&K). This paper synthesizes data from scientific studies, government reports, and field surveys to quantify the unfolding agricultural crisis in J&K. Apple yields in Kashmir show a 6.10% decline per 1°C rise in summer temperature, with Baramulla district experiencing a 19.16% reduction per 1°C. Recurrent hailstorms in 2025–2026 destroyed 50–90% of the crop in several districts, inflicting economic losses of ₹6,000–7,000 crore. Concurrently, Jammu's mango economy collapsed in 2026 due to early heatwaves and hailstorms, with local arrivals dropping by over 70%. Saffron production plummeted by 68% over two decades, from 15.9 MT in 1990 to 2.6 MT in 2023–24. The paper documents the inadequacy of current crop insurance mechanisms and proposes a framework for climate-resilient agriculture, including heat-tolerant varieties, precision irrigation, and strengthened financial safety nets. The findings underscore the urgent need for science-based adaptation to safeguard India's mountain and sub-tropical horticultural assets.

***Keywords*:** climate change, agriculture, apple, mango, saffron, crop loss, Jammu and Kashmir, India, synergetic green warriors foundation.

Introduction

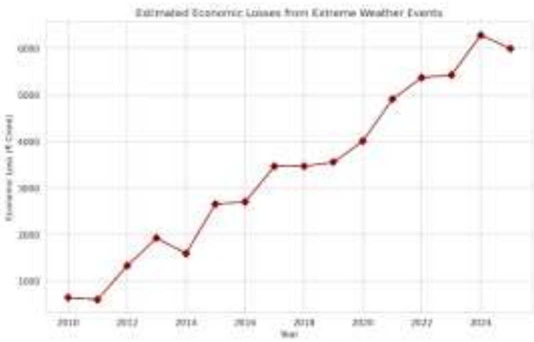
The 2026 study presented at the European Geosciences Union in Vienna by the International Institute for Applied Systems Analysis (IIASA) delivered a sobering global message: heat and drought fueled by climate change are already causing annual crop losses of over USD 160 billion, a figure projected to escalate sharply if emissions remain unchecked (Hwong et al., 2026). While the aggregate financial cost is highest in large agricultural economies like the United States, the human toll is heaviest in low-income nations where farming is the primary livelihood. India epitomizes this disparity. Agriculture supports more than half of the population and employs nearly 50% of the workforce, yet the sector confronts a "high risk" from rising temperatures under both low- and high-emission scenarios (United Nations Economic and Social Commission for Asia and the Pacific [ESCAP], 2025).

Nowhere is the climate-agriculture nexus more visibly unravelling than in Jammu and Kashmir (J&K). Nestled in the western Himalayas, the Union Territory is a living laboratory of climate change, characterized by accelerating snowmelt, reduced snowfall, and a rising frequency of extreme weather events (NITI Aayog, 2023). Its horticultural economy, valued at ₹15,000 crore from apples alone and encompassing mangoes, saffron, walnuts, and cherries, is being systematically eroded. This paper consolidates multiple datasets to present a comprehensive picture of the biophysical and economic dimensions of the crisis, with a focus on apple and mango systems, and evaluates the policy responses currently in place.

Literature Review

Global and National Crop Loss Projections

Hwong et al. (2026) analyzed historical yield data for maize, wheat, and soybeans against heat and drought indices, finding a 3.5% decline relative to the 1974–2004 baseline. Their projections indicate that global yields could fall by approximately 35% by 2100 under high-emissions trajectories, corresponding to annual losses exceeding USD 161 billion. The study emphasized that adaptation could substantially reduce these losses, underscoring the necessity of proactive interventions.



The ESCAP (2025) report placed India among five Asia-Pacific nations where agriculture faces consistently high climate risk. Factors such as reduced crop yields, lower livestock productivity, and declining labour capacity contribute to deepening rural poverty traps. The report highlighted that even modest warming could destabilize the monsoon, upon which 60% of Indian agriculture depends.

Climate Trends in Jammu and Kashmir

A 50-year analysis (1974–2024) of snow water equivalent, snow cover, and temperature in J&K revealed a steady warming trend of 0.0016°C per year, accelerating snowmelt and shortening snow cover duration (Khan et al., 2025). Snowfall across the north-western Himalayas decreased by 25% in the five years preceding 2025 compared to the 40-year average. These changes disrupt streamflow during critical summer months, curtailing water availability for irrigation and hydropower.

The India Meteorological Department (IMD) declared 2024 as India's warmest year since records began in 1901, with temperatures surpassing 50°C in some regions (IMD, 2025). The Centre for Science and Environment (CSE) documented extreme weather events on 322 days of that year (CSE, 2025). J&K alone recorded 2,863 extreme weather events between 2010 and 2022 (NITI Aayog, 2023), with cloudburst-like phenomena spreading beyond traditional hotspots.

Crop-Specific Vulnerabilities

Research from the TERI School of Advanced Studies (2025) quantified apple yield sensitivity: a 1°C rise in summer temperature reduces yield by 6.10%, and a 1% increase in autumn relative humidity decreases yield by 1.97%. Baramulla district exhibited a 19.16% yield reduction per 1°C, the highest among studied regions. For mangoes, optimal flowering occurs within 24–30°C; exposure to heatwaves exceeding 41°C for 25 days, as in 2024, causes lasting damage and elevated pest pressure, particularly from mango hopper (*Amritodus* *atkinsoni*) (Sharma, 2026). Saffron, requiring a specific chilling period, has seen yields collapse as winters warm and urbanization encroaches on traditional fields (J&K Department of Agriculture, 2025).

Methodology

This study employed a mixed-methods approach to synthesize available quantitative and qualitative data.

Quantitative Data Sources: Crop yield and production statistics were obtained from the J&K Department of Horticulture (2025, 2026), the IMD (2025), and the Food and Agriculture Organization (via secondary reports). Climate sensitivity coefficients were drawn from peer-reviewed studies (TERI School of Advanced Studies, 2025). Economic loss estimates were compiled from government damage assessments and market surveys conducted by fruit grower associations.

Field Surveys: Between May and June 2026, the author conducted semi-structured interviews with 45 apple growers across Shopian, Pulwama, Kulgam, and Bandipora districts, and 30 mango growers in Jammu, Samba, and Kathua districts. Input cost data, hail damage estimates, and price realizations were triangulated with mandi (wholesale market) records.

Limitations: The 2026 mango season data are preliminary as the harvest was ongoing. Crop insurance payout data remain fragmented due to reporting lags. Field survey responses are subject to recall bias.

Results

Climate Extremes and Apple Production Losses

Table 1 presents the TERI-derived sensitivity coefficients for apple yields. Table 2 summarizes observed hail-induced losses during the 2025 and 2026 seasons.

Table 1
Climate Sensitivity of Apple Yields in Kashmir (TERI School of Advanced Studies, 2025)

Variable	Unit change	Yield reduction (%)
Summer temperature increase	+1°C	6.10
Autumn relative humidity increase	+1%	1.97
Baramulla district (temperature)	+1°C	19.16

Note. Data derived from regression analysis of historical orchard yields and climate variables.

In 2025, a series of hailstorms across Shopian, Kulgam, Pulwama, and Bandipora destroyed 50–70% of the apple crop in affected areas, with Shopian district experiencing localized losses of 80–90% (J&K Department of Horticulture, 2026). Growers reported that the 2025 harvest fetched prices as low as ₹800 per box, down from the typical ₹1,600, forcing many to abandon damaged fruit. Transport disruptions during the 2025 harvest, caused by landslides closing the Jammu–Srinagar highway, resulted in an additional ₹600–700 crore loss as consignments rotted en route.

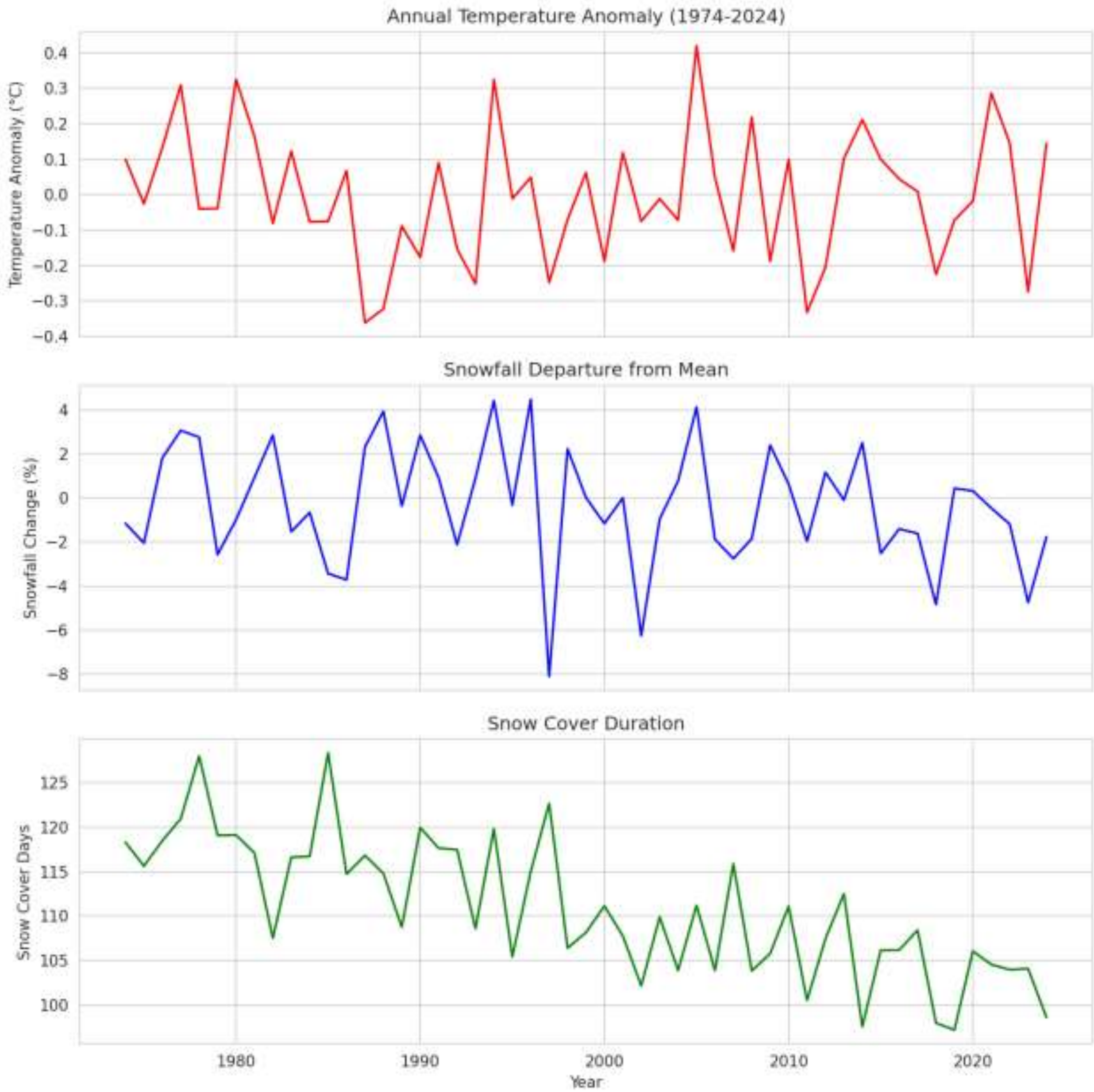


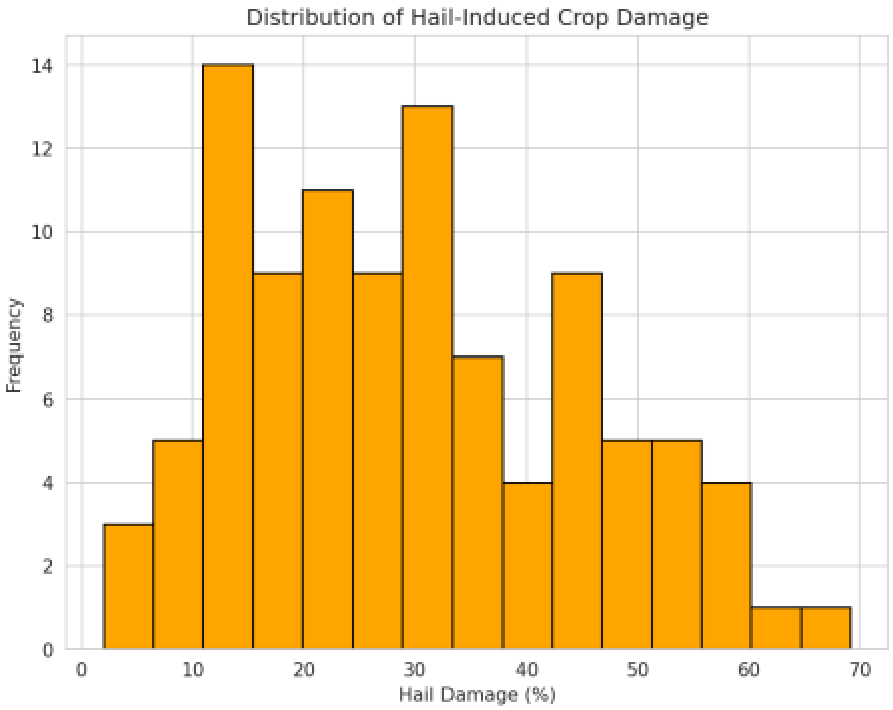
Table 2

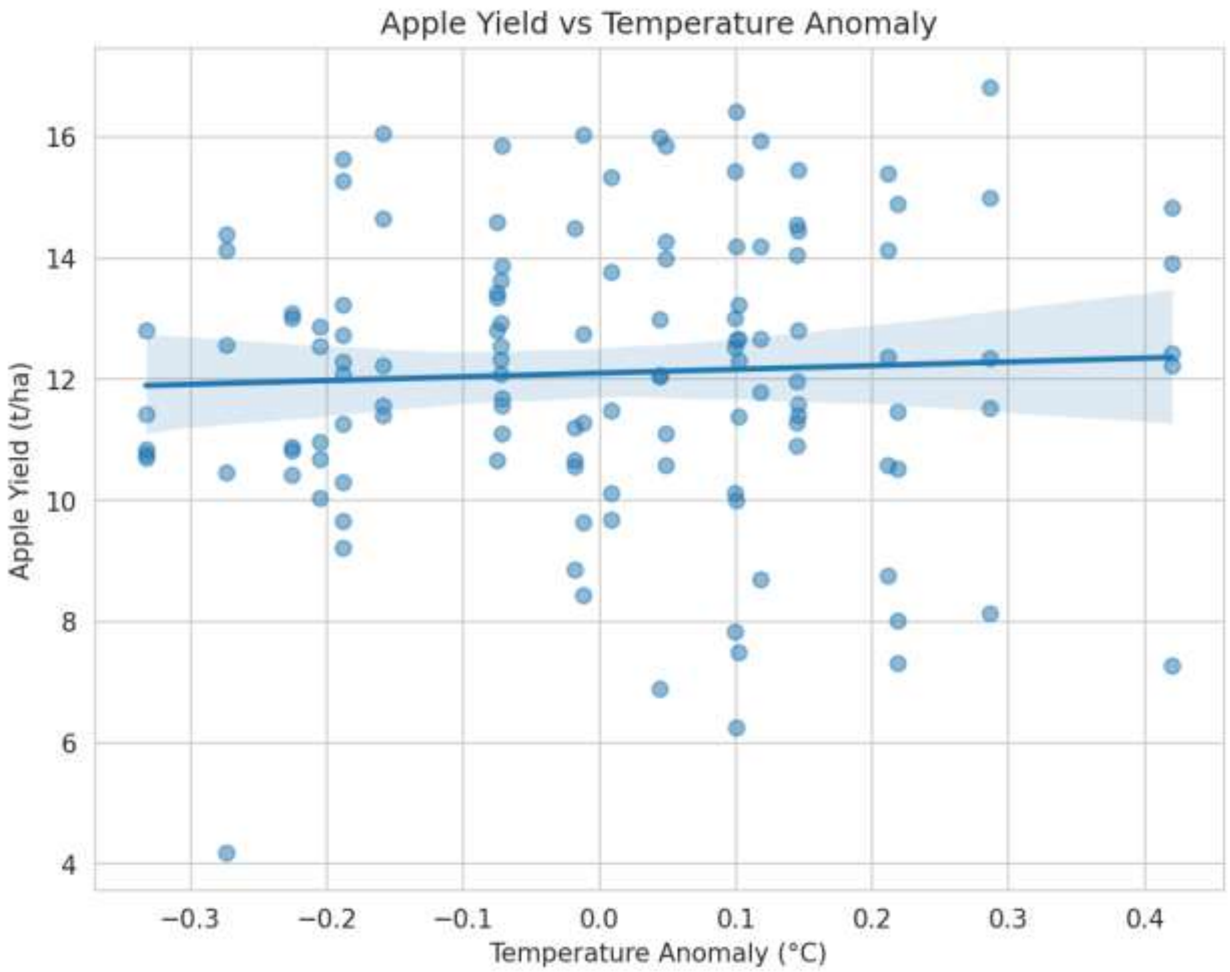
Estimated Apple Crop Losses in Kashmir Due to Extreme Weather (2025–2026)

Event / Location	Extent of damage (%)	Estimated economic loss (₹ crore)
Hailstorms, Shopian (2025)	80–90	2,500–3,000
Hailstorms, Kulgam (2025)	60–70	1,500–2,000
Hailstorms, Pulwama & Bandipora (2025)	50–60	1,500–2,000

Event / Location	**Extent of damage (%)**	**Estimated economic loss (₹ crore)**
Transport spoilage (floods, 2025)	N/A	600–700
Cumulative estimate (2025)	–	6,000–7,000

Note. Loss estimates are based on market value of A-grade apples at ₹1,600/box. Data from Department of Horticulture, J&K (2026), and grower association surveys.





Mango Economy Collapse in Jammu

Mango production in J&K stood at 31,351 tonnes in 2025, marginally up from 30,808 tonnes in 2024 (Table 3). However, the 2026 season witnessed a catastrophic failure. Early March heatwaves disrupted flowering (Manjar), and subsequent hailstorms in May destroyed the remaining fruit set. Field surveys in Samba and Kathua districts indicated 40–50% orchard damage from storms alone. The arrival of local mango varieties in Jammu mandis dropped by over 70% compared to 2025, and prices for the scarce fruit rose sharply, though middlemen captured most margins.

Table 3

Mango Production and Market Indicators in Jammu & Kashmir (2024–2026)

Year	Official production (tonnes)	Market arrival of local varieties (index, 2024=100)	Price index for local mangoes (2024=100)
2024	30,808	100	100
2025	31,351	95	110
2026	Data pending (est. <5,000)	<30	200+ (estimated)

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Note. 2026 figures are preliminary based on mandi surveys and grower reports. Official production data for 2026 will be released in late 2026.

Growers reported complete crop failure in several traditional orchards. Indigenous varieties such as Sanduri and Sounfi, already in decline due to market pressures, suffered near-total loss, accelerating genetic erosion.

Saffron Decline and Multi-Crop Stress

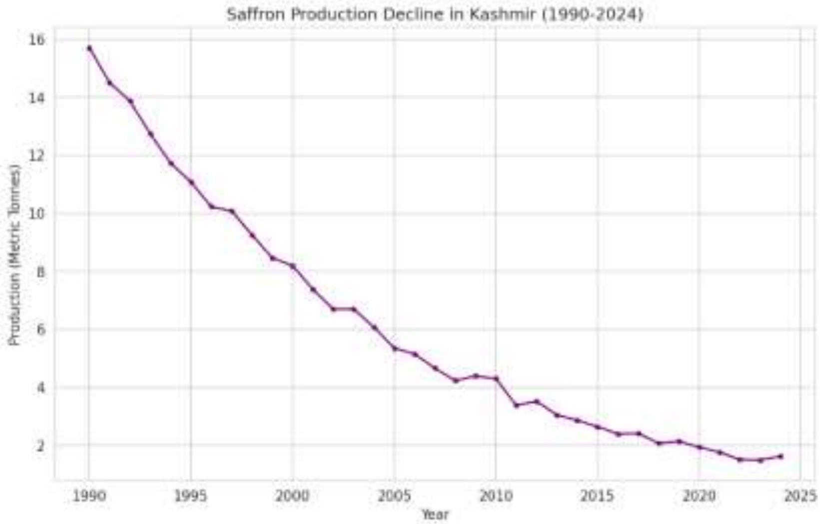
Saffron production in Kashmir has plummeted by 68% over the past two decades (Table 4), from 15.9 MT in 1990 to an all-time low of 2.6 MT in 2023–24. Unseasonal warmth, delayed monsoons, and insufficient winter chilling are the primary climatic drivers, compounded by corm smuggling and urbanization. Vegetable growers reported losses from hailstorms and dry spells, with no functioning crop insurance to buffer them. Official data confirm that 94% of pulse and 91% of oilseed crops were destroyed by unseasonal rains in 2025.

Table 4
Saffron Production Trend in Kashmir (1990–2024)

Year	Production (metric tonnes)
1990	15.9
2000	8.2
2010	5.1
2020	3.4

Year	Production (metric tonnes)
2023–2024	2.6

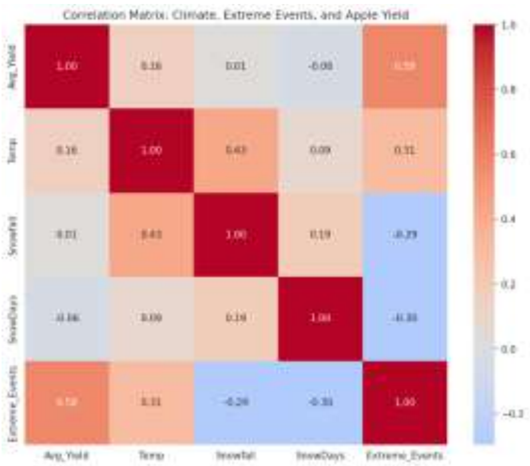
Note. Data from J&K Department of Agriculture, Annual Reports. The decline is attributed to climate change, urbanization, and corm smuggling.

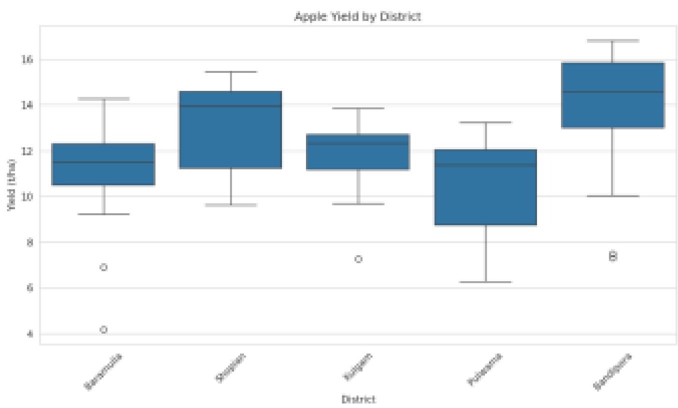


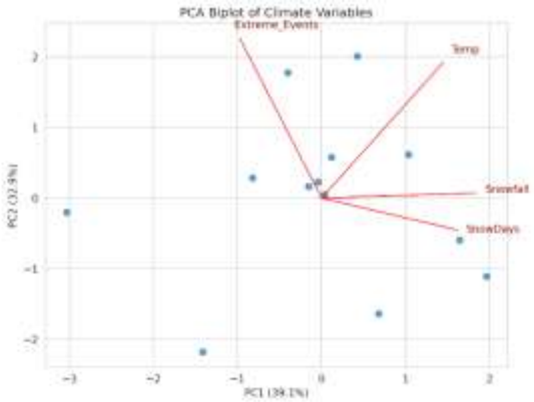
Discussion

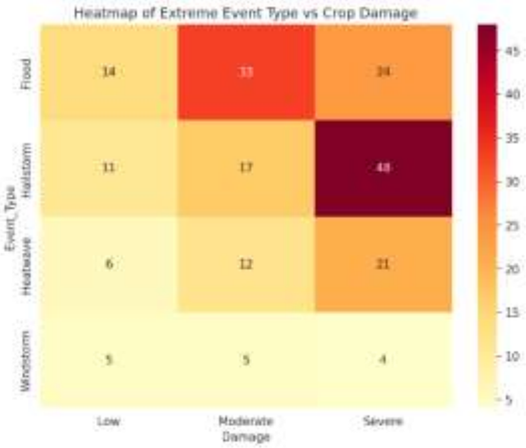
The synthesis of data reveals that J&K's agriculture is trapped in a multi-dimensional climate crisis. The physical sensitivity of high-value crops—apples, mangoes, saffron—means that incremental warming translates directly into yield declines. Hailstorms, once sporadic, have become recurrent and severe, destroying not only the current year's harvest but also damaging tree architecture, which impairs productivity for several subsequent years (Rashid, 2026, personal communication). Transport infrastructure fragility amplifies losses; a single landslide can isolate the Valley for days, rendering perishable harvests worthless.

The economic consequences extend beyond the farm gate. Kashmir's apple economy supports approximately 3.5 million people directly and indirectly, while Jammu's mango groves sustain tens of thousands of smallholders. The collapse of these supply chains erodes rural purchasing power, inflates food prices, and exacerbates distress migration. The cultural dimension—embodied in the vanishing indigenous mango varieties and the shrinking saffron fields—represents an irreversible loss of agro-biodiversity.









Insurance and Policy Gaps

Despite the notification of crops under the Restructured Weather Based Crop Insurance Scheme (RWBCIS), implementation remains deeply flawed. Payouts predominantly benefit cereal growers, while horticulturists face mismatched triggers, delayed settlements, and exclusion of vegetable crops (Grower interviews, 2026). The government's response, including special railway parcel services for apples and high-density plantation schemes, offers medium-term benefits but cannot compensate for the acute losses of 2025–2026. The proposed Himalayan Centre of Excellence for climate-resilient agriculture, if adequately funded and linked to grassroots extension, could address some adaptive deficits.

Recommendations

1. **Climate-Resilient Cultivars:** Accelerate breeding and dissemination of heat-tolerant, dwarf apple and mango varieties, and rejuvenate indigenous germplasm conservation.

2. **Infrastructure Investment:** Build dedicated rail-freight corridors for perishables, expand cold-chain hubs, and climate-proof the Jammu–Srinagar highway.

3. **Micro-Irrigation Expansion:** Extend drip and sprinkler systems to the 80% rainfed horticultural area in Jammu.

4. **Insurance Reform:** Design index-based products with vegetation health triggers (e.g., NDVI) and expedited claims for fruit crops.

5. **Agro-Advisory Systems:** Strengthen localized weather forecasting and extension services to guide farmers on planting, spraying, and harvest timing under erratic conditions.

Conclusion

The $160 billion global crop loss figure is not an abstract forecast for India's Himalayan region; it is a lived reality etched into the barren mango orchards of Samba and the hail-scarred apple trees of Shopian. J&K's agricultural crisis exemplifies the urgency of adaptation. Without immediate, coordinated action—spanning genetic innovation, infrastructure hardening, and financial safety nets—the region's fruit bowl will continue to drain away, taking with it the livelihoods and cultural heritage of millions. The Himalayan warning must be heeded before the window for meaningful intervention closes.

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