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Changing Climatic Patterns and its Impact on Apple Production and Productivity in Himachal Pradesh

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Abstract

Himachal Pradesh (H.P) is next only to Jammu and Kashmir in the production of apple in India. Horticulture in general and apple in particular has emerged as the backbone of Himachal Economy. Apple, being a temperate fruit is grown in the high altitude regions and in Himachal Pradesh almost all the districts, except Una, apple production takes place in various magnitudes. As Hills are early indicators of climate change, any significant change in climatic pattern would definitely have cascading effect on the hill economies like Himachal Pradesh. Since, a considerable part of Gross state domestic product (GSDP) and employment comes from that subsector of the hill economy, it is important to study how it is affected by changing climatic patterns. This paper is an attempt to quantify the impact of changing climatic patterns on the production and productivity of apple in H.P using the empirical methods.

Keywords: Apple, Altitude, Climate Change, Gross State Domestic Product (GSDP), Hill Economy, Temperate Fruit

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1. Introduction

1.1 Climate Change

Climate change is a reality[1]. There is a general consensus among the scientists that the Earths' climate is changing. The genesis of climate change could be attributed to the excessive utilization of hydrocarbon or the fossil fuels in the post industrial revolution resulting in increase in the concentration of the Green House gaseous (GHGs) in the atmosphere. The concentration of Green House Gaseous(GHGs) increased at alarming rate from 280 ppm in pre-industrial period to 380 ppm in 2005 and its' rising at the rate of 1.52 to 1.8 ppm per year. The concentration of CO_2 is likely to be doubled by the end of 21st century (Keeling et.al., 1995). Intergovernmental panel on climate change (IPCC,1996) using the general circulation model (GCM) predicts that doubling of carbon dioxide (CO_2) will raise the global surface temperature of 1.0 to 3.5 degree Celsius by 2100 resulting in the increase in the average precipitation by 10 to 15 percent and an abrupt rise in sea level. The model also agrees that the northern latitude will warm more than the tropics.

In India studies confirmed that last century observed increasing trend in surface temperature (Srivastva et. al., 1992; Singh et. al., 2002, Birthal et. al., 2014), no significant trend in rainfall on all India bases (Kriplani et al., 1996, 2003, Singh and Sontakke 2002,Birthal et al, 2014).

2. Literature Review

Mountains are early and important indicators of climate change which depicts far reaching consequences on our ecosystem, agriculture and livelihood of farmers (Singh et al, 2010). The Himalayan mountain system ecosystem is also facing serious challenges posed by climate change due to increasing aridity, warmer winter season, and variability in receiving precipitation and snow (Guatam et al,2014). During last three decade, the Himalaya region has warmed faster than most places in the world. An analysis of data of last two decades of major apple growing areas (Shimla, Kullu, Lahul and Spiti) indicates that minimum temperature is decreasing per year from November to April, whereas maximum temperature has been showing an increasing trend from November to April (Rana et al, 2009). The chilling units are critical for the apple production have also showed a decreasing trend. Chill units have been recorded to decrease up to 2400m msl from Bajaura in Kullu at 1221m msl to Sharbo in Kinnaur at 2400 m msl. Increase in precipitation and decrease in snowfall during winter consequently reflected in the low chilling hours in the region. Trend analysis indicated that snow fall is decreasing at the rate of 82.7 mm/annum in the entire region. Another study reports from the Kullu valley that rainfall has decreased by about 7 cm, snowfall by about 12cm the mean minimum and maximum temperature have increased by 0.25^0 and 1^0c respectively, in 1990s compared to 1980s (Negi et al,2012).

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Consequences of these climate changes are observed clearly in the shifting of apple cultivation from lower elevation to higher altitude in H.P. Some of those important locations are Kullu valley in Kullu Districts, Rajgarh in Sirmour district, theog and Kotkhai in Shimla district, Churag and adjoining areas in Solan district (Gautam et al, 2014). Apple – growing areas in low altitude like Solan have been reduce by as much as 77% between 1981 and 2007(…6) During the same period, apple farming began in the higher – altitude areas of Kinnaur, lahul &Spiti, which were earlier considered too cold and dry. Apple cultivation has shifted to higher altitude and apple yield mainly in lower altitude has declined due to inadequate chilling as the temperature at lower altitude is rising(Negi et al,2012 and Rana et al, 2009). Overall decrease of about 2-3% in yield has been reported in Shimla, Kullu, Lahul and Spiti districts in mid 2000s and maximum decline of about 4% was witness in marginal farms. In adition to direct impact of climate change apple productivity, it has also aggravated infestation of some diseases and pests resulting in more losses in yield (Sharma, 2012,Gautam et al,2013). In Kinnaur district, 72.5% of farmers from low hills believed that change in climate, especially increasing temperature, was responsible for decline in fruit size and quality and 39% of farmers in the high hills considered climate change a deterrent in maintaining fruit quality (Basannagari et al, 2013).

3. Apple (Malus Pumila)

Apple (Malus Pumila) is commercially the most important temperate fruit and is fourth among the most widely produced fruits in the world after banana, orange and grape[2]. China is the largest apple producing country in the world. The apple tree (*Malus domestica*) is a deciduous tree in the rose family best known for its sweet, pomaceous fruit, the apple. It is cultivated worldwide as a fruit tree, and is the most widely grown species in the genus *Malus*. The tree originated in Central Asia, where its wild ancestor, *Malus sieversii*, is still found today. Apples have been grown for thousands of years in Asia and Europe, and were brought to North America by European colonists. Apples have religious and mythological significance in many cultures, including Norse, Greek and European Christian traditions. About 80 million tons of apples were grown worldwide in 2013, and China produced almost half of this total (FAO,2015). The United States is the second-leading producer, with more than 6% of world production. Turkey is third, followed by Italy, India and Poland (FAO,2015). India occupies fifth position in the production of apple in the world.

3.1 Apple Production in India

In India, Jammu and Kashmir leads the rank followed by Himachal Pradesh in the production of apple. The area under apple cultivation in India increased by 24% from 1.95 lakh ha. in 1991-92 to 2.42 lakh hac. in 2001-02 although production increased by less than 1% (i.e. from 11 to 12 lakh tones). Apple in India is grown mostly in the states of Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Arunachal Pradesh and Nagaland. An analysis of data from the Table 4.1 show that at the all India level the area under the apple crops has been increased consistently from 1991-92 to 2013-14. Area under apple farming has increased from 194.5 hectare in 1991-92 to 313 hectare in 2013-14.During the same period, the production of crops also registered an increasing trend and increased from 1147.7 thousand metric tons in 1991-92 to 2497.7 thousand metric tons in 2013-14. Productivity too has increased from 5.9 million tons per hectare in 1991-92 to 8.0 million tons in 2013-14.

Table 1. Areas, Production and Productivity of Apple in India

Year	Area in '000 Hac	Production in '000MT	Productivity in MT/Hac
1991-92	194.5	1147.7	5.9
2000-01	239.8	1226.6	5.1
2001-02	241.6	1158.4	4.8
2002-03	193.1	1348.4	7
2003-04	201.2	1521.6	7.6
2004-05	230.7	1739	7.5
2005-06	226.6	1814	8
2006-07	252	1624	6.4
2007-08	264	2001	7.6
2008-09	274	1985	7.2
2009-10	282.9	1777.2	6.3
2010-11	289.1	2891	10
2011-12	321.9	2203.4	6.8
2012-13	311.5	1915.4	6.1
2013-14	313	2497.7	8

Source; Indian Horticulture Database, 2014

Table 2. Average Growth Rate of Area, Production and Productivity in India

	Average Growth Rate of Area, Production and Productivity in India		
Year	1991-92 to 2001-02	2001-02 to 2011-12	1991-92 to 2013-14
Area	0.94	2.19	0.94
Production	0.04	2.79	1.52
Productivity	-0.90	.60	.58

Source; Calculated by Author

Further, if we look at the annual average growth rate of area, production and productivity over an interval of ten years and over the period of time (22yrs), the area under the apple crop has registered annual growth rate of .94% during 1991-92 to 2001-02. It was 2.19% during the time interval 2001-02 to 2011-12 and 0.94% during the entire time period, i.e. from 1991-92 to 2013-14. Growth rate of production of apple during first time interval, i.e. 1991-92 to 2001-02 was less than one percent and it was 0.04 %. While it was 2.79% during second time interval Source; Indian Horticulture Database, 2014 and 1.52% during the study period. Whereas the productivity after registering negative growth rate (-0.90%) during 1991-92 to 2001-02 become positive and become more than one percent (1.51%) in 2001-02 to 2011-12. Overall, productivity registered 0.60 % growth rate during the entire study period. Thus, at all India level all the variables; area, production and productivity of apple show positive growth rate over the period of time.

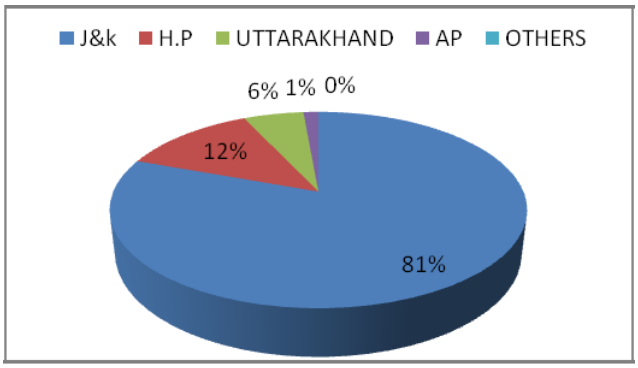

Figure 1. Share of states in apple production in India in 2013-14.

As the table 4.3 shows the production of apple India is led by the state of Jammu and Kashmir. Jammu and Kashmir leads not only in production but also in the area under apple farming as well as in the productivity. Himachal Pradesh ranks second in the production, area under crop and productivity of apple. If we compare the productivity of Himachal Pradesh with Jammu and Kashmir, it's quite low. So, there is ample scope for the raising productivity in Himachal Pradesh.

4 Area and Production of fruits in Himachal Pradesh

The rich diversity of agro climatic conditions, topographical variations and altitudinal differences coupled with fertile, deep and well drained soils favor the cultivation of temperate to sub-tropical fruits in Himachal. The region is also suitable for cultivation of ancillary horticultural produce like flowers, mushroom, honey and hops. This particular suitability of Himachal has resulted in shifting of land use pattern from agriculture to fruit crops in the past few decades. The area under fruits, which was 792 hectares in 1950-51 with total production of 1200 tones increased to 2,11,295 hectares during 2010-11. The total fruit production in 2010-11 was 10.28 lakh tones Apple is so far the most important fruit crop of Himachal Pradesh, which constitutes about 49 percent of the total area under fruit crops and about 89 percent of the total fruit production. Area under apple has increased from 400 hectares in 1950-51 to 3,025 hectares in 1960-61 and 1,01,485 hectares in 2010-11[3].The area under temperate fruits other than apple has increased from 900 hectares in 1960- 61 to 27,063 hectares in 2010-11. Nuts and dry fruits exhibit area increase from 231 hectares in 1960- 61 to 11,022 hectares in 2010-11, Citrus and other sub-tropical fruits have increased from 1,225 hectares and 623 hectares in 1960-61 to 22,305 hectares and 49,420 hectares in 2010-11[4].

Table 3. State wise area, production and productivity of apple in India

Area in '000 hectare		**Production in'000 MT**		**Productivity in MT/HC**					
		2011-12			**2012-13**			**2013-14**	
States	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
J&k	170.6	1775	10.4	157.28	1348.2	8.6	160.9	1647.7	10.2
H.P	103.6	275	2.7	106.23	412.4	3.9	107.7	738.7	6.9
Uttrakhand	33.7	122.7	3.6	33.76	123.2	3.7	30	77.5	2.6
Arunachal Pradesh	13.9	30.5	2.2	14.07	31	2.2	14.3	31.9	2.2
Others	0	0.1	4.3	0.2	0.6	3	0.2	2	8.5
Total	**321.8**	**2203.4**	**6.8**	**311.5**	**1915.4**	**6.1**	**313**	**2497.7**	**8**

Source: As in Table 1

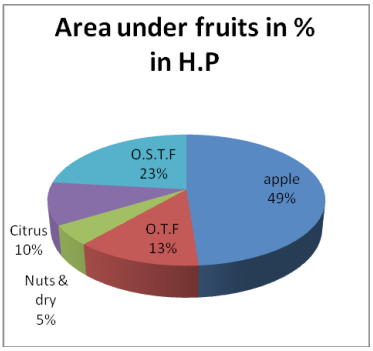

Figure 2. Area under different fruits in H.P in 2013-14 in percent.

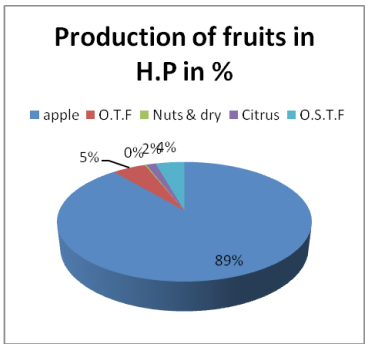

Figure 3. Share of different fruits in total production in H.P in 2013-14.

As the Table 4 shows the area under the apple crop as a proportion of total crop is insistently increasing. The share of apple farming has increased from the 41.46% in 2001-02 to 48.79% in 2013-14. Whereas the share of apple production in total fruits production has increased from 68.53% in 2001-02 to 88.85% in 2014-15. It shows the importance of apple in the economy of Himachal Pradesh.

4.1 Area, Production and Productivity of Apple in Himachal Pradesh

Apple cultivation in Himachal Pradesh has shown a remarkable growth. The process of planned growth was initiated in 1950 after the State was constituted in the present geographical form. Indeed a small step taken by Evans Stokes in 1914 at his Tea Estate in Thanedhar has brought about tremendous economic gains to the farmers, traders and others as was visualized by him[5]. A large varieties of apple is produced in the state among them Royal delicious, Rich-e- Red, Red Delicious, Red chief, Golden Delicious and Red gold are world famous. The major apple producing belt identified in the state is Shimla (Kotkhai, Jubbal, Rohroo, Rampur, Theog, Chopal, Kumarsain, Kotgarh Dodra Kawar), Kullu (Kullu, Anni, Manali, Nirmand, Sainj), Mandi (Karsog, Janjhaili, Banjar), Chamba (Pangi, Bharmour,Saluni), Kinnaur (Rekong Peo, Ropa Valley, Sangla Valley, Chango, Pooh), Lahul Spiti (Kaza, Lahul), Kangra (Multhan, Bara, Bhangal, Chota Bhangal), Sirmour (Rajgarh)[6].

Table 4. Average annual growth rate of production, area and yield of apple in H.P in Percentage

Year	Production	Area	Yield
1965-70	9.57	4.24	5.33
1970-80	1.19	-0.77	1.95
1980-90	5.25	3.83	1.41
1990-00	-8.43	-9.92	1.50
2000-10	-0.86	-1.29	0.42
1965-10	3.17	0.62	2.55

Source: Calculated by Author.

An analysis of annual growth rate reveals that production of apple has increased at rate of 3.17% per annum over last 45 years and the area under the crop has increased at the rate of .62% per annum. Whereas the productivity of apple has displayed a growth rate of 2.55% per annum. Production and area under the crop has depicted a negative growth rate during the decade of 1990s' and 2000s. During the decade (2000 to 2010) the growth rate of crop was less than one percent. The table 1.4, shows that the growth rate of productivity of apple is constantly falling from 1970s except in 1990s when there is a marginal improvement over the past decade.

4.2 District wise Area, Production and Productivity of Apple in Himachal Pradesh

Apple farming is practiced in the nine districts of the state, while three other districts are not suitable for apple production due to their physiographical character. A district level analysis will throw more light on our understanding the nine districts where the apple is produced is as; Chamba, Kangra, Kinnaur, Kullu, Lahul & Spiti, Mandi,Shimla, Sirmour, and Solan. Let's analyze one by one each districts where apple is produced.

4.2.1 Chamba

Chamba district lies at the northern part of the Himachal Pradesh. It shares boundary with the state of Jammu and Kashmir. The area under the apple crop has increased from 1582 hectares in 1980-81 to 13692 hectares in 2009-10 registering an increase of about 8% during the thirty years' time interval. While the production of crop has increased from 1736 ton in 1980-81 to 11990 ton in 2009-10 an increase of about 6% during the same time interval. Productivity does not show any linear trend. If we look at the annual growth rate of production, area and productivity

then it comes out from the table 1.5, it shows that growth rate of production was 3.69% during the 1980s' it falls to -1.79% during 1990s and picks up and becomes 4.27% per annum during the 2000s. The growth rate of yield was less than one percent in first decade of the study become negative during1990-00 and positive and more than two percent 2000 -10. The overall growth rate of yield was -0.35% from 1980 to 2010. Growth rate of area under the crop was positive throughout the period and it has grown at the rate of 3.15% per annum.

4.2.2 Kangra

Kangra district fall in the low hill area and is one of the most populated district in Himachal Pradesh. Its contribution to the total apple production in state is very low and even less than one percent. The area under the crop throughout the period is stagnant and it has increased marginally from 416 hectares in 1980 to 450 hectares in 2009-10. The production of crop has decreased from 694 ton in 1980 to 401 ton in 2009. The district has produced highest ever production of 822 ton in 1981 since then it never crossed that highest mark. District has one of the lowest productivity in the state. The production and productivity has marked the negative growth rate during 1980 to 2009-10 as shown in table1.5.

4.2.3 Kinnaur

District Kinnaur, which was earlier considered not suitable for apple cropping due of high altitude, has emerged as one of the most prominent apple producing district in Himachal Pradesh. It is now known as 'apple bowl' of the state. In 2009-10, Kinnaur has contributed 14% of total apple production in state. The area under the crop has increased from 2026 hectares in 1980-81 to 9999 hectares in 2010-11, thus, registering over four percent growth from 1980-81 to 2010-11. At the same time the production of crop has increased from 7151 ton in 1980 to 70305 ton in 2010-11, an increase of about nine percent. All the three variables has exhibited positive growth rate during the thirty years interval. The production of apple has recorded annual growth rate of 3.30 percent and area has registered 2.31% during the study period. The growth rate of yield is positive but less than one. Kinnaur has depicted one of the highest increases in production and area during the last thirty years as depicted in table 5.

4.2.4 Kullu

Kullu district is also one of the most important apple producing districts in the state. Kullu is the second largest producer of apple in the state next only to Shimla. In 2009-10, Kullu's share in the total production was 18%. The area under the crop has grown from 10264 hectares in 1980-81 to 24002 hectares in 2010-11, thus increasing over 1.33%. The production of crop has increased from 29058 ton in 1980-81 to 210773 ton in 2010-11 marking an increase of 6.25 percent. Area under the crop has registered a growth rate of 1.22 percent over the period of time. Whereas, the crop production and crop productivity has recorded a growth rate of 2.68 and 1.64 percent per annum over the period of time. A wide fluctuation in the productivity has observed in Kullu district, the productivity after registering 4.86 percent growth in 1980s declines by 11 and .7 percent in1990s and 2000s presented in table 6.

4.2.5 Lahul and Spiti

The most remarkable change is found in the district of Lahul and Spiti. Like Kinnaur, Lahul and Spiti was earlier considered not suitable for the apple production because of its location at high altitude. Apple production has grown to 213.8 ton in 2010 from zero production in 1980-81. The area under the crop too has registered an impressive growth during the period. It has grown from 48 hectares in 1980-81 to 1320 hectares in 2010-11. The area under the crop has increased at the rate of 4.80 percent per annum during the study period.

Table 5. Average annual growth rate of production, area and yield of apple in Chamba, Kangra and Kinnaur Districts in Percentage

	Chamba			Kangra			Kinnaur		
Year	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area
1980-90	3.69	0.25	3.43	-2.84	-4.12	1.29	2.09	-0.9	3
1990-00	-1.79	-5.43	3.64	-5.83	-5.94	0.1	2.26	0.64	1.62
2000-10	4.28	2.62	1.65	1.33	2.6	-1.27	3.09	1.2	1.89
1980-10	2.8	-0.35	3.15	-0.79	-0.91	0.34	3.3	0.98	2.31

Source: calculated by author

Table 6. Average annual growth rate of production, area and yield of apple in Kullu, Lahul & Spiti and Mandi Districts H.P in Percentage

	Kullu			Lahul & Spiti			Mandi		
Year	**Production**	**Yield**	**Area**	**Production**	**Yield**	**Area**	**Production**	**Yield**	**Area**
1980-90	**6.29**	4.87	1.42	0.00	0.00	3.68	3.83	-3.96	7.79
1990-00	**-9.81**	-11.12	1.31	3.17	-2.43	5.59	-6.15	-7.47	1.31
2000-10	**0.07**	-0.75	0.82	2.75	0.22	2.53	-0.29	1.75	-2.04
1980-10	**2.87**	1.64	1.22	-	-	4.80	1.90	-0.56	2.46

Source: calculated by author

4.2.6 Mandi

Mandi district falls under the category of mid hill districts. In 2009-10, the district has contributed about four percent of total production in Himachal Pradesh. The area under the crops has increased from 1582 hectares in 1980-81 to 15353 hectares in 2008-09 then it suddenly falls to 8659 hectares in 2009-10. The crop production has increased from 4190 ton to 30300 ton in 2008-09 and falls to 15531 ton in 2009-10. The production of crops after registering about four percent per annum growth in 1980s registers negative growth rate in 1990s and 2000s. The productivity of crop in Mandi district shows positive growth rate in the interval of 2000-10 and overall negative growth rate during the thirty year interval(shown in table 1.6). Whereas the area under the apple farming registers negative growth rate in the decade 2000-10 and overall it has grown at the rate of about three percent per annum during the study period.

4.2.7 Shimla

Shimla district is most important district as far as the apple farming is concerned in the state. Shimla districts has largest share in the production of apple crop in the state. About sixty percent of apple production comes from the Shimla district. District Shimla ranks first in terms of area under production as well as the productivity of crop. Area under the crop increased from 18887 hectares in 1980 to 34612 hectares in 2010. At the same time the production has increased from 73521 ton to 664338 ton in 2010 which is largest ever produced in the district. The district has lowest productivity in 1999-00 when it was 595kg/hectares and highest in 2010-11 when the productivity per hectare was 19193 kg. An analysis of annual growth rate shows that production has increased at the rate of 5.20 percent per annum during 1980-90 and negative(10%) and (1.6%) during the decade of 1990-00and 2000-10. The productivity per hectares has increased at the rate of 2.30 per annum during the thirty years interval (table 7). It has grown at negative rate during the 1990s after recording highest growth rate in 1980s. The area under the crop increased at the rate of .087 percent per annum over the period.

4.2.8 Sirmour

Sirmour district is another district where the apple farming takes place although its share in States' kitty is quite low. District has one the lowest productivity in the state and the production of crop shown a wide fluctuation over the period of time. The area under the crop has increased from 2897 hectares in 1980-81 to 3248 hectares in 2009-10. The production of crop, which was 1169 ton in 1980-8, falls to 242 ton in 2009-10(table 7). The productivity of apple is quite low in the district and it never touches the three digit figure. The annual growth rate of production and productivity was negative throughout the period and the area under the crop has increased at the rate of .17 percent per annum during last thirty years.

4.2.9 Solan

Apple farming also takes place in district Solan although the district is located at low altitude. Apple farming has shown dismissal picture in district, the production and area under the crop has

Table 7. Average annual growth rate of production, area and yield of apple in Shimla, Sirmour and Solan Districts in H.P in Percentage

	Shimla			Sirmour			Solan		
Year	**Production**	**Yield**	**Area**	**Production**	**Yield**	**Area**	**Production**	**Yield**	**Area**
1980-90	5.21	4.17	1.04	-0.90	-1.75	0.85	-6.20	-6.54	0.35
1990-00	-10.73	-12.09	1.36	-7.89	-8.33	0.44	-3.27	-3.46	0.19
2000-10	-1.60	2.49	-0.05	-1.75	-0.77	-0.98	-5.48	2.17	-7.65
1980-10	3.19	2.31	0.88	-2.28	-2.45	0.17	-4.18	-1.83	-2.35

Source: Author

shown the declining trend throughout the period. The production of crops after attaining highest (627 ton) in 1981-82 falls consistently and it becomes 28 ton in 2009-10. All the observations depicts negative growth rate of various magnitude during the study period (table 7).

5. A Trend Analysis of Climatic Variables

For the purpose of our study we have taken the three districts namely; Kinnaur, Kullu and Shimla. Together these three districts produce more than ninety percent of apple and seventy one percent of cropped area lies there in these three districts. At the same time climatic variables of these districts are available and collected from various governmental agencies. Climatic variables like minimum temperature, maximum temperature, relative humidity morning, relative humidity evening, rainfall and snowfall are analyzed

5.1 Temperature

Temperature has been measured in Celsius and average annual mean minimum and maximum temperature is taken for the purpose of analysis. It has been come out from the analysis that annual mean temperature has shown an increasing trend in the district kullu and district Shimla, whereas the annual mean minimum temperature is decreasing in the kinnaur district. Kinnaur has decreasing trend with coefficient value (-.02). The highest increase has been recorded in Kullu district where the coefficient has been found to be 0.19 and in Shimla the value of coefficient remains .09. The maximum temperature has shown an increasing trend in all the districts with the highest rate of increase being observed in Shimla district followed by Kinnaur and Kullu. Thus it can be inferred from the figure 4a and the graphs that minimum mean temperature is increasing up to the height of 2000mtr and thereafter it shows a decreasing trend. Whereas the maximum temperature has shown an increasing trend over all elevations figure 4b.

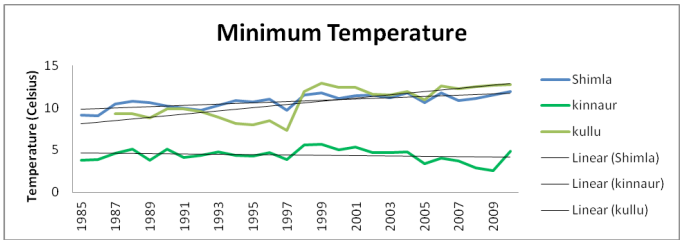

Figure 4a. Minimum temperature.

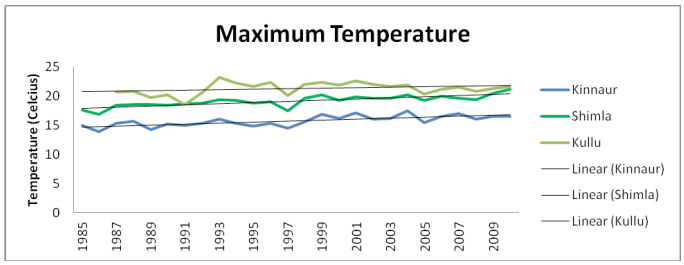

Figure 4b. Maximum temperature.

5.2 Relative Humidity

Relative humidity is measured in percentage term and is recorded for the morning (7:30 am) and evening time (5:30 pm). It has come out from our study that relative humidity is also increasing and it has been increasing at all the stations with different magnitude. Relative humidity at the evening time has shown higher increase than at morning time. Thus, we can infer that climate is getting warmer and warmer shown in figure 4c.

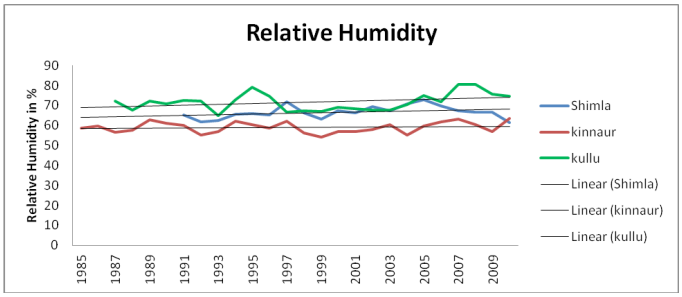

Figure 4c. Relative humidity.

5.3 Rainfall

Rainfall is measured in millimeter (mm) and average annual rainfall is analysed over the period of time. A wide variation has been recorded in the rainfall variable across the district. Rainfall has shown decreasing trend in Kinnaur and Kullu districts and an increasing trend in the Shimla district. District Kullu has shown maximum decline in rainfall over the period.

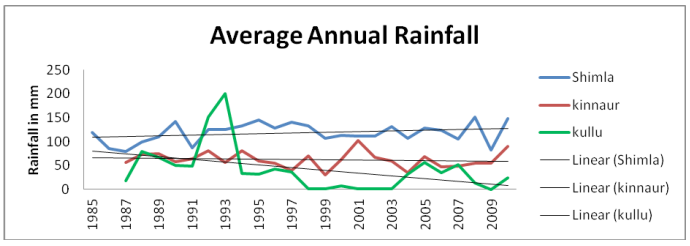

Figure 4d. Average Annual Rainfall.

5.4 Snowfall

Snowfall is one of important ingredient for the apple production and timely snowfall is considered good for the apple cultivation and it helps in maintaining the minimum temperature which further helps in accumulation of chilling units for the plants. Snowfall is measured in centimeter (cm) and annual snowfall is taken for the study. It comes out from the study that snowfall is decreasing in course of time and all the districts have recorded the decreasing trend. Further, district Kullu has recorded maximum fall in snowfall over the period of time.

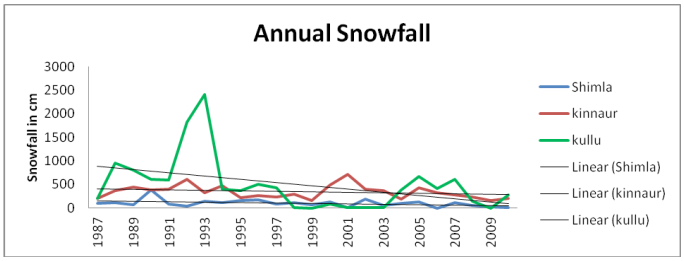

Figure 4e. Annual Snowfall.

It has been come out from the analysis of climatic variables that weather in Hill area is getting warming in course of time. Both the minimum and maximum temperature have shown increasing trend over the period with exception of Kinnaur district where the minimum temperature is falling. Literature says that apple plants require at least 1000 hours of chilling unit for good crop but increasing temperature may pose hurdle in this direction. Relative humidity has also recorded an increasing trend which means weather is getting warm and humid in course of time. As literature says relative humidity of 50 to 60 percent is conducive for apple crop depending upon the season. If the humidity increases further then it would help in breading of germs, pests and disease which will further increase the cost of production. Rainfall has shown the wide fluctuations which confirm the study from the north Indian plains where an erratic behavior of rainfall has been recorded. Further rainfall has shown decreasing trend in Kullu and Kinnaur. Snowfall is another important variable for the apple cultivation as it is considered as 'white manure' and brings the nitrogen which is very important for plants. Further, snowfall helps in maintaining minimum temperature and flow in rivers necessary for irrigation and electricity production. Thus, we can confer that climatic patterns are changing in course of time in Himachal Pradesh.

6. Impact of Climate Change on Apple Productivity

Apple is a perennial crop and it goes though the four stages namely (i) Dormant stage from December to March (ii) flowering and fruit set stage April to May (iii) Growth and development stage from June to September and (iv) Pre dormant stage from October to November. It has been found that each stage has been observed to be having specific requirements of weather parameters i.e., specific range of maximum and minimum temperatures, rainfall, snowfall, humidity and evaporation for uniform growth and development of vegetative and reproductive parts of the apple plant. Production and productivity of apple over the period of time has not been found to be dependent on man-made factors only. Natural factors which are uncontrollable have huge impact in bringing significant variations in production of fruits in general and apple in specific. As the production/productivity is a combination of both controllable and uncontrollable factors, so we have taken variables like infrastructure, agricultural inputs and uncontrollable but manageable climatic variable. The important factors like labor could not be taken because of paucity/ unavailability of data. The log linear model is taken for this purpose. The model is defined as;

$$\text{Log } Y = \alpha + \beta_1 X + \beta_2 X_1 + \beta_3 X_2 + \beta_4 X_3 + \beta_5 X_4 + \beta_6 X_5 + \beta_7 X_6 + \beta_8 X_7 + \beta_9 X_8 + \varepsilon$$

Where 'Y' is productivity per hectare,α is constant, β, β_1, β_2, β_3……..β_9 are the elasticities of independent variables and ε is error term. And X is maximum temperature, X_1 is minimum temperature, X_2 is relative humidity, X_3 is square of rainfall, X_4 is fertilizer used per hectare,X_5 is cropping intensity,X_6 is percentage of villages electrified ,X_7 is population bank ratio ,X_8 is literacy rate, and ε is error term.

Regression result presented in the above table shows the causal linkage between yield (productivity of apple) and factors like infrastructure, climatic condition and agricultural inputs. It shows a negative and significant effect of minimum temperature and literacy rate, positive and significant effect of rainfall square, fertilizer used and bank population ratio on the crop yield. Whereas the cropping intensity, maximum temperature, and relative humidity and percentage of villages electrified seems to have insignificant effect on crop yield. The effect of minimum temperature is negative showing lower the minimum temperature higher will be the crop yield. Although the regression result shows the minimum temperature has negative effect on the crop productivity. Literature says that minimum temperature is crucial determinant of production and hence productivity, a minimum chilling hour is required during the 'dormant stage' (December to march). If the plants don't receive the minimum 'chilling hours' during this stage it will have negative impact on production and productivity. Fertilizer use and rainfall and bank population have positive and significant effect on apple production. Here the regression coefficients are the elasticity of dependent variable with respect to independent variable.

```
Random-effects GLS regression                   Number of obs      =        70
Group variable: var2                            Number of groups   =         3

R-sq:  within  = 0.3884                         Obs per group: min =        23
       between = 1.0000                                        avg =      23.3
       overall = 0.5926                                        max =        24

                                                Wald chi2(9)       =     87.27
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
       yield |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     maxtem |    79.8385   281.1183     0.28   0.776    -471.1432    630.8202
     mntemp |  -528.5662   238.3227    -2.22   0.027    -995.6702   -61.46219
        rhm |  -2.092353    75.7568    -0.03   0.978     -150.573    146.3883
  sqrainfall |   .0008162   .0003852     2.12   0.034     .0000613    .0015712
     fckghec |   104.1621   15.95228     6.53   0.000     72.89624     135.428
   intensity |   61.48559   35.95213     1.71   0.087    -8.979291    131.9505
  ofvillelec |   21.20689   18.93011     1.12   0.263    -15.89544    58.30922
     popbank |  -.9699594   .2717737    -3.57   0.000    -1.502626   -.4372927
    literacy |  -109.4042   41.54836    -2.63   0.008    -190.8375   -27.97089
       _cons |   4696.991   4444.931     1.06   0.291    -4014.914    13408.89
-------------+----------------------------------------------------------------
     sigma_u |           0
     sigma_e |   2160.9466
         rho |           0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

7. Conclusion

Apple (Maus Pumila) is commercially most important temperate fruit produced in the world. In India, an increasing trend has been observed in area, production and productivity of apple. India's productivity is low compared to other leading producers in the world. Jammu and Kashmir is the largest producer of apple followed by Himachal Pradesh. The temperate climate of Himalayan region makes it suitable for the cultivation of apple. Apple is most important crop of Himachal Pradesh. It constitutes about 50% of area under fruits and 90% of total fruit production. The area under the under crop has increased from 400 hectares in 1950-51 to 101485 hectares in 210-11. Royal delicious, Richese-Red, Red Delicious, Red chief, Red Gold are world famous produced in Himachal Pradesh. The production of crop in the state increased at the rate of 3.17% per annum from 1965 to 2010. Whereas, the area under the crops recorded 0.62 percent growth and yield 2.55% per annum during the same period. A district wise analysis shows that out of twelve districts apple farming is done in nine districts. Shimla is the largest apple producing district in the state followed by Kullu and Kinnaur. About 60% of crop is being supplied by district Shimla alone. Together with Kullu and Kinnaur, Shimla supplies more than 90% of crop in Himachal Pradesh. Apple production and productivity has shown negative growth in low height district like Sirmour and Solan. Whereas the area under crop is shown significant increase in two high hill districts like Kinnaur and Lahul &Spiti, which were earlier considered as not suitable for apple cropping because of high altitude.

An analysis of climatic variables over the period of time shows that a significant changes in the state. Minimum temperature has shown increasing trend in districts Shimla and Kullu, while district Kinnaur has shown decreasing trend. The maximum temperature is increasing in all the districts. Rainfall has shown erratic behavior and Shimla district has recorded increasing trend of rainfall and Kullu and Kinnaur decreasing trend over the period of time. Snowfall has registered a decreasing trend in all the districts. Thus, results show the climate of Himachal Pradesh is getting warm and humid in course of time. Further, fertilizer consumption per hectare and rainfall square and bank population ratio has emerged as having the positive and significant influence on the yield of apple in the state whereas the minimum temperature and literacy rate has negative and significant impact on productivity.

8. References

1. Anon. Horticulture–Area under fruits/Production of fruits. Statistical Outline of H.P. Economics and Statistics Department, Shimla, H.P. 2007.
2. Anon. Horticulture development: facts and figures. Directorate of Horticulture, Himachal Pradesh. 2009.
3. Bhagat RM, Rana RS, Kalia V. In Global Climate Change and Indian Agriculture (ed. Aggarwal, P. K.), ICAR, New Delhi. 2009; 48–53.
4. Crosson P. Climate Change and Mid-Latitudes Agriculture: Perspectives on Consequences and Policy Responses. Climate Change. 1989; 15(1):51–73. https://doi.org/10.1007/BF00138845
5. FAO production data. FAO. Retrieved 2 July 2015.
6. Intergovernmental Panel on Climate Change (IPCC). Climate Change 1995, Contribution of Working Group II, Cambridge University Press.1996
7. Kayasth SL, Mishra SN. Himachal Region. In: Singh R. editor. India: A Regional Geography. National Geographical Society of India, Varanashi. PMCid:PMC4162897

8. Liu X, Chen B. Int J Climatol. 2000; 20:1729–42. https://doi.org/10.1002/1097-0088(20001130)20:14<1729::AID-JOC556>3.0.CO;2-Y
9. Mall RK, Bhatia M, Rathore VS, Singh R. Mitigating Climate Change Impact on Soya bean Productivity in India: A Simulation Study. Agriculture and forest Meteorology. 2004; 121,1-2:113–25.
10. Maslin M. Global warming a very short introduction. 2007.
11. Mendelsohn R et al. The Impact of Climate Change on Agriculture: A Ricardian Analysis. American Economic Review. 1994; 84(4):753–71.
12. Mitto HK. Himachal Pradesh, India-The Land and People, National Book Trust, India. 1993.
13. Negi GCS, Samal PK, Kuniyal JC, Kothyari BP, Sharma RK, Dhayani PP. Trop Ecol. 2012; 53(3):345–56.
14. Rana RS, Bhagata RM, Kalia V, Lal H. Impact of climate change on shift of apple belt in Himachal Pradesh. ISPRS Archives XXXVIII 8/W3 Workshop Proceedings: Impact of Climate Change on Agriculture. 2008; 131–7.
15. Rana R et al. Impact of Climate Change on Shift of Apple Belt in Himachal Pradesh. 2009.
16. Rosenberg NJ. Towards an Integrated Assessment of Climate Change: The MINK Study, Kluwer Academic Publishers, Boston. 1993; 173 pp. https://doi.org/10.1007/978-94-011-2096-8
17. Rosenzweig C, Parry M. Potential Impact of Climate Change on World Food Supply. Nature. 1994; 367:133–8. https://doi.org/10.1038/367133a0
18. Swant SD, Achuthan CV. Agricultural Growth across Crops and Regions: Emerging Trends and Patterns. Economic and Political Weekly. 1995; 30:17–25.
19. Sharma IM. In Proceedings of the National Symposium on Blending Conventional and Modern Plant Pathology for Sustainable Agriculture. Indian Institute of Horticultural Research, Bengaluru. 2012.
20. Singh NP, Kumar R, Singh RP. Diversification of Indian Agriculture: Composition, Determinants and Trade Implications. Agricultural Economics Research Review. 2006; 19:23–36.
21. State Statistical abstract of Himachal Pradesh 2011-12. Department of Economics & Statistics, Himachal Pradesh, Shimla.
22. Statistical Outline of Himachal Pradesh 2011-12. Department of Economics & Statistics, Himachal Pradesh, Shimla.
23. Available from: htpp://www.csmonitor.com/World/Asia-South-Central/2013/0422/Climate-changesends-India-s-apple-farmers-up-the-Himalayas
24. Available from: http://www.robertscribbler.wordpress.com/2013/08/19/the-glacial-megaflood-globalwarming-
25. Available from: poses-growing-glacial-outburstflood-hazard-from-himalyas-to-greenlandand-west-antarctica/
26. Available from: http://www.ndtv.com/article/india/himachal-s-apples-hit-by-global-warming-11995.
27. Available from: http://kastoria.teikoz.gr/icoae2/wordpress/wp-content/uploads/articles/2011/10/012-2008.pdf

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