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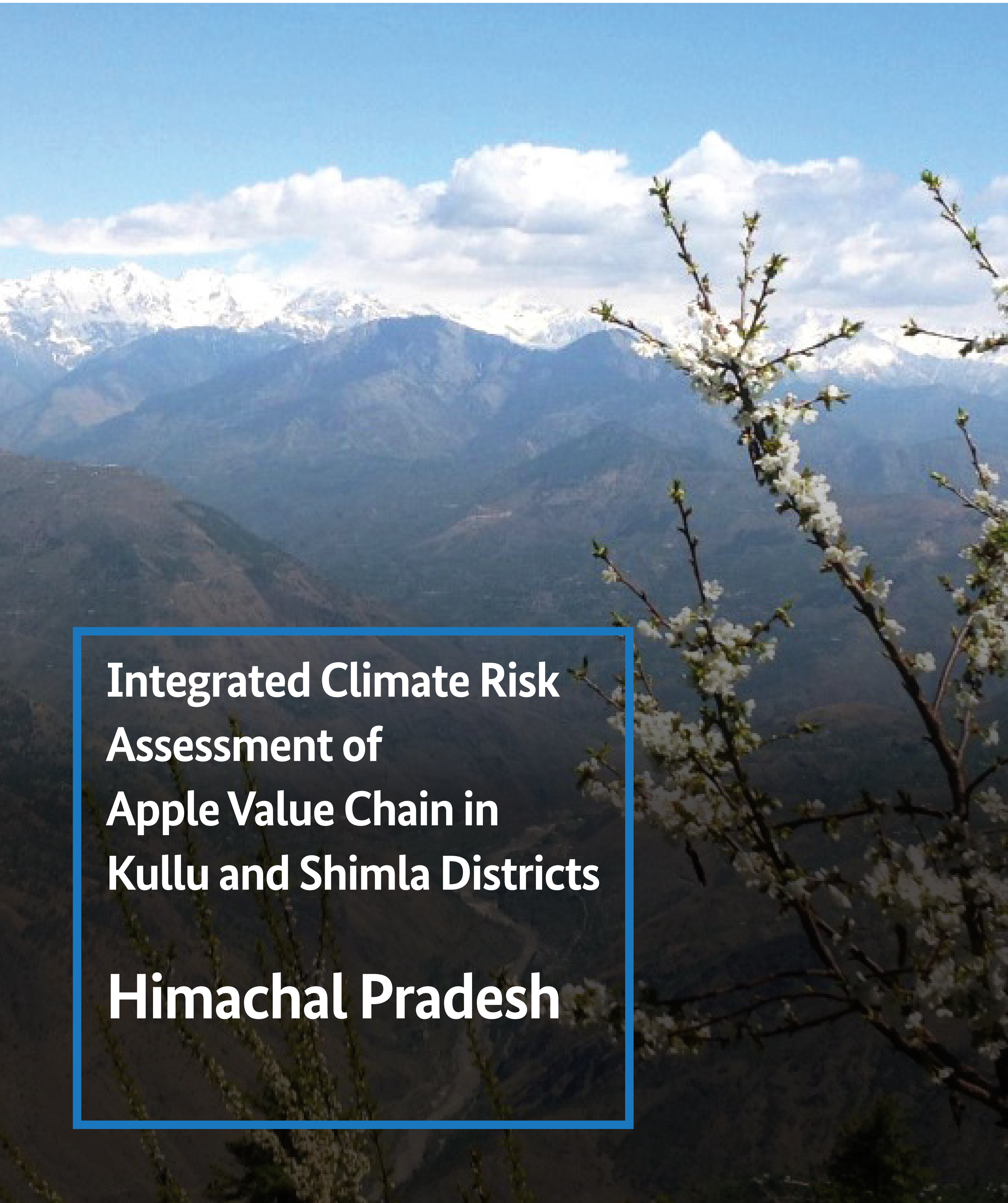

Integrated Climate Risk Assessment of Apple Value Chain in Kullu and Shimla Districts

Himachal Pradesh

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Green Innovation Centres for the Agriculture and Food Sector - India
No. 38/43, First Floor, 10 A Main Road, Fifth Cross
Block 1, Jayanagar
Bengaluru – 560 011, India
T (India) +91 80 46664000 (Extn. 6000)

E greeninnovationcentreindia@giz.de
I www.giz.de/india

Assignment supervisors from GIZ:
Ms. Somya Bhatt, CAFRI and
Ms. Regina Sanchez Sosa y Hernandez, GIC India
Consulting Expert: Mr C V Reddy
Team Coordinator: Mr Narender Singh Rathore

Technical partners:
Suvigya Management Consultants Private Limited
193, Lane 7 Motinagar
Queens Road – Jaipur – 302021
nrathore333@gmail.com
+91 99003-93800

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INTEGRATED CLIMATE RISK ASSESSMENT OF APPLE VALUE CHAIN IN KULLU AND SHIMLA DISTRICTS, HIMACHAL PRADESH

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EXECUTIVE SUMMARY

01

Climate change has been recognised as one of the key challenges for India, with the agriculture sector being extremely vulnerable.

Smallholder farmers with high exposure to climate events are vulnerable to climate change and suffer the most due to their low resilience to such events. Kullu and Shimla are major apple-producing districts in the state of Himachal Pradesh. However, climate trends indicate an increasing vulnerability of apple production to climate change. Climate change impacts and variability, such as rising temperatures and intensity of precipitations and an increase in related hazards such as prolonged droughts, intense monsoon rains and cyclones, landslides, floods, and soil erosion, loss of agrobiodiversity, and depletion of forest cover. Moreover, apple farmers in both Shimla and Kullu Districts use an excessive quantity of chemical-based fertilisers and pesticides that is far beyond the limits prescribed by the Department of Horticulture (DoH). This results in the decimation of pollinators, which in turn affects production. New systems for adaptation must be developed for these farmers in the face of the increasing intensity, frequency, and variety of climate risks. This will require consideration of agriculture value chains, their vulnerabilities, and their adaptation potentials. These systems of adaptation build sustainable resilience by creating assets and institutional linkages for farmers.

Climate change and vulnerability to climate change

Apple farmers in the districts of Shimla and Kullu are vulnerable to climate change. An analysis of past trends and future projections of climate elements (SAPCC-I; SAPCC-II) indicates:

- Total rainfall, snowfall and number of rainy days are decreasing (SAPCC-II) in Shimla and Kullu districts. About 17% decrease in rainfall in Shimla has been observed from 1996 onwards.
- While the winter discharge in the rivers is increasing due to warming, the monsoon discharge is decreasing.
- The projected mean annual precipitation changes by mid-century indicate a 5.9% increase under RCP4.5 and 14% increase under RCP8.5.
- The temperature in Himachal Pradesh is increasing. The analysis of 63 years' worth of data suggests that there has been an increase in the annual minimum and maximum temperatures in the state (high significance in the trend).
- The mean annual maximum temperature for the RCP4.5 scenario is projected to increase by 1.4°C by mid-century. For the RCP8.5 scenario it is expected to increase by 1.6°C by mid-century. The mean annual minimum temperature for the RCP4.5 scenario is projected to increase by 1.4°C by mid-century. For the RCP8.5 scenario it is expected to increase by 1.8°C by mid-century.

The projected increase in temperature, rainfall, and rainfall variations and intensities in the state may lead to accelerated summer flows, in turn resulting in situations like floods and flash floods in the northwestern parts of Himachal Pradesh. An increase in rainfall events may lead to floods, vector-borne diseases, losses due to disruption of transportation etc.

Climate hazards and vulnerability of stakeholders

Less snow (i.e. reduction in chilling hours), hailstorms, incidence of diseases, drought and heavy rainfall leading to floods are major hazards that pose severe threat to the apple value chain. While assessing the vulnerability of key value chain actors, producers show a higher vulnerability score for reduced snowfall and higher incidence of hailstorms. Hailstorms, specifically, can damage the apple crop beyond repair. On the other hand, any pre-processing damage to the produce brings an additional responsibility to wholesalers and storage service providers to minimise any further loss of quality and quantity. In a catastrophic year, it is understood that the amount of quality produce will be lower but the demand for it will remain high. All stakeholders will take extra care to preserve the produce and seek higher prices in response to the rise in demand.

Recommendations

Apple landscapes are gradually contributing to an ecological disaster due to excessive use of chemicals and monocultures. The dimension of its impacts remains unclear due to limited research on the impact of apple production on human, animal and overall ecosystem health. Under the circumstances, sustainable intensification of horticulture, as adapted from the Sixth Assessment.
Report of the Intergovernmental Panel on Climate Change (IPCC-AR6), could provide possible solutions focusing on:

- Improving efficiency through precision horticulture (optimisation of resource use); genetic improvement; use of irrigation technology for water use efficiency; and scaling up of organisations (reaching out to grassroots stakeholders).
- Promoting the substitution of chemicals by promoting green fertiliser, the use of biological control, and the production of alternative crops and high value products to improve farmer income.
- System diversification through integrated farming, pest management, knowledge transfer, and nutrition management.

Specific policy recommendations include the adoption of a landscape approach to horticultural development, gradual promotion of natural farming, adoption of integrated cropping, pollination management, evidence-based decision making, robust monitoring, and scaling up of innovations promoted by organisations like GIZ.

Others include the enhancement of infrastructure for storage facilities, cold chain, and research and development; the promoted use of renewable energy; the setting up of ICT infrastructure and an information portal; hydro-meteorological forecasting; certified nurseries for supply of quality genetic material; and training facilities.

The institutional setup in the state needs to be strengthened, such as Farmer Producer Groups, Fruit Grower Associations, DoH, and the Department of Environment, Science & Technology, Government of Himachal Pradesh.

Markets for responsible production systems can be promoted through eco-labelling and certification, development of green business plans of Farmer Group Associations (FGAs), development and implementation of relevant banking plans, value addition and diversification of products, and social and environmental cost-benefit assessment of current practices.

Given below is the action plan for meeting challenges for each type of critical hazard. The financing source for each activity, and the adoption rate and sustainability in terms of cost-effectiveness, impact-handling capacity, and feasibility is given in section 9.5.

Table 1: Critical hazards and suggested coping and adaptation strategies (CAS)

Stage	Priority
Hazard 1: Less snowing and chilling hours during winters	
Impact 1.1. Fewer Chilling Hours (Impact rating 4)	• Propagation and promotion of apple varieties that can tolerate fewer chilling hours (LT) • Investment in research and trials of appropriate varieties (LT) • Certification of apple varieties unaffected by low chilling hours (LT) • Development of certified nurseries with tested germplasm (LT) • Awareness and technical capacity-building of private nurseries (LT)
Impact 1.2. Water scarcity due to drying of springs and less water flow in the streams because of less snowfall (Impact rating 3)	• Better management of adjoining forest cover (LT) • Conservation of all key water sources (ST) • Soil and water conservation measures to protect water sources (MT) • Construction of water-harvesting structures and distribution networks (MT) • Micro-irrigation (MT) • Rainwater harvesting (MT) • Weather forecasting of drought conditions
Hazard 2: Hailstorms	
Impact 2.1: Crop damage and loss of production (Impact rating 4)	• Mapping of hotspots – areas vulnerable to hailstorms (ST) • Distribution of hail nets (ST) • Establishment of weather stations in each apple landscape (MT) • Weather forecasting (MT)
Impact 2.2.: Loss of Quality (Impact rating 3)	• Setting up of processing facilities (chips, juices, jams) for processing of affected crops (ST) • Local facilities for temporary storage of affected crop (ST)
Impact 2.3: Stress Sale (Impact rating 3)	• Setting up and strengthening of FPO collective sales through Farmer Producer Organisations or Societies (MT) • Collective marketing of good quality produce at higher prices as a result of shortfall in production due to hailstorms (MT) • Local cold storage facilities for crops pre-harvested during or in anticipation of hailstorms (MT) – private sector investment (e.g. Adani)
Hazard 3: Droughts	
Impact 3.1: Mortality of younger orchards and trees (Impact rating 3)	• Weather forecasting (MT) • Instalment of more weather stations especially in higher areas where apple is being planted (MT) • Development, management, and conservation of water sources through soil and water conservation measures, and natural farming (MT) • Insurance/low interest/no interest loan link to Farmer Group Association (FGA) (MT) • Casualty replacement and better management of remaining crop (ST) • Awareness-raising of Fruit Growers Societies and additional focus on marginal farmers (ST)

Stage	Priority
Impact 3.2: Production shortfalls (Impact rating 2)	• Collective marketing through FGA for better price realisation (MT)
Hazard 4: Heavy Rains and Floods in spring/flowering time (Impact rating 5)	
Impact 4.1: Poor pollination and production loss (Impact rating 3)	• Density of pollinators, conservation of local honeybees (MT) • Canopy management with mixed orchards (ST) • On-farm surface water management and upper catchment soil conservation treatments (ST) • Soil conservation measures in and around orchards and in upper catchments
Impact 4.2: Soil erosion (Impact rating 3)	• Soil conservation measures in and around orchards and in upper catchments
Impact 4.3: Waste of chemicals due to washout (Impact rating 3)	• Use of chemicals only after weather forecast and not during rains (ST) • Regular monitoring of spraying equipment and use of safety standards (ST) • Regular awareness and training of labour on the safe use of technologies and chemicals (ST)
Hazard 5: Diseases and pests due to climate variability and resultant stress in plants (drought, heat, evapotranspiration, water stagnation, etc.)	
Impact 5.1: Loss of production and quality (Impact rating 4)	• Plant protection through use of bio-pesticides and use of scientific spray schedule prescribed by the DoH (ST) • Use of mobile applications for identification and treatment of pests and diseases (ST) • Farmer-to-Farmer Networking Portal and social media for information-sharing (ST) • Link to research institutions for disease and pest surveillance and awareness (MT) • Diversification to 20% to 30% of mixed and other stone fruits (MT) • Propagation of local pollinators (ST) • Adoption of natural farming and landscape management approach
Impact 5.2: Excessive use of pesticides (Impact rating 4)	• Awareness-raising on the correct and timely use of pesticides (ST) • Closer control on type and dose of chemicals (ST) • Regular soil and leaf tests, and soil remediation (MT)

BACKGROUND

02

The agricultural sector in Himachal Pradesh is dominated by horticulture commodities, that account for about 44% of the cropped area and contribute to about 48% of its agricultural Gross Domestic Product (GDP).

Himachal Pradesh has emerged as a leading producer of fruits and off-season vegetables. The horticulture sector annually contributes INR 3,000-5,000 crores to the state economy, which was about 7% of the state GDP (in 2013-14). Apple has come to form the backbone of the horticulture economy of the state, estimated to be about INR 5000-6000 crores, contributing about 91.39% of the temperate fruit production and about 83.14% of the total fruit production in Himachal Pradesh. The state produced about 6.25 lakh MT of apples in 2014-15 that constituted 28.55% of the total apple production in the country. Apple production is very sensitive to climate change, i.e. increase in temperature and variability in precipitation. Therefore, it is evident that any negative impact on apple production due to climate change will impact the horticultural economy[1] that provides livelihoods and income for several stakeholders across the value chain from production to consumption.

The excessive use of chemical fertilisers and pesticides has decimated the populations of most pollinators (bees, butterflies, and insects); poor pollination has in turn compromised apple production.

Table 2: Apple production in Kullu and Shimla Districts[2]

Particulars	1970-71		2020-21	
	Area	Production	Area	Production
Kullu	6500 ha	N/A	27,528 ha	92,260 MT
Shimla	12,633 ha	N/A	42,085 ha	247,179 MT

According to on scientific observations, modelling and studies, Himachal Pradesh is experiencing the impacts of global warming. The agriculture and allied sectors are vulnerable to the immediate and future impacts of climate change and variability, such as rising temperatures and intensity of precipitations and an increase in related hazards such as prolonged droughts, intense monsoon rains and cyclones, landslides, floods, and soil erosion, loss of agrobiodiversity, and depletion of forest cover. The degradation of landscape-based ecosystem services presents additional challenges across the various agro-ecological zones that threaten the country's food, nutritional, water, livelihood, and income security.

Smallholder farmers with high exposure to climate events are vulnerable to climate change and suffer the most due to their low resilience to such events. Adaptation options must be developed for these farmers in the face of the increasing intensity, frequency, and variety of climate risks. This will require consideration of agriculture value chains, their vulnerabilities, and their adaptation potentials. These adaptation options build sustainable resilience by creating assets and institutional linkages for farmers.

1 Department of Horticulture, Govt of HP
2 State Strategy and Action Plan for Climate Change (SAPCC-I; SAPCC-II)

The aim of this document is to provide a comprehensive climate risk assessment and specific recommendations for managing the current and future climate risks of apple value chains in Kullu and Shimla Districts of Himachal Pradesh. It is based on the Climate Risk Management (CRM) Framework developed by developed by GIZ projects 'Global Programme on Risk Assessment and Management for Adaptation to Climate Change' and 'Climate Change Adaptation in Rural Areas of India', commissioned by German Federal Ministry for Economic Cooperation and Development (BMZ), in collaboration with KPMG India and IIASA, and published by National Institute of Disaster Management, and is an outcome of the desk review and the field survey conducted on climate hazards of apple value chain stakeholders to determine their relative vulnerability to climate change. The past trends and future projections for climate change are based on the State Strategy and Action Plan for Climate Change of Himachal Pradesh (2012; 2021) and past data as well as knowledge exchange with different stakeholders during field visits. Through virtual consultations and field visits, different stakeholders were consulted to draft a comprehensive implementation plan for Climate Change Adaptation (CCA) for apple value chains in Kullu and Shimal districts, Himachal Pradesh.

Under GIZ India, this is supported by the Indo-German development cooperation projects 'Green Innovation Centres for the Agriculture and Food Sector - India (GIC India)', 'Climate Adaptation and Finance in Rural India (CAFRI).' GIC India is part of a larger global programme under the Special Initiative "Transformation of Agricultural and Food Systems" by the German Federal Ministry for Economic Cooperation and Development (BMZ).

CLIMATE CHANGE IN KULLU AND SHIMLA DISTRICTS

03

3.1.1 Precipitation

An analysis of past trends in precipitation in Himachal Pradesh shows that:

- The total rainfall and number of rainy days are decreasing (SAPCC-II).
- There has been a decreasing trend in the snowfall in Himachal Pradesh since 1974 (SAPCC-I).
- An analysis of annual rainfall data in the last 25 years in different districts of Himachal Pradesh reveals an increasing trend of about 33.5%, 54.3% and 51.5% in Kinnaur, Chamba, and Lahul and Spiti Districts respectively, and a decrease of about 8.7%, 13.3% and 26.6% in Solan, Shimla, and Sirmaur Districts respectively (SAPCC-I).
- A decrease of about 17% in rainfall in Shimla is observed from 1996 onwards. The decreasing trend in seasonal snowfall in Shimla is very conspicuous since 1990 and it was lowest in 2009 (SAPCC-I).
- Monsoon discharge in the Beas River has shown a significant decrease. Winter discharge in the Chenab River has shown a significant increase. River Sutlej is showing an increasing trend in winter and spring discharges (SAPCC-I).

According to SAPCC-II, the projected mean annual precipitation changes by mid-century indicate a 5.9% increase under RCP4.5 and a 14% increase under RCP8.5. The increase in rainfall events may lead to floods, vector-borne diseases, and losses due to disruption of transportation, among others.

According to SAPCC-II, the simulations by Indian Institute of Tropical Meteorology (IITM), Pune, have indicated that summer monsoon intensity may increase from 2040 and reach 10% by 2100 under the A2 scenario of the IPCC. The PRECIS simulation indicates:

- The annual rainfall in the Himachal region is likely to vary between 1268±225.2 and 1604±175.2 mm in the 2030s.
- The projected precipitation in Himachal Pradesh is likely to increase by 5% to 13% in the 2030s with respect to the 1970s.
- The rate of increase is expected to be more in northwestern parts of the state, i.e. areas of the districts of Kangra, Chamba, Kullu, and Una are likely to receive rainfall with increased intensity.
- The High Hill areas like Kinnaur, Lahul and Spiti, and some parts of Chamba and Kullu Districts may also experience rainfall in place of snowfall with increased temperature.
- The number of rainy days may increase in Himachal Pradesh with a decrease in average intensity.
- An increase in rainfall in the pre-monsoon and post-monsoon months, with an increasing incidence of storms, may be observed in Himachal Pradesh.

3.1.2 Temperature

An analysis of past trends in temperature in Himachal Pradesh (SAPCC-I) shows that:

- In the last century, the Indian northwestern Himalayan region saw a rise in temperature of about 1.6°C, a significant warming compared to the global average.
- Temperatures rose at a lower rate until 1930, but thereafter grew at a modest rate during the decade of 1961-1970. The warming rate was higher during the period from 1991 to 2002 as compared to the earlier periods and the gross rise in mean temperature from 1980 to 2002 was about 2.2°C. The temperature rise varied for different altitudinal zones in Himachal Pradesh; the rate of increase in the maximum temperature at higher altitudes was more than that at the lower altitudes.
- Between 1990 and 2010, there has been increase in the winter mean air temperature in Himachal Pradesh. The mean air maximum temperature has increased by 3.2°C, the mean air minimum temperature has increased by 0.8°C, and the average winter air temperature has increased by 2.2°C.

According to SAPCC-II, the mean annual maximum temperature for the RCP4.5 scenario is projected to increase by 1.4oC by mid-century. For the RCP8.5 scenario, it is expected to increase by 1.6oC by mid-century. The mean annual minimum temperature for the RCP4.5 scenario is projected to increase by 1.4oC by mid-century. For the RCP8.5 scenario, it is expected to increase by 1.8oC by mid-century. The general implications of temperature increase may include heat stress, water-borne diseases, increase in energy demand for cooling, and additional evaporation and evapotranspiration losses resulting in increased irrigation requirement for the crops.

According to SAPCC-I, there have been different projections made on future change in temperature using different scenarios:

i. From simulations done by Indian Institute of Tropical Meteorology (IITM), Pune, the annual mean surface temperature will rise by the end of century, ranging from 3°C to 5°C under A2 scenario and 2.5o to 4°C under B2 scenario of the IPCC with warming more pronounced in the Northern Parts of India.
ii. As per the PRECIS simulation, the mean annual temperature of Himachal Pradesh is projected to increase from 0.9 ± 0.6°C to 2.6 ± 0.7°C in the 2030s. The net increase in temperature ranges from 1.7°C to 2.2°C with respect to the 1970s. Temperatures also show a rise in all seasons.
iii. CORDEX South Asia have made projection for climatic data on precipitation and temperature for 20 districts in Himachal Pradesh at three levels: Baseline (1981-2010), Mid-Century (2021-2050) and End-Century (2071-2100). The study used two IPCC scenarios: IPCC AR5 RCP4.5 and IPCC AR5 RCP8.5. The IPCC AR5 RCP4.5 projects the average annual maximum temperature to increase by about 1.40°C towards the mid-century and by about 2.50°C towards the end-century. Similarly, the IPCC AR5 RCP8.5 projects the average annual maximum temperature to increase by about 1.60°C towards the mid-century and by about 2.5°C towards the end-century for Himachal Pradesh.

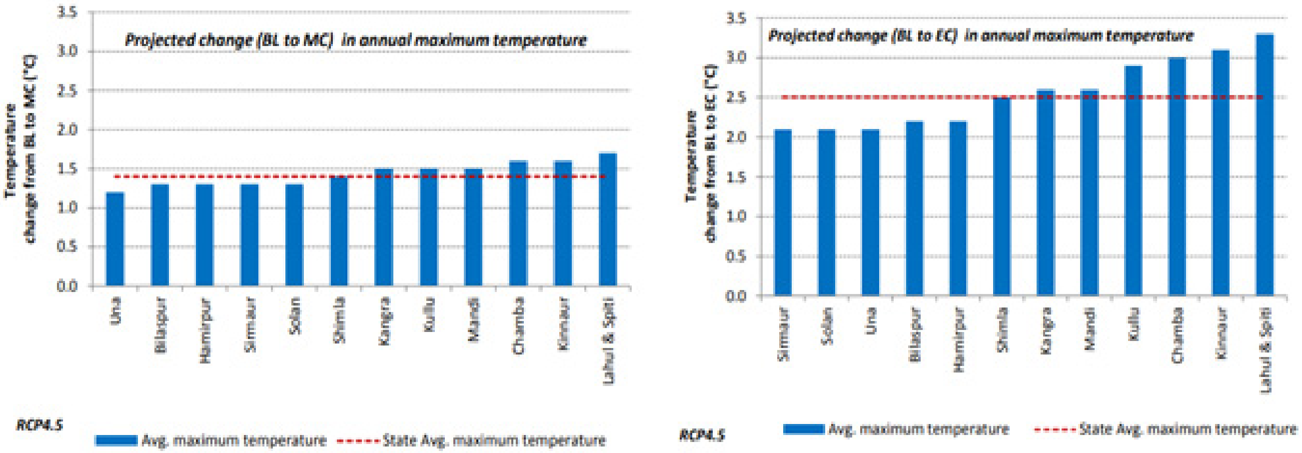


Figure 1: Projected annual and seasonal maximum temperatures for IPC AR5 RCP4.5 scenario (Himachal Pradesh)

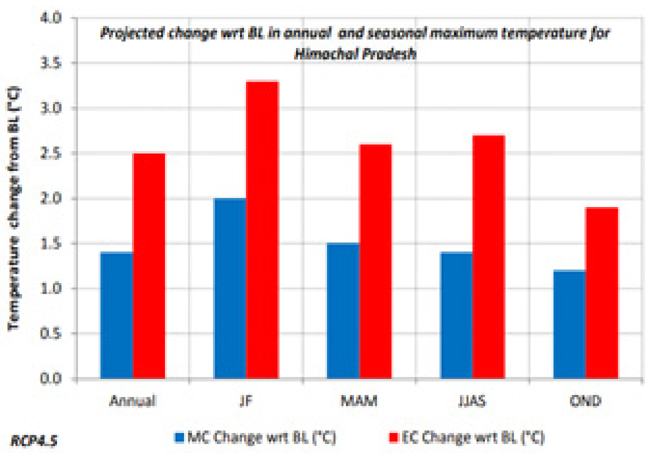


Figure 2: Characteristics of projected annual and seasonal maximum temperature for IPCC AR5[3] Extreme weather events

3 GIZ, Climate Change Impact and Vulnerability Assessment in Himachal Pradesh

3.2 Extreme weather events

- The number of rainy days in Himachal Pradesh may increase by 5-10 days on an average in the 2030s. The rainy days will increase by more than 15 days in the northwestern part of the state. The intensity of rainfall is likely to increase by 1–2mm/day.
- With changes in rainfall patterns and increased variability in the future, some regions (southeastern parts) may experience less rainfall. Drought-like conditions may prevail as per some projections.
- Projected increase in temperature, rainfall, and rainfall variations and intensities in the state may lead to accelerated summer flows, in turn resulting in situations like floods and flash floods in northwestern parts of the state.
- Health risks are also associated indirectly with extreme events in submontane, low hills, and sub-humid agroclimatic zones of the state.

3.3 Impact of climate change

By 2030, climate change will have significant impacts on agricultural and horticultural production, water resources, forests, and natural wetlands. These may include:

- Reduced snow and chilling hours: The increase in temperature (average, average maximum, and average minimum temperatures) has led to the reduction of observed cumulative Chill Units in Kullu. At the same time, the apple crop productivity decreased at the rate of 0.183 MT/ha/year between 2005 and 2014. Every one of the farmers interviewed reported less snow, increased winter temperature, and less chilling hours, which negatively affects apple crop production. Farmers are therefore looking for low-chilling varieties to continue the business-as-usual approach of high input-oriented apple production. In Shimla and Kullu, precipitation has decreased, especially in winter and in all seasons except for the monsoon season. This has repercussions since low precipitation in winter means less snow and, in turn, less chilling hours for the crop.
- Hailstorms: Hailstorms are very common in the districts during spring and autumn. Hailstorms destroy flowers and fruits, causing farmers to incur heavy losses. Hailstorms also result in severe soil erosion in exposed fields.
- Incidence of diseases: With a general increase in temperature, variability of precipitation, and resulting moisture stress, there has been a rise in the incidence of diseases that affect apple production. The most common diseases are apple scab, marssonina leaf blotch (premature leaf fall), black rot canker, collar rot, powdery mildew, sooty blotch and fly speck, apple mosaic and other virus diseases, alternaria leaf spot/blight, core rot, brown rot, white rot/root rot, and seedling blight.
- Floods: With the increase in warming, erratic rainfall, and rainfall changes, floods and water yield in major rivers will be more frequent by 2030. Flooding will become more frequent in the rainy season due to glacial melts. Currently flood-free areas will suffer from occasional floods and flash floods. An increased occurrence of floods and an increased flow in rivers and dams will result in increased instances of soil erosion.
- Drought: Various parts of the state will face moderate to extreme drought severity, despite an overall increase in precipitation. The change in precipitation patterns will result in less than the normal water recharge in lakes and rivers over a longer period, creating serious drought-like conditions. Reduced spring and summer rainfall will cause regular water shortages, especially in the mid hills, affecting both people and the ecosystems. Rainfed crops will face major water stress.
- Water problems: According to SAPCC-II, under the RCP4.5 and RCP8.5 scenarios for the southwest monsoon, an increase in precipitation by up to 23% is projected towards the mid-century, and by up to 41% towards the end of the century. It also projects an increase in runoff in Kullu, Chamba, and Lahaul and Spriti Districts, and an increase in evapotranspiration in Shimla and Sirmaur Districts. Kullu, Kinnaur, Mandi, Kangra, Chamba, and Lahaul and Spiti are also projected to have a high

magnitude of floods.

- Forest degradation: The forests of the state, and in particular its high-altitude dense forests, are highly vulnerable. Forest-type shifts may occur in more than 80% of forested grids, as per 2080 scenarios. Forest vegetation type of four eco-sensitive regions is anticipated to be vulnerable to projected climate change in the short term, i.e. in the 2030s, even under a moderate climate change scenario (A1B). The occurrence of forest fires may increase. Reduction in forest flora will affect the pollinators, and ultimately apple production, in the state.

The SAPCC-II projects a high incidence of forest fires and an increase in heat waves, heavy rainfall, floods and droughts in the "Climate Vulnerability Assessment for the Indian Himalayan Region using Common Framework 1." An increase in tree mortality due to reduced snowfall in higher altitudes is expected. Erratic rainfall and increasing temperature have triggered the introduction and expansion of invasive and exotic species at the cost of native flora and fauna. Rare mountainous species may face extinction due to invasion of exotic species and the variation in precipitation. Some of the impacts of these trends include:

- Loss of infrastructure: High intensity rainfall will result in landslides, erosion, flooding, and environmental changes with severe threat to infrastructures (storage, transportation, communication).
- Health hazards: Health risks are likely to increase in the state. Instances of malaria, water-borne diseases, and jaundice may present themselves along riverbeds.
- Land use and land use change: The area has undergone drastic land use/land cover changes in the last three decades. Land cover changes have manifested in terms of decreasing permanent snow-covered areas, and forest degradation with respect to decreasing forest density. Land use changes are associated with the expansion, intensification, and encroachment of horticulture and settlements on natural landscape. The latter are also responsible for increased vulnerability because most of the expansion has taken place in physically vulnerable areas, especially in the proximity of rivers or steep mountain areas. Enhanced vulnerability in the face of natural disasters and associated damages become a distinct possibility in light of these changes. The scenario is more worrisome for the sensitive landscape that forms part of a major river basin. In a situation of changing climate, the importance of these changes may increase.

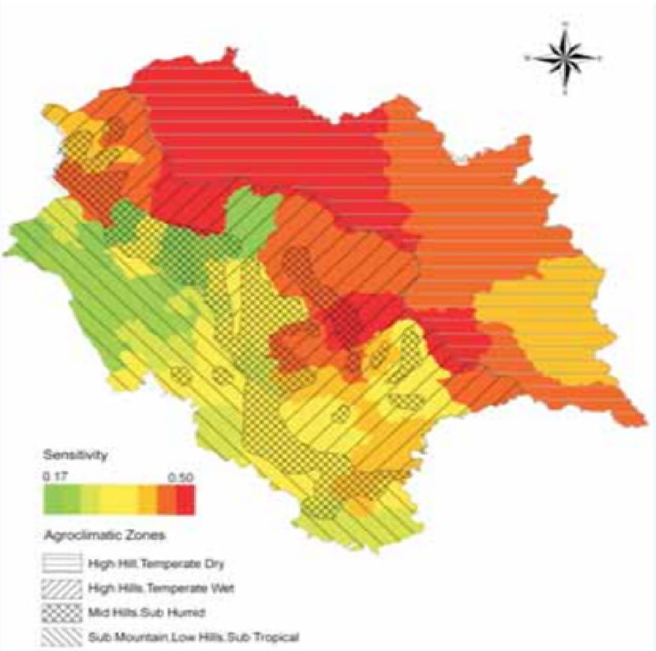


Figure 3: Drivers of Impact of climate change

It has been widely reported in the media and by the interviewed farmers that climate change-related extreme events bring new challenges for crop production. For instance, strong hailstorms have led to a heightened need to use hail protection nets for apple production. The vast set of nets have become a common sight across the landscape of Shimla District, as well as in Kullu. Often, farmers complain about the lack of availability of these nets. Moreover, an increase in the area under apple production means more threats due to landslides, roadblocks, heavy erosion, and run-off of surface water with chemicals into the landscape and river basins. The frequency of these biophysical and hydrological events indicate that future risks are unavoidable. Similarly, cold waves and droughts, especially in the peak times of plant growth, will affect apple production in the future. All interviewed farmers confirmed that in most months out of the year, one of these weather events occurs and causes human, animal, and material losses. Since the welfare state compensates farmers after these events, crop insurance is not an attractive option for them.

The risk assessment has shown (Bhatt, 2021) that heavy rainfall, related flood discharge, and landslides are all projected to increase across the Kullu District by mid-century (under RCP4.5 and RCP8.5), increasing the threat to livelihoods and infrastructure, and compounding the effects of water scarcity, heat stress, and drought. These findings are in line with farmers' perceptions in Shimla that have highlighted significant and increasing impacts relating to flooding, cloudbursts, and plant diseases, linked to rising temperature and water stress. Regarding the risks to livelihoods, the highest risk levels under both current and future conditions are seen in the blocks of Kullu and Nirmand, while risk to infrastructure is highest in the block of Anni and Nirmand. On the other hand, farmers indicated that winter snow and spring rains are key during production time, thus raising the significance of chilling factor completion and the growth of trees in the months between March and April.

More studies may be needed focusing on the importance of apple varieties and their ability to adapt to local climate. There is insufficient information available on whether and how imported apple varieties affect local production systems, biodiversity and the ecosystem.

Table 3: Assessment of hazard impact on resources

Future expected hazard type	Hazard rating	Impact on natural resources		Impact on physical capital	
		Nature of Impact (H/M/L)	Probability of impact (H/M/L)	Nature of Impact (H/M/L)	Probability of impact (H/M/L)
Less snowfall	5	M	M	M	H
Hailstorms	5	H	M	M	H
Diseases	4	M	M	M	H
Drought	4	H	M	M	M
Heavy rainfall/ floods	3	M	L	M	M

Note: H – High, M – Medium, L – Low

The analysis of statements provided by interviewed farmers regarding the importance of the different hazard in the future revealed less snow and its implication for chilling hours as the highest-ranking of the hazards. Similarly, hailstorms were seen as a major threat for future apple production. Most of the small-to-medium orchards use hailstorm-protection that not only significantly changes the look of the landscape, but may also have negative effects on local ecosystems, birds, butterflies, native flora, and more.

Impact on health of the farming community: There are no available studies on how current apple management practices affect the health and hygiene of farming communities, especially women. However, interviewed farmers are wary of the effects of the heavy chemical inputs that apple crops need, and often attribute diseases such as cancer to these inputs. These effects must be assessed through comprehensive research and monitoring.

3.4 Vulnerability to climate change

3.4.1 State-level vulnerability to climate change

Vulnerability assessment was conducted in SAPCC-I based on proxy variables at block level.

Table 4: Variables for climate change vulnerability assessment

Component	Indicator	Proxy variable
Exposure	Temperature	Annual Mean Max. Temperature(°C)
		Annual Mean Min. Temperature (°C)
	Rainfall	Annual Mean Rainfall (mm)
Sensitivity	Agriculture	Agriculture Population (%)
		Rainfed Farming (%)
	Agroclimatic Zone	Altitude (Mean) (m)
		Irrigated Area (%)
	Health	Birth rate, Family Size (%)
	Forests	Forest Cover (%)
		Biodiversity richness (%)
Adaptive Capacity	Economic Capacity	Poverty Rate (%)
	Education	Literacy Rate (%)
	Environmental Ca-pacity	Population Density (persons/sq km)
	Physical Capacity	Road Network (%)

Table 5: Districts vulnerability Index

Agroclimatic zone	Elevation (m)	Districts/ area	Climate component	Change	Impact	Vulnerability index
			Exposure	Sensitivity	Adaptive capacity	
Mid hill sub humid	651 to 1,800 m	Parts of Kullu, Rampur Tehsil of Shimla	High	Moderate	Moderate	Moderate High
High hill temperature wet	1801 to 2,200 m	Shimla, Kullu	Moderate	High	Moderate	Low to high

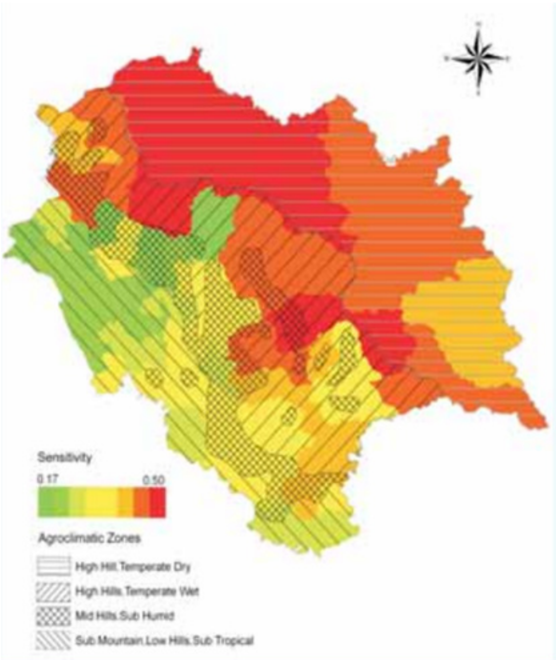


Figure 4: Climate change sensitivity as per agroclimatic zones at block level

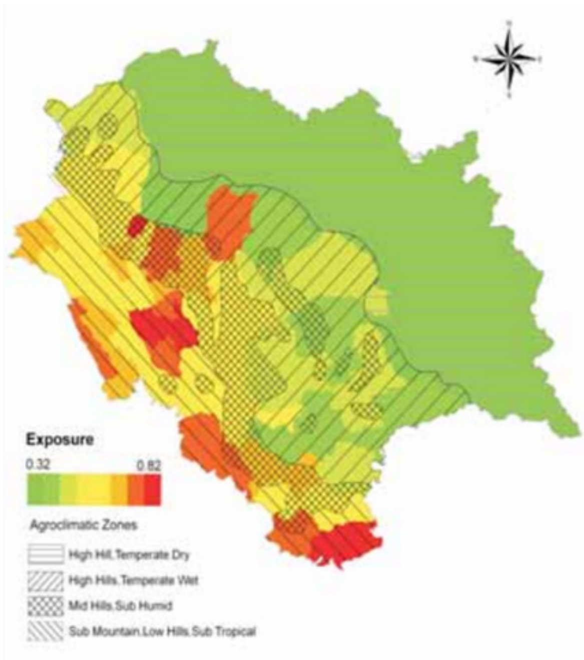


Figure 5: Climate change exposure as per agroclimatic zones at block level

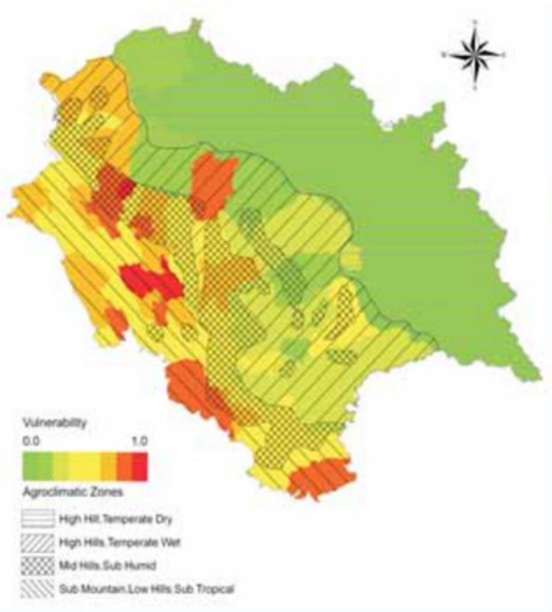


Figure 6: Vulnerability variation as per agroclimatic zones at block level

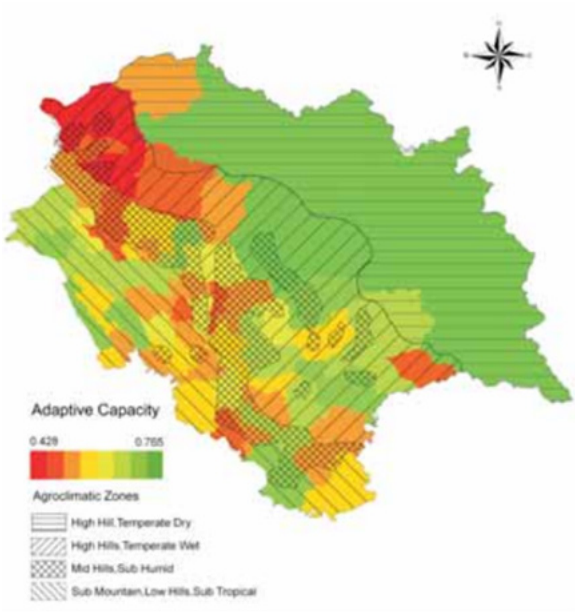
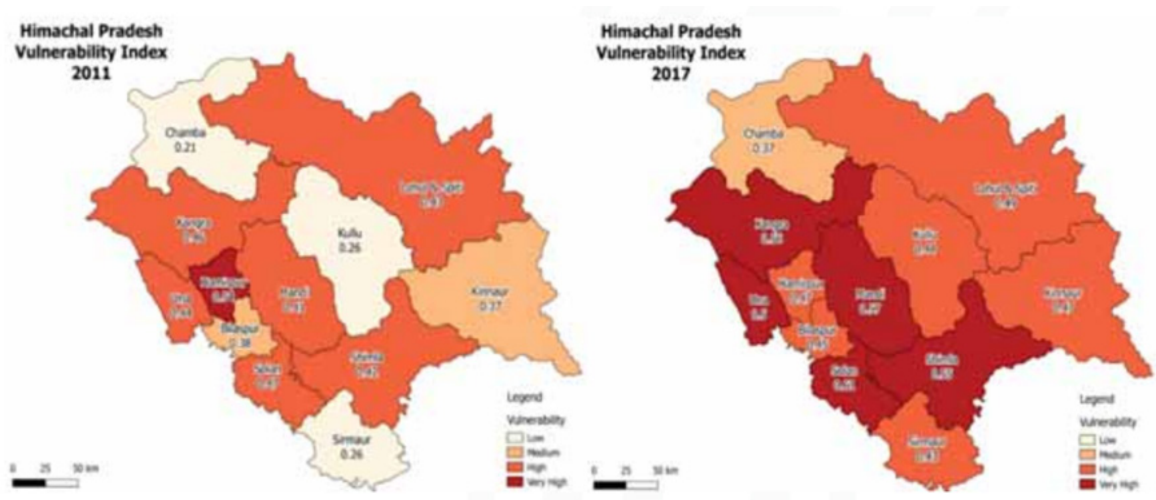


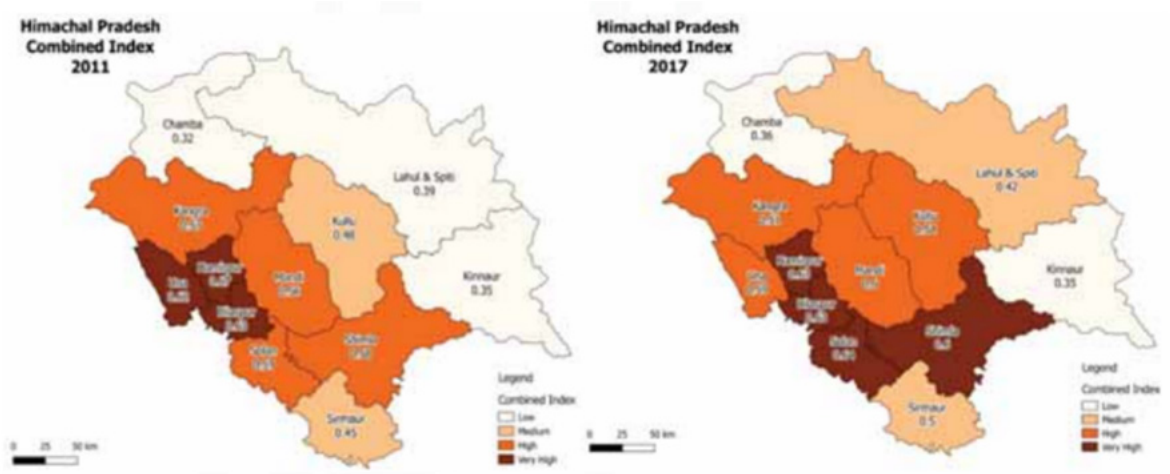
Figure 7: Adaptive capacity as per agroclimatic zones at block level

According to SAPCC-II report, the baseline vulnerability index between 2011 and 2017 for Kullu District has moved from “low vulnerability” to “high vulnerability” and for Shimla District, it has shifted from “high vulnerability” to “very high vulnerability." Similarly, the baseline composite risk index for Kullu District has moved from “medium” to “high” and for Shimla District, it has moved from the “high” to “very high” category.



Source: MoEFCC, GIZ and DoE

Figure 8: Baseline vulnerability index for 2011 and 2017 (SAPCC-II)



Source: MoEFCC, GIZ and DoE

Figure 9: Baseline composite risk index for 2011 and 2017 (SAPCC-II)

3.4.2 Vulnerability assessment of value chain stakeholders

The vulnerability assessment of three most prominent hazards – landslides, hailstorms, and diseases incidences – on various participants of the apple value chain is given below:

Table 6: Vulnerability assessment of value chain participants

Participants	Most critical climate hazards											
	Landslides				Hailstorms				Diseases			
	F	A	M	VS	F	A	M	VS	F	A	M	VS
Producers	3	4	3	36	4	4	4	64	3	3	3	27
Packaging	2	2	2	8	2	2	2	8	1	1	1	3
Storage	2	3	3	18	2	3	4	24	1	1	1	3
Transporters	1	1	1	1	1	1	1	1	1	1	1	3
Warehousing	2	2	2	8	2	2	2	8	2	2	12	48
Retail traders	1	1	1	1	1	1	1	1	1	1	1	3

Note: F – Frequency of hazard, A – Area affected, M – Magnitude of Hazard, VS – Vulnerability score

The assessment of the vulnerability of key value chain actors revealed that producers feel most threatened by hailstorms because these can damage the apple crop beyond repair. Any pre-processing damage to the produce gives an additional responsibility to wholesalers and storage service providers to prevent any further loss to the quality and quantity of the produce. In a catastrophic year, there will be a reduction in the quantity and quality of produce, but demand will remain high. Both these stakeholders prioritise the preservation of produce and seek higher prices according to fluctuations in demand and scarcity.

RECOMMENDATIONS

04

4.1 General

The current practices of apple production in Himachal Pradesh (lower and higher altitudes) includes the uncontrolled use of chemicals and eutrophication of soils and water resources with unknown risks for human and livestock health (Business as Usual Scenario, considering only the economical element of the apple sector). If this trend continues, the intensification of landscape use will follow. This will escalate the deterioration of the state's fragile mountain landscape, which already faces both climatic and non-climatic risks. This, in turn, will reduce the resilience of humans and ecosystems, while making adaptation in the future extremely expensive. The evidence, collective observations and testimony from key stakeholders indicate that apple production in Himachal Pradesh may be leading to an ecological disaster, the dimension of which is still not clear due to limited research on the impact of apple production on human and animal health. After decades of extensive use of chemicals, , intensive soil and water restoration measures are required for a sustainable transition to natural and organic farming. Moreover, it will be difficult for farmers to commit to natural or organic farming schemes that lack a tested design and delivery system in an already eutrophicated landscape. Farmers perceive that, due to the landscape and land use change in the past three decades, organic or natural farming in its true sense cannot be carried out.
In chemical horticulture, a specific insecticide may be applied to quickly address a particular insect pest. Chemical controls can dramatically reduce pest populations in the short term, yet they also unavoidably eliminate or starve natural control insects and animals, causing an increase in the pest population in the long term and creating an ever-increasing problem. Repeated use of insecticides and herbicides also encourages rapid natural selection of resistant insects, plants, and other organisms, promoting greater chemical use, or requiring more powerful control measures.

Most of the apple orchards have been developed on subsistence farming lands earlier used for crops like rice and wheat; the spread of apple farms has been driven mostly by the perceived potential incomes and profits by farmers, with no evaluation of climate vulnerability. The repercussions of the spread of horticulture or apple cultivation on local food security in the long run could not be assessed.

The following recommendations are based on the “Business as Usual” scenario. Nonetheless, a further intensification of horticulture and apple production in the long run is likely, since subsidies are readily available, the private sector is growing, and each year regulatory regimes are announced that promote apple cultivation.

Table 7: Approaches to sustainable intensification of horticulture (adapted from IPCC-AR6)

Approach	Sub-Category	Example
Improving Efficiency	Precision Horti-culture	High and low technology options to optimise resource use
	Improving Efficiency	Improved resource-use efficiency through crop or live-stock breeding
	Irrigation Tech-nology	Increased production in areas currently limited by precipi-tation (sustainable water supply required)
	Organisational Scale-Up	Increasing farm organisational skills (e.g. cooperative schemes) can increase efficiency via facilitation of mecha-nisation and precision farming techniques
Substitution	Green Fertiliser	Replacing chemical fertiliser gradually by green manures, compost (including vermicompost), biosolids and by-products of anaerobic digestion to maintain and improve soil fertility
	Substitution	Pest control by encouraging natural predators
	Alternative crops	Replace annual with perennial crops reducing the need for soil disturbance and reducing erosion
	Premium Prod-ucts	Increase farm-level income with less output by producing a premium product
System redesign	System Diversi-fication	Implementation of alternative farming systems: organic, agroforestry and intercropping (e.g. using legumes)
	System rede-sign	Integrated pest and weed management to reduce the quantity of inputs
	Knowledge Transfer	Implement integrated nutrient management by using crop- and soil-specific nutrient management, guided by soil test-ing
	Nutrition Man-agement	Using knowledge-sharing and technology platforms to ac-celerate the uptake of good agricultural practices

4.1.1 Policy Initiatives

Intensification of existing schemes: Numerous schemes and programmes exist that enhance resilience and adaptation to climate change. The Government of Himachal Pradesh is promoting adaptation through the provision of agriculture insurance (weather-based crop insurance by the DoH, Rashtriya Krishi Bima Yojana, PMFBY), the promotion of poly-houses (Dr. Y S Parmar Kisan Swarojgar Yojana), the development of micro-irrigation (National Mission for Micro-Irrigation by the DoH, Rajiv Gandhi Micro-Irrigation Scheme), and promoting irrigation (NMSA), water harvesting structures (PM Krishi Vikas Yojana), and energy for agriculture and solar-powered irrigation (Jal Se Krishi Ko Bal scheme). However, farmers have expressed their limited access to, and the limited outreach of, these schemes. It is recommended to further promote the implementation of the schemes.

Landscape approach to the development of horticulture: According to the landscape approach, apple production is part of a socio-ecological system with value chain actors connected to each other at several levels of decision-making, policy, management, monitoring, and markets. Since the landscape approach is recommended in most of the national natural resource management-related policies and strategies (Watershed Management, Forest, Wildlife and Biodiversity Management, Water security), apple production needs to be seen as part of the landscape with links to all ecosystem services that emerge from that landscape.

In this context, land use planning based on zonation needs to be developed and applied. In the future, policies must be reinforced that consider not only economic perspectives such as profit, income, and employment but also the ecological aspects while facilitating apple production.

An assessment is needed on how apple agroecosystems affect surrounding ecosystems. Reliable studies also need to be conducted to ascertain how production and productivity may be affected by soil toxicity, erosion, and loss of nutrients. Similarly, there is no research on the potential impact of apple monocultures on the availability of water from various sources and its seasonality (ground water recharges, irrigation facilities, eutrophication and toxicity). The Government should consider intensive implementation of its eco-village scheme in apple-growing areas. As apple cultivation is making inroads into the innermost areas and higher landscapes, keeping land degradation and changing climate in view, the Government needs to consider the environmental trade-offs should they continue to invest in apple monocultures.

Systematic and gradual promotion of natural farming: The Government of Himachal Pradesh is promoting natural farming. New State directives and standard operating practices that consider climatic and non-climatic factors (e.g. excessive use of chemicals), and branding and marketing of eco-friendly products, are needed to ensure the promotion of natural farming in a sustainable manner. This will lead to eco-friendly development of future apple production and foster a proactive response by farmers .

The Government, for example, can promote organic production in upper apple catchments and support farmers with incentives to promote natural farming from the ridge downwards, as these areas will have less impact of neighbouring flow of chemicals. The government can also fix minimum support prices for organically or naturally grown apple so that the initial loss of production is compensated, and it thereby attracts the interest of other farmers.

Integrated cropping and development of diversified ecosystems: To face future climatic and market fluctuations, apple monocultures need to be incrementally converted into more mixed and diversified ecosystems that enhance the resilience of the landscape as well as of farmers (e.g. intercropping, pollinator herbs and shrubs, insects, honeybees).

Crop diversification is one of the main adaption strategies for the mitigation of the effects of climate change. While monocultures may deliver bumper harvests during favourable weather and market conditions, it may also expose producers to the risk

of absolute failure. On the other hand, production systems with high agricultural or horticultural biodiversity can bring stability in yield, limit pest and disease outbreaks, and increase resilience to climatic disturbances. Keeping this in view, under the HPHDP, the diversification of varieties is being promoted within the same crop by introduction of alternative varieties and colour strains such as Jeromine, Red Velox, King Rot, Red Cap Valtod, Schlet Spur, Gala and Fuji. Promoted crops for multi-cropping include improved varieties of pear, cherry, peach, plum, apricot, and walnut with the objective of having an alternate source of income on small farm holdings. This also helps withstand fluctuation in commodity prices, provides resilience to highly variable weather conditions resulting from climate change, and increases profits by reducing the cost of production. These horticultural diversity initiatives should be promoted in apple-dominant districts and the Government needs to consider if Himachal Pradesh, as a state, can rely only on apple production when it comes to horticulture since other horticulture products such as pear, cherry, and apricots in a retailer market have similar prices and a lower need for chemicals and pesticides.

Pollination management: It is important that rare species that serve as pollinators are given special attention and that reproduction and in-field management guidelines are developed. Forest flora with potential benefits for apiculture should be promoted in the vicinity of apple orchards. Moreover, apiculture should be promoted as a secondary activity with apple farmers. This will highlight the relevance of ecosystem-based approaches to development based of activities. All apple growers can be made aware of the benefits provided by the MMMVY scheme.

Evidence-based planning and decision-making: The development of open access data portals that gather information on the inventory of each apple farmer, their orchard sizes, types of crops, list and seasonality of inputs used, pest and disease surveillance data, and business plans are necessary. This will allow the development and monitoring of social and environmental safeguards for market linkages and information portal envisioned by HPHDP. Further, this

will to enable evidence-based decision-making when managing climate risks.

Robust integrated monitoring: To integrate the apple sector with other ecosystems in the Himachal Pradesh landscape, a multi-sectoral disciplinary body by the Horticulture Board and DEST can be established to consider and evaluate policies and programmes while keeping climatic, environmental, social, and overall rural resilience aspects in view and promoting state-level monitoring and data analysis.

Soil and water monitoring stations and sites need to be installed to assess the effects of intensive input-oriented apple production on ecosystems and biodiversity. This will minimise the risk of ecological problems in the future because the longer this remains unaddressed, the more expensive and difficult the implementation of adaptation measures (e.g. cleaning water or soil of toxins) will be, and the harder it will be for farmers to prepare their soil for organic farming.

Biodiversity-monitoring protocols like the ones developed for forest biodiversity could be adapted as agroforestry and apple plantation biodiversity registers that provide information on biodiversity on non-forest land and serve as evidence to incentivise orchardists to promote favourable conditions for biodiversity in their farms.

Scaling up of GIZ's innovative support model: All the awareness and trainings given by the GIC project, impemented by GIZ India must be converted into technical management packages with stronger links with the DoH, the UHF and private actors. They should be shared and mainstreamed, given the current lack of professional support for orchard management (e.g. pruning operations, mixed orchard management, fertiliser use).

4.2 Infrastructure development

Enhance controlled atmosphere storage facilities and cold chains: Small and marginal farmers have limited access to cold storage facilities. The establishment of smaller cluster-based cold storages at Gram Panchayat level would therefore allow marginal farmers to absorb the market price shocks and fluctuations, rather than selling to retailers for lower prices out of fear of losing apple quality if the produce is not sold instantly.

Farmers require Cold Storage facilities that are either based on a PPP model or wholly controlled by the Government or through a government partial subsidy model to store their produce during glut and sell it later when the demand is high. Without this, farmers are forced to transport their produce in trucks or other vehicles, which leads to a deterioration in quality of the product by the time it reaches local or distant markets. There is also a high demand for refrigerated vans and vehicles that can transport the produce at the proper storage temperature.

Use of renewable energy: Solar power-based local equipment, such as for collective grading and packaging, cold storage, ropeways and more, should be promoted.

ICT infrastructure and information portal: The HPHDP has planned the development of a Common Communication and Information Portal that provides all the information on the value chain and its requirements, public schemes that apply to the apple value chain, management requirements according to apple variety, policies and strategies, market and marketing-related guidelines, and institutions that provide goods and services. The GoHP has established a market intelligence cell under the HPHDP. However, orchardists are not aware of this cell and depend on their private network for market information and infrastructure.

Expansion of training infrastructure: Industrial training institutes (ITI) and other vocational training and awareness institutions of the state must offer courses on technical management of apple that build the knowledge and skills of future labour and marginal farmers regarding picking, handling, packaging, storage, transport, and aspects of post-harvest tasks, as well as the requirements of the below mentioned certification system.

The Ministry of Skill Development and Entrepreneurship can launch a special skill development programme for labourers in apple-picking and farm management. Only certified labour would be engaged for picking operations and would be registered in a database that would be updated regularly. Since employment around the apple value chain is seasonal, it would be important to identify alternative livelihood activities during the off-season, keeping local context in mind. MGNREGA labour investments for activities such as soil conservation measures, recharging and restoration works for water sources, plantation of pollinators, and similar works, could be considered to contribute to the preservation of ecosystem services.

Strengthen research and development infrastructure: Research and monitoring that assesses the impact of apple production on the ecology of landscapes and ecosystem services (biodiversity, water, soil health) need to be reinforced. This would ensure the establishment of social and environmental safeguards to keep the fragile mountain landscape of Himachal Pradesh healthy. Studies in this context could be supported so that GoHP can make informed decisions about the horticulture approach it wants to promote in the future.

To face climate variability, research and development needs to be undertaken for adaptative varieties and improved technologies, including packages of practices for management of high-density planting, pollination, fertility management practices, labour-saving agricultural technologies for women, and use of bio-control agents and bio-fertilisers. An adaptive research program is being built on the existing technologies developed by the UHF and those sourced internationally. Nevertheless, it is too early to see

how orchardists are benefiting, or the awareness and outreach that has been achieved. In the sites visited, farmers were unaware of research and development initiatives.

Future trend analysis (climate and non-climate) needs to be regularly tested and more parameters need to be added. The data should be made available to value chain actors and especially producers to make informed decisions about future investments.

Establishment of weather stations and hydro-meteorological support: More weather stations are needed to capture the diversity of microclimates in the extremely undulated terrain of Himachal Pradesh, and to anticipate climatic events. This would provide customised information from local contexts that would guide producers and insurance companies to recognise extreme weather events such as cloud bursts, droughts, hailstorms, and the damage they may cause.

The long-term meteorological data must be interpreted from the perspective of short-term impacts so that early warning systems can be developed that help orchardists to prepare for calamities related not only to weather but also to pests.

Upgrade and certification of nurseries: All private nurseries must be subject to a certification and monitoring system, and their operations and sale details registered. Their plant material should be screened periodically. The Himachal Pradesh Fruit Nurseries Registration and Regulation Act 2015 should be thoroughly implemented, and private nurseries should be supported by means of special schemes of back-end subsidies for their modernisation and upgradation. The DoH could provide a limited-period buy-back guarantee for the seedlings raised in these nurseries. This would allow these nurseries to develop better quality clonal rootstocks that provide higher yields and aid in pruning, thinning and fruit harvesting operations.

4.3 Institutional development

Networking and strengthening of Farmer Producer Organisations and Farmer Group Associations: All producers are directly or indirectly linked to Fruit Growers Societies, which provide most of the services to its members and even non-members. Networking activities between them would allow them to share experiences and knowledge, and their capacities could be built according to future challenges of the apple sector through awareness on certification, the landscape approach, and marketing strategies. Other activities could include supporting the transition of FGAs to FPCs, developing their capacity and skills for marketing to allow them to access wider markets and investment, and supporting them in establishing common service centres. These could be small-scale aggregation facilities owned, managed, and operated by the FPC, keeping the long-term benefits, financial counselling, and resilience-building of farmers in focus.

Delivery of DoH services though Grower Associations: Wherever feasible and appropriate, most of the services of the DoH (subsidies, technology, and guidance) should be delivered through the Grower Associations. The DoH could develop good practices and standard operating procedures for these associations. Once registered, the associations can be developed into enterprises and supported by GoHP with all the facilities and grants applicable to trade and industry.

Building the technical, financial and institutional capacity of the DoH: Although the state has emerged as a leading producer of fruits and offseason vegetables, the productivity level of the fruit crops in Himachal Pradesh remains far below international standards. This is due to various factors: (i) limited access to appropriate production technologies and to quality planting materials, (ii) insufficiently developed water management systems, (iii) limited research systems and extension services, and (iv) high post-harvest losses, paired with low value addition, exacerbated by inadequate storage, processing,

and marketing capabilities. The challenges of the sector, institutions and policies need to be addressed systematically, if the full potential of this industry is to be realised and translated into a sustainable development impact.

4.4 Market development

Certification, eco-labelling and development of environmental and social safeguards: Consumers are increasingly aware of the environmental, social and health implications of the use of chemicals and unsustainable practices in horticulture. A niche market for organic and eco-friendly products is developing quickly. A certification system should be developed for the apple sector which ensures the monitoring of standard operating procedures and social and environmental safeguards being adopted by producers and other value chain actors. Natural and organic farming based on a renewed design and delivery concept needs to be complemented with a sound branding and certification system and a set of direct and indirect incentives for producers, while focusing on the ecology and need to sustain the economy in Himachal Pradesh.

Green Business planning by FGA: Each Fruit Growers' Association should prepare a long-term green business plan facilitated by the DoH. The activities should converge in local Gram Panchayat and Block plans to assure efficiency and effectiveness of landscape-based investments and interventions by other sectors (e.g. forest, water).

Cost-benefit analysis of chemical use: The DoH, besides providing the schedule of chemical application, should provide a cost-benefit assessment that includes the impacts of the various types and doses of chemicals it prescribes on health and ecosystems. This will help farmers in making informed decisions about the use of various pesticides, fungicides and fertilisers in their fields.

Value addition and product diversification: The diversity of products that can be developed by on- and off-site processing needs to be fully explored with a focus on potential markets and local enterprise development that strengthens local resilience-building.

4.5 Kullu-specific recommendations

Specific recommendations for Kullu were developed regarding its unique challenges such as rising temperatures, being dominated by side valleys that allow limited road access, and scarce post-harvest infrastructure.

- The density of weather stations in Kullu Valley needs to be increased because its geographical location, terrain, and individual microclimate of side valleys makes weather forecasting particularly challenging.
- Kullu's apple production has shifted from Bhunter to higher reaches, so monitoring and evaluation of selected farms and landscapes could be used to observe how climate change is unfolding. The findings could be used to develop further adaptation measures. In Bhunter, stone fruits have replaced apple production. It could thus provide valuable data on climate change and its effects on horticulture and farmers.
- Kullu's limited accessibility is an impediment to planting apple in larger areas. Solar energy-operated ropeways could be installed, and eco-friendly or green roads could be promoted.
- Since the use of chemicals per ha in Kullu is still lower compared to other areas, the establishment of natural farming or organic horticulture sites from the top of a catchment (ridge to valley approach) should be explored and enforced. The GoHP should consider a maximum support price for organic agriculture to promote it as a viable strategy against climate change and lower long-term costs for adaptation.
- The CA storage facilities in Kullu are very limited and it is likely that storage will become an issue in the future. Electric-driven multi-utility refrigerated vans or vehicles could be introduced.
- There are few local apple nurseries in Kullu; most of the farmers purchase stick/rootstock from

Shimla. Apple germplasm used in Kullu should be evaluated and a strong awareness programme must be promoted to encourage farmers to plant local varieties. The DoH along with the UHF must be proactive in recommending varieties adapted to Kullu .

- The varieties grown in nurseries must be monitored and true-to-type varieties adapted to Kullu need to be promoted on a larger scale. Nurseries must also be encouraged to produce local or traditional polliniser plants and it should be mandatory for farmers to plant them.

4.6 Climate hazard-specific coping strategies, sources of funds and their sustainability

Short forms used for table below:

- CH: Critical Hazard
- IT: Impact Type and Severity of the Impact
- 1-5 where 1 means low and 5 means very high
- CAS: Suggested Coping and Adaptation Strategies
- LT – Long Term, MT – Medium Term, and ST – Short Term
- L – Low, M – Medium, H – High

Table 8: CAS and duration strategy

CH, IT (1-5 rating)	CAS and duration of the strategy (LT/MT/ST)
Hazard 1: Less snow and chilling hours during winters	
Impact 1.1. Fewer Chilling Hours (Impact rating 4)	• Propagation and promotion of apple varieties that can tolerate fewer chilling hours (LT) • Investment in research and trials for appropriate varieties (LT) • Certification of apple varieties unaffected by low chilling hours (LT) • Development of certified nurseries with tested germplasm (LT) • Awareness and technical capacity-building of private nurseries (LT)
Impact 1.2. Water scarcity due to drying springs and less water flow in the streams as a result of less snowfall (Impact rating 3)	• Better management of adjoining forest cover (LT) • Conservation of all key water sources (ST) • Soil and water conservation measures to protect water sources (MT) • Construction of water harvesting structures and distribution networks (MT) • Improving organic content of the upper soil to conserve soil moisture • Micro-irrigation (MT) • Rainwater harvesting (MT) • Weather forecasting of droughts
Hazard 2: Hailstorms	
Impact 2.1: Damage to crops and production loss (Impact rating 4)	• Mapping of hailstorm hotspots and vulnerable areas (ST) • Distribution of hail nets (ST) • Establishment of weather stations in each apple landscape (MT) • Weather forecasting (MT)

Resource requirement	Level of adoption (L/M/H)	Sustainability and effectiveness of CAS (1-5)
• Mission for Development of Horticulture (MIDH) • Horticulture Cluster Development Programme • Local banks and fruit grower societies	Medium	4
• Links with integrated watershed management schemes and efficient water-use inputs • Links with fruit producers societies • Links with DoF/DoH/DoA programmes • Links to HPHDP Water Management Systems • National Water Mission and Jal Shakti Abhiyan, District-Amrit Sarovar • PM's Agriculture Irrigation Project (marginal farmers up to 2 ha, 80% subsidy; medium to small farmers up to 45% subsidy) • Links with DoF through local Joint Forest Management Committee (JFMC) and Biodiversity Management Committees (BMC) • Linking apple production to agroforestry models • Linking Projects implemented by GIZ India with other internationally funded projects (e.g. JICA, KfW, World Bank) • Linking apple farmers to the overall micro plans of villages or Panchayat development plans for better complementary services of public schemes to build resilience	Medium	5
• Follow-up of weather forecasts by Indian meteorological news during hailstorm seasons • Department of Horticulture trainings and awareness programmes and timely availability of anti-hail nets as horticulture equipment • UHF/DoH/DoA/Palampur Agriculture University investments in installing weather stations and their data collection/interpretation	H	4

CH, IT (1-5 rating)	CAS and duration of the strategy (LT/MT/ST)
Impact 2.2: Loss of quality (Impact rating 3)	• Setting up of processing facilities (chips, juices, jams) for processing of affected crops (ST) • Local facilities for temporary storage of affected crops (ST)
Impact 2.3: Stress sales (Impact rating 3)	• Setting up and strengthening of collective sales through Farmers Producers Organisations and Societies (MT) • Collective marketing of good quality produce at higher prices because of shortfall in production due to hailstorms • Local cold storage facilities for crops pre-harvested in anticipation of, or during, hailstorms (MT) – by promoting private sector investment (e.g. Adani)
Hazard 3: Droughts	
Impact 3.1: Mortality of younger orchards/trees (Impact rating 3)	• Weather forecasts (MT) • Installation of more weather stations especially in higher apple-planting areas (MT) • Development, management, and conservation of water sources through soil and water conservation measures, and natural farming (MT) • Linking FGA to insurance and low or no interest loans (MT) • Casualty replacement and better management of remaining crop (ST) • Awareness-raising of fruit grower societies and additional focus on marginal farmers
Impact 3.2: Production shortfalls (Impact rating 2)	• Collective Marketing through FGA (MT)

	Resource requirement	Level of adoption (L/M/H)	Sustainability and effectiveness of CAS (1-5)
	• PM's programme on Farmers Micro-enterprises and HPHDP Agro-Based Enterprise Development, which can be evolved further by GIC India in its pilots • Use of subsidy up to 50% offered by the DoH	M	3
	• Farmer Producer Organisations and fruit grower societies' capacities to be built further by HPHDP, DoH, GIZ, and UHF • Use of Corporate Social Responsibility funds to support marginal farmers • Connect with subsidies for complementary horticulture production diversification of DoH/HPHDP • Online Market Information and Intelligence System (ICT-based) through Horticulture Portal of the State	H	3
	• Linkage with NMSA and MIDH with fund of landscape-based treatment under national schemes of Rainfed Area Development (100ha) needs to be explored • Prime Minister's Agriculture Irrigation Project – Increase of Production Per Drop • Community Water Resource Development (Rs 25 lakhs/30000 sq m) • Natural Farming (85% Subsidy) • NABARD funds to be explored based on its watershed program models • DoH/UHF monitoring of private nurseries under a certification system	H	5
	• Links to Agro-Enterprise development through HPHDP and GIZ. The latter can also focus on canopy management for higher production activities • Market information/intelligence online system	M	3

CH, IT (1-5 rating)	CAS and duration of the strategy (LT/MT/ST)
Hazard 4: Heavy rains and floods in spring and flowering time (Impact rating 5)	
Impact 4.1: Poor pollination and production loss (Impact rating 3)	• Weather forecasts (MT) • Improvement of pollinator density, conservation of local honeybees (MT) • Canopy management with mixed orchards • On-farm surface water management and upper catchment soil conservation treatments
Impact 4.2: Soil erosion (Impact rating 3)	• Soil conservation measures in and around orchards and in upper catchments
Impact 4.3: Waste of chemicals due to washout (Impact rating 3)	• Use of chemicals based on weather forecasts and not during rains (ST) • Regular monitoring of spraying equipment and use of safety standards
Hazard 5: Increased diseases and pests due to climate variability and resulting stress in plants due to drought, heat, evapotranspiration, water stagnation, etc.	
Impact 5.1: Loss of production and quality (Impact rating 4)	• Plant protection through use of bio-pesticides and use of the scientific spray schedule prescribed by the DoH (ST) • Use of mobile applications for the identification and treatment of pests and diseases (ST) • Farmer-to-farmer networking portal and social media for information sharing • Link to research institutions for disease/pest surveillance and awareness (MT) • Diversification to 20% to 30% of mixed and other stone fruits (MT) • Propagation of local pollinators • Adoption of Natural Farming and land scape management approach
Impact 5.2.: Excessive use of pesticides (Impact rating 4)	• Awareness raising on the right and timely use of pesticides (ST) • Closer control on type and dose of chemicals (ST) • Regular soil and leaf tests and soil remediation (MT)

Resource requirement	Level of adoption (L/M/H)	Sustainability and effectiveness of CAS (1-5)
• Facilitation through watershed management programme and use of subsidies at landscape scale	M	3
• Linkage with integrated watershed management schemes and efficient water-use • Links with DoH/DoA/DoF according to a Landscape Management Plan; the model can be supported by GIZ • PM Agriculture Irrigation schemes can be applied	L	3
• Awareness programmes by DOH/UHF, HPHDP and GIZ need to be scaled up, and programmes that give subsidies need to be tapped (HR Trainings Rs 1000/day/farmer) • Use of DoH 2022 Spray Schedule	LM	3
• DoH/DoA for training of farmers (costing INR ₹1000/- per farmer) and prescription of pesticides • Subsidies under Chief Minister's Apiculture Development Project • GIC India Project's Awareness and Canopy Management Training is to be scaled up by providing training of trainers district level personnel and institutions • Apiculture Development Project (40% subsidy) • Horticulture Equipment (40-50% subsidy, INR ₹600/- to INR ₹63,000/- subsidy amount) • Integrate pollinator promotion between departments (DoF, DoH, DoA) and through use of the Apiculture Development Project and its subsidies	L	5
• Regulation of DoH pesticide subsidy • DoH/DoA and GIZ can jointly initiate soil restoration and tree management programmes by regular soil/water/leaf tests and suggest remediation measures for detoxification and for balanced nutrient management of soils, promote canopy management with less pesticides and efficient use of fertilisers both chemical and organic; link to Natural Farming programme • Use of environmental safeguards with respect to the use of pesticides (prescribed the World Bank, KfW, JICA, etc.)		

List of Abbreviations

BMZ	German Federal Ministry for Economic Cooperation and Development
0C	Degree Celsius
CAS	Coping and adaptation strategies
CCA	Climate Change Adaptation
CRM	Climate Risk Management
DoA	Department of Agriculture
DoF	Department of Forestry
DoH	Department of Horticulture
DEST	Department of Environment, Science and Technology
FGA	Farmer Fruit Grower Associations
FPC	Farmer Producer Company
FPOs	Farmer Producer Organisations
FSG	Farmer Study Group
GIC India	Green Innovation Centre for the Agriculture and Food Sector
GoHP	Government of Himachal Pradesh
GoI	Government of India
HPMC	Himachal Pradesh Horticulture Produce Marketing Corporation
HPHDP	Himachal Pradesh Horticulture Development Project
IPCC-AR6	Sixth Assessment Report of the Intergovernmental Panel on Climate Change
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MoAFW-GoI	Ministry of Agriculture and Farmers' Welfare, Government of India
MIDH	Mission for Integrated Development of Horticulture
MMMVY	Pradhan Mantri MUDRA Yojana
MT	Metric Ton
NABARD	National Bank for Agriculture and Rural Development
PMFBY	Pradhan Mantri Fasal Bima Yojana
RCP	Representative Concentration Pathway
SAPCC	State Action Plan for Climate Change
SHG	Self-Help Group
UHF	YS Parmar Horticulture and Forestry University

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Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Green Innovation Centres for the Agriculture and Food Sector - India
No. 38/43, First Floor, 10 A Main Road, Fifth Cross
Block 1, Jayanagar
Bengaluru – 560 011, India
T (India) +91 80 46664000 (Extn. 6000)