FARMER'S PERCEPTIONS ON CLIMATE CHANGE AND ITS IMPACT ON APPLE CULTIVATION IN SHIMLA DISTRICT, HIMACHAL PRADESH

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ABSTRACT

Assessing farmer's perceptions on climate change is vital to evolve and implement suitable adaptation strategies to climate variability. This study looked at farmers' perception of climate change impacts, with special reference to apple cultivation. Empirical data gathered from household surveys conducted in Cheog and Baldeyan panchayats of district Shimla, Himachal Pradesh. Using this data, the study explores farmers' perception of climate change and its associated impact on horticulture. Results recommend that most farmers perceived climatic change and its negative impact on horticulture and considered climate change as a significant threat for prospect livelihood and economic development.

Keywords: Farmer's perceptions, climate change, apple cultivation, chilling hours, horticulture

1. INTRODUCTION AND BACKGROUND

Climate change has emerged as one of the serious concerns for the human society threatening the socio-economic development, agriculture, natural resources, health, food security and livelihood [1, 2, 3]. Climate change involves variations in temperature, precipitation and climatic extremes. It also manifest in form of changes in atmospheric CO_2 level and ground-level ozone concentrations, besides deviances in sea level [4].Perception governs the action and strategies being adopted by the farmers for dealing with the climate-induced threats and shapes the adaptation strategies [5]. Mistaken belief about climate change and its linked risks may result in misconception [6]. The mountain ecosystems are currently facing the challenges posed due to increasing seasonal variability and erratic natural phenomenon, posing threats to agriculture and horticulture crops. Phenological change is one of the earliest responses to climate change and could possibly have serious implications because plants depend on climatic conditions for their growth and development, and fruit crop is no exception to this. The current international scientific viewpoint is that global warming conditions indicate a fairly stable long-term trend with natural variability of local climate [7]. Rural communities with limited access to climate information are more likely to face the varying climatic conditions, mainly extreme weather events, which in turn affect their rituals and cultural practices [8]. Opinion about climate change among rural communities is shaped by multiple forces [9]. This paper looks at farmers' perception of climate change impacts, with special reference to apple cultivation in selected panchayats of Shimla district, Himachal Pradesh.

2. MATERIAL AND METHODS

Data was gathered using the semi-structured questionnaire, besides assessing the demographic and socio-economic profile of respondents, perceptions of extreme weather conditions, and how these changes affect the farming practices. Respondents selected for the study were the individuals living in the study area and practicing horticulture including the well-conversant horticulturists, representatives of community. Purposive sampling technique was used in the selection of study area and respondents. A total of 50 sampled respondents were interviewed using a semi-structured questionnaire with closed-ended questions framed on Likert scale. Analysis of secondary data, which was collected from Directorate of

Horticulture, H. P. Shimla, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Meteorological Department and Regional Horticultural Research Station, Mashobra, Dr. Y.S. Parmar University of Horticulture and Forestry, has been correlated with the primary data on farmer's perceptions.

The study area included Cheog and Baldeyan panchayats of district Shimla, Himachal Pradesh. Baldeyan, a small village panchayat, about 31 kms away from Shimla is located at 31.13^0N longitude and 77.23^0E latitude. It lies at an altitude of to 2148 msl. The production of apple in this panchayat is not common due to low-lying area however some of the farmers are associated with apple cultivation with regular help from Regional Horticulture Research Station, Craig Nano. Primary data was also obtained from Cheog which is located 2500 msl. Cheog is located around 15 kms away from Shimla and lies between $31^0$5'N and $31^0$10'N and $77^0$22.5'E and $77^0$30'E. Scientists working at Regional Horticulture Research Station were consulted for giving scientific explanation to the findings.

3. RESULTS AND DISCUSSION

3.1

The socio-economic profile of farmer's community affects the organization and management of agriculture besides providing options for production and marketing strategies. Thus, it seems important to take into account the profile of sampled respondents. The characteristics of sampled respondents give a general view of prevailing situation in the study area. The information on age, education qualification and occupation of 50 respondents was gathered.

Age-wise Distribution: The age-wise distribution of sampled respondents is presented in Table 1. Table reveals that majority of respondents (34 percent) belonged to the age group of 36-45 years, followed by 26 percent from 26-35 years age group and 16 percent from 15-25 years age group. Only ten percent of the respondents were above fifty-five years of age.

Education Qualification: Education is a vital factor for accelerating the process of economic development of any society and depicts the quality of available human resource. The educational status of respondents is presented in Table 2. Educational qualification of respondents was recorded and placed in five categories, i.e., illiterate, matric, up to 12^{th}, up to graduation and up to post-graduation.

The distribution of the respondents in different educational groups showed that most of the respondents (n=19) were educated up to graduation, followed by post graduates (n=11), up to 10^{th} (n=6) and up to 12^{th} (n=5). Only 18 percent of the respondents were uneducated.

Occupation: The distribution of respondents according to occupation is analyzed and presented in table 3. It can be seen from the table that in addition to agriculture as main and subsidiary occupation, people were engaged in government job and private sector. The table indicates that amongst these occupations, agriculture was the main occupation accounting for 54 percent. Next to agriculture, 30 percent of the respondents were engaged in government job. However, some respondents (n=7) were also employed in private sector. Table 4 shows that out of fifty respondents interviewed, 72 percent have been practicing agriculture from 15-25 years followed by 26 percent who were involved in farming from one year to fourteen years.

Horticulture in study area: List of the fruits and apple varieties cultivated by the respondents in Cheog and Baldeyan are presented in table 5 and 6. Table 5 shows that, Plum, Pear, Apricot, Almond, Kiwi and Peach are cultivated in both the panchayats. Cherries, Persimmon and Pomegranate are cultivated by the respondents of Cheog panchayats, while respondents of Baldeyan panchayats prefer cultivation of stone fruits in addition to other fruits. Apple varieties cultivated by the respondents of both Cheog and Baldeyan panchayats include Royal Delicious, Red Delicious, Golden Delicious, Tydeman, Scarlet Spur, Early Worcester, Starkrimson, Fuji and Gale Gala. Cultivation of Kali Devi, Ace Spur and Oregon Spur is common in Cheog panchayat while Super Chief and Vance Delicious are cultivated by the respondents in Baldeyan panchayat.

3.2

In order to assess people's perceptions about impact of climate change on apple cultivation, a questionnaire developed on three point Likert scale was used. People's opinion was gathered on apple cultivation trend and impact of climate change (table 7).

On statement, '*started growing new varieties of apple*', 98 percent of the respondents were of the view that people have started growing new varieties of apples. 96 percent of them were satisfied with the increased yield from new varieties of apple. For the statement, '*area under apple cultivation has increased in the recent years*', 96 percent respondents expressed affirmative opinion, the reason being that '*new varieties of apple yield more produce*' to which about 98 percent respondents agreed. Everyone was of the view that apple cultivation has increased because it is more profitable. However, when the people are switching over to apple cultivation, they have either stopped cultivating traditional crops or have decreased the area under cultivation of traditional crops. 80 percent of the respondents had replaced traditional crops for apple cultivation, while 16 percent had still maintained the cultivation of traditional crops and remaining respondents gave no opinion in this regard. While discussing about the changing cropping patterns, informants said:

> In the recent years, the family structure has changed from joint family system to nuclear, which has affected the availability of manpower per family. Less manpower is available to manage the orchards. Some of the family members have migrated out for getting higher education and jobs. Thus, those who are left behind are overburdened and the orchards are left at the mercy of migrant laborers from Nepal. Looking after apple orchards needs skilled labor, but migrant laborers being unskilled are not able to manage the orchards in an appropriate manner. These factors though seem to be inconsequential, contribute equally for apple production in terms of quantity and quality.

Since the area under cultivation of apples has increased and people have switched over to high yielding varieties of apple, hence the apple production has increased. To this, 94 percent of the respondents gave affirmative reply. 96 percent of the respondents were of the view that apple production has increased because new varieties of apple yield more produce. Out of total 50 respondents, 33 were of the view that '*apple cultivation has improved because of recent pest control practices*,' while 16 disagreed to this statement.

The impact of global climatic change on farming has recently become a matter of great concern. While talking about the changing climate, 98 percent of the respondents said that '*the snowfall pattern has changed in the recent years'*. The changing climate is believed to have repercussions on faming and allied activities. According to 96 percent of respondents, in the last few years, the temperature has increased, while four percent were indifferent to this.

'*Flowering in apple depends on climatic factors including appropriate chilling hours, snowfall, rainfall, hailstorm, etc*.', to this statement, all the respondents gave affirmative opinion. According to 94 percent respondents, flowering is affected because of improper climatic condition before flowering, while remaining were either ignorant about the role of climatic factors in determining the flowering or had contrasting statement.

Dormancy is a technique through which a plant safeguards the delicate tissue from unfavorable climate. The dormancy and chilling requirements are affected by the climatic factors. The instantaneous climatic change might affect the adaptability of fruit crops. Effective apple cultivation requires successful winter chilling requirement, failing which may result in abnormal pattern of bud-break. If the chilling conditions are not achieved, trees exhibit uneven and spread out flowering, leading to irregular growth. Warming may affect the chill requirements and ultimately results in varying crop sizes and maturity stages at the time of harvest.

92 percent respondents said that flowering is either early or delayed because of shift in climate or erratic behavior of climate and rainfall while remaining respondents were indifferent to this. According to 46 percent respondents, '*flowering time has been disturbed because of the shift in climate*,' while 46 percent opposed the same. Hence, there was mixed opinion to this statement. The change in the flowering time generally affects the production. It may be premature or delayed. 92 percent of the respondents were of the view that early flowering affects the production and 90 percent opined that the production is affected by delayed flowering. Hence, the timely flowering is essential to ensure good production.

Another factor which affects the apple production is pollination, which in turn is governed by climatic factors. Pollination is a decisive phase in the reproduction of flowering plants, and pollinating agents are vital. Table 7 shows that 86 percent of the respondents were of the view that '*pollination is affected by shift in climate or erratic behavior of climate and rainfall'*. The early rise in temperature or delayed winters often disturbs the life cycle of pollinators. This in turn affects the pollination process. 62 percent respondents were aware of the fact that untimely rise or fall in temperature affects the pollination process, while remaining were either ignorant (16 percent) or deviated (six percent) from this fact. Climate change during the last few years has critically affected the apple pollination. Rains during the flowering season affect the pollination. Low temperatures in later stages of development seriously disturb the fruit set in apple.

The appearance of fruit is a main yardstick in making the buying decision. Appearance is characterized by size, shape, structure, color, condition and absence of disease. Thus, maintenance of production conditions that reduce undesirable appearance is necessary. Color of fruits perhaps adds more to the valuation of quality than any other factor. Buyers have evolved distinct links between color and quality of fruits. 96 percent of the respondents opined that the size and color of apple depends on climatic factors, if the climatic conditions are favorable, both size and color are satisfactory. According to most respondents:

> Large sized apples with a balanced shape and attractive color fetch more cash; however people here harvest small sized apples having poor color with slight shine. Hence, farmers are unable to commercially market the crop.

The growers talked about numerous indicators of climate change that affect apple cultivation. Invasion of pest and diseases are the indicators of climate change that augment the production cost owing to increased use of pesticides and chemical fertilizers. Respondents observed a definite reduction in snowfall over the years. Informants revealed that the schedule of snowfall has undergone a transformation. According to them, schedule of snowfall at the onset of early December and January has shifted and prolonged through the months of February and March. Respondents opined that early snow was long-lasting and tough to thawing in comparison to the late snow. According to the old respondents, early snow helped in retaining the soil moisture for a longer period.

Respondents reported no apparent change in the intensity of precipitation, though there is shift in the distribution of rain which at times is unpredictable. According to the respondents, the monsoon has somewhat shifted beyond mid-August. The untimely rain during the months of March or April has shifted the summers and these months are relatively colder than before. The increase in incidences of hailstorms and other natural disasters like flash floods, cloudbursts, landslides, also affect the horticulture in general and apple cultivation in particular. While narrating about the recent incidence of repeated hailing in 2012, the respondents said:

> In some areas, the hailstorms completely injured and damaged the dense apple orchards. Coming down at a great speed, hailstones hit the plants with fresh shoots with great power, stripping the new shoots and leaving a thick flooring of flowers on the ground. This is likely to brutally affect the fruit setting and in turn the production during the season.

According to another respondent:

> Unexpected and untimely snowfall and hailstorm in 2015 not only spoiled the blooming apple crop but unexpected cold weather conditions deteriorated the scope of better crop. When the apple was in blooming stage untimely cold temperature and hailstorm adversely affected the crop.

Since the climatic factors govern the pollination, thus according to 42 percent of the respondents, the apple production has been affected in last few years because of improper pollination, which is the consequential of climate change, while 48 percent of the respondents disagreed to this statement. In addition to this, the apple cultivation is affected by the attack of pests. According to 42 percent respondents, apple production has been disturbed because of attack of pests, while 46 percent were indifferent to this statement (table 7). While discussing about the incidence of pests and diseases, the respondents opined:

> Pests and diseases affect the apple crops severely. To save the crop from the attack of pests, people have started using pesticides and insecticides. This has increased the cost of cultivation. Prior to this, people used local methods of pest control,

> but these are no longer effective. Now people have switched over to chemical fertilizers. In the beginning these seem to be quite useful and yielded positive results in sustaining the crop and maintaining its quality. But in the long run, these have affected soil's fertility.

According to the respondents:

> Owing to small land holdings, the marginal farmers are more susceptible to climatic changes, while the big cultivators have the capability to cope-up with the situation. They have sufficient cash to purchase an orchard at different location, where the climate is friendly for apple cultivation.

It was found during the survey that many farmers have started upgrading their apple orchards by introducing new varieties of apple. However, the cost of maintenance is relatively higher. Few farmers have started switching-over to other vegetables and fruits.

3.3

To ascertain if respondents' perceptions of climate variability correspond to long-term climatological records, meteorological data for district Shimla has been analyzed. Analysis of data shows that apple production has shown significant changes with varying climatic parameters, viz., temperature, rainfall and snowfall. The area under production has increased gradually, but the average productivity of apple in Himachal Pradesh is 3.3 MT/ha, which is lower than the national productivity of 5.1 MT/ha and much lower than that of Jammu and Kashmir with 10.1 MT/ha. The data collected from State Horticulture Board is presented in the table 8, which shows that during 1985-99 the production of apple in district Shimla has decreased even though the area under cultivation has increased. This is attributed to the fact that the chilling conditions required during the flowering stage could not be achieved due to higher temperature in the months of December, January and February even though the precipitation was appropriate. The subsequent years received bumper production along with enormous increase in the area under apple cultivation. The production decreased all of a sudden in the year 1994-95, nevertheless the area under cultivation showed a gradual increase. In spite of having ideal precipitation range in 1994, the reason behind reduced production was increased temperature during the flowering and incidence of spring frost. In year 1995, premature leaf fall affected more than 40 percent of all apple orchards in Himachal Pradesh. According to the researchers, due to premature leaf fall, the quality of produce was affected badly and fruit bearing capacity decreased [10]. Later a study carried out in 2000 revealed that the reason behind premature leaf fall was incidence of fungal disease called Marssonina Blotch or more commonly '*Apple Blotch*' [11].

Year 1994 and 1999 were the hottest years of the decade. Again, in the year 2000, the production of apple saw a tremendous downfall where the production decreased (20536 MT) from lakhs to thousands in Tons. This is attributed to the fact that high temperature affected the crop during the dormancy or pre-flowering stage. Moreover the precipitation was comparatively low during the flowering, fruit-set and fruit developmental stage. The ideal temperature during the pre-flowering phase is 12^0C while in flowering stage, fruit growth and post-harvest phases, it should be 15-18^0C, 21-24^0C and 15^0C. Table 3 shows that the annual temperature in 1985-1986 was quite high during all three phases, i.e., 14.44^0C in pre-flowering phase, 26.90^0C in flowering phase, 25.26^0C in fruit-growth and development phase besides a quite warm winter during the post-harvest phase. Thus, the production during this year faced a major reduction. Similarly, in the year 1990-91, the production of apple went down to 243042 MT which was 243938 MT in 1989-90 due to higher temperature during all phases of apple growth. In the year 1989-90, the ideal temperature during the three phases was more or less maintained while in 1990-91, it was 2.78^0C more than the previous year. This is believed to have affected the production. In 1994-95, there was a major decline in production from 172851 MT in 1993-94 to 75250 MT. In 1999-2000, the same trend was witnessed with a temperature difference of 5.40^0C between 1999-2000 and 1998-1999. The subsequent years showed a gradual increase in production due to favorable climatic factors, but again in 2006-2007, there was a minor decline in apple productivity. Lower temperature in March and higher temperature during the winters affected the flowering pattern and in turn the yield. In the year 2006-2007, the rainfall was comparatively lower than previous years during the flowering, fruit-set and fruit developmental stage.

Table 8 shows that in the subsequent years, like 2009-10 a drastic fall was noticed from 171945 to 336753 in the preceding year. Year 2009-10 experienced the most severe drought and inappropriate chilling hours, which affected the production. A higher temperature was recorded in all the phases, i.e., 17.66^{0}C during the pre-flowering, 27.90^{0}C during the flowering, 24.76^{0}C during the fruit growth stage and 16.66^{0}C during the post-harvest.

In 2011-12, the production rolled down due to insufficient rainfall and warmer weather. In 2014-15, a decline of 91671 MT was noticed from the preceding year due to high temperature, which affected the dormancy, bud-break, fruit-set and chilling hours of the apple plants. Table 8 shows that during the years 2006, 2007 and 2008, when the annual average temperature was recorded slightly lower than the preceding years temperature, a higher production of was recorded. The annual maximum and mean temperatures showed an inconsistent trend from year to year, ranging from 19.76ºC to 25.66ºC and 15.90ºC to 17.58ºC respectively.

From the table 8, it is clear that 2010-11 followed by 2013-14 made a bumper production of 602684 MT and 499422 MT apples respectively due to appropriate climatic conditions. It was observed that variation in the annual diurnal temperature between 11.0ºC and 20.5ºC with a mean annual temperature between 15.5-17.0 ºC favored the better apple production.

The table 8 further reveals that during the years 2001, 2002, 2003, 2005 and 2007, an optimum annual precipitation (>200 mm) was recorded but higher production was recorded in the years 2005 and 2007 only, when the diurnal temperature fluctuations were relatively low. In the year 2003, a moderate snowfall (87 cm) was recorded and thus an average production was recorded but during the years 2005, 2007 and 2008 higher apple production was recorded in spite of poor snowfall of 14.0, 8.0 and 8.0 cm respectively. It could be due to reduction in the intensity and fluctuations in the timing of snowfall. Thus, it can be inferred from the data that snowfall pattern has showed an inconsistent pattern. It is evident from the table 4.4 that except for the years 1989-90, 1996-97, 1997-98, 1999-2000, 2003-04, 2002-03, 2004-05, 2008-09, 2010-11, 2011-12, 2012-13, 2013-14 and 2014-15 snowfall occurred more frequently during the months of February instead of regular timings of December-January. As a matter of fact, the water requirement of trees increases during the spring season when the surface area of leaf increases. The water requirement of a tree increases with air temperature or higher intensity of sunlight. Hence, there is probability of water deficiency in the trees even though there is sufficient soil water. The data obtained from State Horticulture Board of Himachal Pradesh reveals that in the last thirty years, the area under apple cultivation has increased in district Shimla and apple has emerged as one of the major crops, but there is varying trend in production due to the impact of climatic factors and incidence of pests and diseases. Thus, in order to earn more profit, the farmers have started substituting traditional crops for apple cultivation.

4. CONCLUSION

Therefore, the changes reported by respondents can be correlated with the meteorological data analyzed, which affect apple production. The main impacts are summarized as:

- Changes in the climatic conditions (manifested as increased temperature, low and erratic rainfall, extreme weather conditions and decreased snowfall);
- Climatic factors affect the size, weight, juice content and color of apple;
- Size and weight of fruits have decreased and the color development is quite poor;
- Duration of winter season has decreased;
- Average winter temperature has increased;
- Chilling requirement are not fulfilled;
- Incidence of snowfall has reduced during the month of December;
- Summers have become prolonged; and

- Changing climate has increased the incidence of pests and diseases

Apple, known to be one of the most viable fruit crops for the farmers of Himachal, has seen transformations over the years. Though some agriculturalists are customized to undertake the customary and age-old farming practices, but many have switched over to modern technology. They are less cognizant about scientific agri-business practices and schemes.

Himachal Pradesh is known for its apple and is one of the most significant commercial fruit crops. The study showed the impact of changing climatic conditions which is adversely affecting the apple production. Similar observations have been made by Basannagari and Kala (2013) while reporting the perceived increase in temperature by farmers which affects the fruit size and quality. Frost was perceived as a major cause for damaging apple farming, besides decrease in snowfall. The secondary data from 1985 to 2015 supports farmer's perceptions as examined during the present study. The changing climatic conditions and consequent difficulties in terms of spread of insect-pest and diseases, loss of soil fertility, accessibility of water, and natural disasters are posing threats for apple cultivation, which must be taken into account for devising sustainable polices for continuance of horticulture in the state. The results show the value of realizing people's perception in evolving effective policies and adaptation strategies permitting people's participation to cope-up with the effects of climate change.

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Table 1: Age-wise distribution of Respondents

Age (in years)	N	%
15-25	8	16
26-35	13	26
36-45	17	34
46-55	7	14
Above 55	5	10
Total	50	100

Source: Primary Data

Table 2: Distribution of Respondents according to Educational Qualification

Educational Qualification	N	%
Illiterate	9	18
Up to 10^{th}	6	12
Up to 12^{th}	5	10
Graduate	19	38
Above Graduate	11	22
Total	50	100

Source: Primary Data

Table 3: Occupation-wise distribution of Respondents

Occupation	N	%
Agriculture	27	54
Private	7	14
Government	15	30
Self-employed	1	2
Total	50	100

Source: Primary Data

Table 4: Distribution of Respondents for the period they are involved in agriculture

Period (in years)	N	%
1-14	13	26
15-25	36	72
26-35	1	2
Total	**50**	**100**

Table 5: List of Fruits cultivated by the Respondents in Cheog and Baldeyan

Fruits cultivated	Cheog Panchayat		Baldeyan Panchayat	
	N	%	N	%
Plum	25	100	21	84
Pear	25	100	21	84
Apricot	25	100	21	84
Peach	12	48	-	-
Almond	9	36	7	28
Cherries	5	20	-	-
Persimmon	4	16	-	-
Pomegranate	2	8	-	-
Kiwi	1	4	9	36
Stone Fruits	-	-	4	16

Source: Primary Data

Table 6: List of Apple Varieties cultivated by the Respondents in Cheog and Baldeyan

Apple Varieties	Cheog Panchayat		Baldeyan Panchayat	
	N	%	N	%
Royal Delicious	25	100	25	100
Red Delicious	25	100	25	100
Golden Delicious	24	96	8	32
Tydeman	22	88	20	80
Scarlet Spur	11	44	8	32
Early Worcester	8	32	3	12
Starkrimson	2	8	5	20
Fuji	2	8	2	8
Gale Gala	2	8	5	20
Kali Devi	1	4	-	-
Ace Spur	1	4	-	-
Oregon Spur	1	4	-	-
Super Chief	-	-	13	52
Vance Delicious	-	-	4	16

Source: Primary Data

Table 7: People's perceptions on Impact of Climate Change on Apple Cultivation

Apple Cultivation Trend	Respondents					
	Agree		No opinion		Disagree	
Statement	**N**	**%**	**N**	**%**	**N**	**%**
Started growing new varieties of apple	49	98	1	2	-	-
New varieties of apple increases the yield	48	96	-	-	2	4
Area under apple cultivation has increased in the recent years	48	96	-	-	2	4
Area under apple cultivation has increased because new varieties of apple yield more produce	49	98	1	2	-	-
Apple cultivation has increased because it is more profitable	50	100	-	-	-	-
Replaced traditional crops for apple cultivation	40	80	2	4	8	16
Apple Production has increased in the recent years	47	94	2	4	1	2
Apple production has increased because the new varieties of apple yield more produce	48	96	2	4	-	-
Apple cultivation has improved because of recent pest control practices	33	66	1	2	16	32
IMPACT OF CLIMATE ON APPLE PRODUCTION						
There is change in snowfall pattern in the recent years	49	98	1	2	-	-
In last few years, the temperature has increased	48	96	2	4	-	-
Flowering in apple depends on climatic factors including chilling hours, winter conditions/snowfall/rainfall/hailstorm, etc.	50	100	-	-	-	-
Flowering is affected because of improper climatic condition before flowering	47	94	2	4	1	2
Flowering is either early or delayed because of shift in climate/erratic behavior of climate/rainfall	46	92	3	6	1	2
There is change in flowering time in the recent years	24	48	3	6	23	46
The early flowering affects the production	46	92	2	4	2	4
The delayed flowering affects the production	45	90	3	6	2	4
Pollination is affected by shift in climate/ erratic behavior of climate/rainfall	43	86	7	14	-	-
Pollinators are affected by early increase in temperature/delayed or prolonged winters	31	62	8	16	3	6
Size and color of apple depends on the climatic factors	48	96	2	4	-	-
Hail storms and other natural disasters affect	50	100	-	-	-	-

apple production						
Apple Production has decreased in last few years because of shift in climate/ erratic behavior of climate/ decreased snowfall	31	62	4	8	15	30
Apple production has been affected in last few years because of decreased snowfall/ hail storm	23	46	8	16	19	38
In last few years, apple production has been affected because of improper pollination	21	42	5	10	24	48
In last few years, apple production has been affected because of attack of pests	21	42	6	12	23	46

Source: Primary Data

Table 8: Area (in ha) under Apple Cultivation and Production (in MT) in Shimla vis-à-vis the Climate Change

Year	Area under cultivation (in Hectare)	Dormancy or pre-flowering stage (January-March)		Snowfall (in cms)					Flowering, Fruit-set and fruit developmental stage (April-June)		Fruit growth and developmental stage (July-September)		Post-harvest Stage (October-December)		Production (in MT)
		Avg. Temp. (in ° C)	Avg. Rainfall (in mm)	Dec	Jan	Feb	March	Total	Avg. Temp. (in ° C)	Avg. Rainfall (in mm)	Avg. Temp. (in ° C)	Avg. Rainfall (in mm)	Avg. Temp. (in ° C)	Avg. Rainfall (in mm)	
1985-86	21611	14.44	15.86	0	0	0	0	0	26.90	74.04	25.26	299.94	16.68	25.22	87593
1986-87	21939	13.19	24	12	7	21	9	49	25.38	58.03	25.03	263.96	16.44	78.60	238364
1987-88	22453	14.19	34.4	1	0	15	0	16	25.4	39.80	26.96	95.10	17.34	19.43	171522
1988-89	23266	14.69	31.1	0	0	0	0	0	27.07	47.73	25.24	277.66	16.84	19.10	105176
1989-90	23980	12.67	37.2	205	0	22	10	237	25.10	28.56	24.88	184.43	16.67	23.30	243938
1990-91	25191	14.08	57.1	0	0	13	33	46	26.52	48.13	24.94	266.90	16.66	6.80	243042
1991-92	26754	13.39	16.7	7	6.6	30	54	97.6	25.35	76.93	25.76	127.26	16.44	18.70	208247
1992-93	27916	13.59	46.4	0	109	26	43	178	25.81	40.16	24.86	177.53	17.66	0.06	191961
1993-94	29123	13.39	23.03	2	1	1	0	4	26.16	68.13	25.39	152.06	17.34	3.06	172851
1994-95	30114	14.60	20.76	7	20	28	10	65	26.23	43.40	25.57	208.43	16.98	14.00	75250
1995-96	31213	12.87	69.43	0	0	0	0	0	27.04	45.90	24.51	259.50	17.57	7.83	199373
1996-97	31956	14.62	53.36	12	5	24	17	58	25.83	100.80	24.01	241.46	16.18	17.60	201781
1997-98	32908	13.81	18.53	28	19	0	63	110	25.02	104.00	25.90	171.80	15.73	15.46	127341
1998-99	33707	12.26	42.3	0	37	15	44	96	26.97	28.80	25.87	205.83	17.98	7.76	258621
1999-00	34465	15.70	18.46	11	26	40	20	97	27.88	48.83	26.51	150.50	18.39	1.13	20536
2000-01	35052	13.68	32.23	0	0	0	0	0	27.04	69.23	26.02	84.66	18.99	8.00	274056
2001-02	27678	14.81	39.1	4	7	10	0	21	26.18	34.73	26.52	90.50	18.74	5.33	110857
2002-03	28247	14.91	31.9	22	17	20	29	88	27.50	24.26	25.85	160.13	17.87	9.67	229207
2003-04	29029	14.94	89.8	56	96.6	67	52	271.6	25.70	26.80	29.3	61.03	19.35	22.30	294402
2004-05	29671	18.03	43.8	4	10	0	0	14	25.33	47.40	25.46	129.76	17	1.33	318449

2005-06	30666	14.94	103.5	0	0	0	0	0	24.98	55.87	25.43	71.06	15.66	10.53	310252
2006-07	31323	13.90	62.3	6	0	2	0	8	25	43.63	24	121.93	16.66	4.06	163301
2007-08	32195	13.99	283.4	2	2	3	1	8	24.96	72.40	24.25	84.10	18.33	5.93	349262
2008-09	32586	14.36	46.5	6.5	8.7	3	1	19.2	26.21	25.67	25	81.07	18	6.06	336753
2009-10	33579	17.66	24.26	0	1.8	4	0	5.8	27.90	39.23	24.76	169.26	16.66	9.46	171945
2010-11	34612	16	38.03	3.5 mm	8.5mm	14.5mm	22.5mm	4.9	29.66	75.16	28.33	281.83	19.33	29.20	602684
2011-12	35778	16	42.46	51	95	0	77	223	31.66	83.50	29	174.23	11	4.16	168634
2012-13	37249	15.66	54.16	14	63.6	43	0	120.6	30.33	40.50	29.33	181.46	18.33	7.16	259779
2013-14	37542	15.33	138.4	7 inch	6.5 inch	0	0	13.5 inch	30.33	119.10	28.66	193.50	19.33	31.13	499422
2014-15	38781	16	101.1	5	1	0	0	6	30	58.30	29	146.33	15	24.33	407751

Source: Directorate of Horticulture, Shimla, Water Portal of India, Meteorological Department of Himachal Pradesh, RHRS, Mashobra

Note: Avg. = Average