Impact of Global Climate Change on Apple farming in the Western Himalayan Region: A Case Study of Kotgarh Village in Shimla District of Himachal Pradesh (INDIA)

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ABSTRACT

In Himachal Pradesh agro-climatic conditions are suitable for the cultivation of variety of fruit crops. The development of fruit crops has greatly fulfilled the needs and objectives of socio-economic growth in the state. Among various fruits grown in the state apple dominate in area as well as production. Himachal Pradesh is the second largest producer of apple in India. But due to environmental change some areas are experiencing decline in the productivity of apple in the state. The area undertaken for present study is Kotgarh village in Shimla district of Himachal Pradesh, which is also experiencing the impact of environmental change on apple orchards. The diffusion of delicious apple in the state has been started from Kotgarh in earlier 20th centaury, as first time the delicious verities of apple were introduced by Samuel Nicholas Stokes in 1918 in this village. This is the major traditional node of diffusion of apple in the state. The present study is an attempt to analyze the changes in the growth of apple orchards in terms of space and time in response to changing environment. The study is empirical observations as well as on secondary data.

Key Words: Environmental Change, Apple, Productivity, diffusion

1. Introduction

Since the evolution of agricultural activities around 10000 years ago the role of climatic conditions in controlling the soil properties, crop growth and land productivity and production has always been a vital interest to the growers and much later to the scientists (Bosal, 2007). Farmers have always experienced the impact of climatic variability on crops but these variations were natural. Most of these climatic changes are attributed to very small variations in Earth’s orbit that change the amount of solar energy our planet receives (NASA,2015), hence did not make much impact on agriculture. But after industrial revolution, race for development in the world started which caused lot of carbon emission in the atmosphere therefore the natural gaseous composition of the atmosphere changed, consequently climate become warmer which is showing its impact on agriculture. Paul, Pandy and Singh (2011) also stated in their study that atmospheric CO2 concentration is 30 percent higher than during pre-industrial times, and is increasing at about 0.5 percent per annum. The current warming trend is of particular significance because most of it is very likely human-induced and proceeding at a rate that is unprecedented in the past 1,300 years (NASA, 2015). Thus climate change is a fact these days which is showing its impact on global economy, ecology and society. Global climate change which is attributed to increased temperature and changing rainfall patterns at global and regional level has largely affected the agriculture because crops growth is higly associated with temperature and rainfall, therefore, a slight change in these two climatic parameters have the ability to change the cropping pattern and crop season of an area. Agriculture is one of the most vulnerable sectors to the expected climate change. Regardless of the technological development, weather and climate are still key factors in determining agricultural output in most of the areas. The anticipated changes in temperature and rainfall patterns, as well as their associated impacts on water availability, pests, disease, and extreme weather events are all likely to affect substantially the potential of agricultural production (Zhai and Zhuang, 2009).
1.1 Climate Change and Horticulture in the Himalayan Region

Mountains are early and important indicators of climate change which depict wide ranging effects on our ecosystem, agriculture and livelihood of the farmers (Singh et al. in Gautam, Sharma and Kumar, 2014). The Himalayan mountains are also facing serious challenges posed by climate change. At present climate change is a big challenge for horticulture farming particularly for temperate fruits in the Himalayan Region. Among temperate crops apple is highly vulnerable for climate change because it is the most important temperate fruit grown in the temperate region of the country which lies in the Himalayan region and unfortunately this region is warming 5 to 6 times more than the global average (Liu and Chen 2000). Nepal's Department of Hydrology said average temperatures in the Himalayas had risen 0.06°C a year for the past 30 years. This is four times the world average (Butler, 2009). Study conducted by SASE (Snow and Avalanche Study Establishment), Chandigarh, revealed that in Indian Himalayan region average winter temperature increased by 0.6 to 1.3 degrees Celsius between 1975 and 2006.

In India apple cultivation is possible only in the Himalayan region but unfortunately due to rapidly increasing temperature and declining snowfall many areas has become unsuitable for apple farming in this part of the country. In this region apple cultivation is not only most remunerative as compared to field crops, but also labour-intensive and thus helps in absorbing ever-growing problems of unemployment.

Table 1 Statewise Area and Production of Apple (2013-14)

<table>
<thead>
<tr>
<th>State/UT</th>
<th>Area (000’HA)</th>
<th>Production (000’ MT)</th>
<th>% of Total Apple Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>160.9</td>
<td>1647.7</td>
<td>51.4</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>107.7</td>
<td>738.7</td>
<td>34.4</td>
</tr>
<tr>
<td>Uttrakhand</td>
<td>30.0</td>
<td>77.5</td>
<td>9.6</td>
</tr>
<tr>
<td>Arunachal Pradesh</td>
<td>14.3</td>
<td>31.9</td>
<td>4.5</td>
</tr>
<tr>
<td>Nagaland</td>
<td>0.2</td>
<td>2.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>313.1</td>
<td>2497.8</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: National Horticulture Board

After Mango, citrus and Banana apple is the fourth major fruit crop of the country. It occupies a total area of 313.1 thousand hectares with production of 2497.8 thousand metric tones (Table 1). It is mainly grown in the states of Jammu and Kashmir, Himachal Pradesh, Uttrakhand and Arunachal Pradesh. Jammu and Kashmir is the largest producer of apple (51.4 percent) followed by Himachal Pradesh (34.4 percent), Uttrakhand (9.6 percent), Arunachal Pradesh (4.5 percent) and Nagaland 0.1 percent (Table 1). Although Himachal Pradesh is the second largest producer of apple after J&K but it is known for the production of quality apples. The state has most suitable agro-climatic and geographical conditions for apple cultivation. Apple used to be the most popular fruit grown in the state and earlier emphasis was given to this fruit (Singh et al, 1990). Apple cultivation in Himachal Pradesh started in the 19th century. The credit of discovering the vast potentialities of growing apple fruits in the state goes to the American and European missionaries.

Table 2 Himachal Pradesh: Area, Production and Productivity of apples

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (Ha)</th>
<th>Production (MT)</th>
<th>Productivity (MT/HA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td>26735</td>
<td>103120</td>
<td>3.9</td>
</tr>
<tr>
<td>1980-81</td>
<td>43331</td>
<td>118013</td>
<td>2.7</td>
</tr>
<tr>
<td>1990-91</td>
<td>62828</td>
<td>342071</td>
<td>5.4</td>
</tr>
<tr>
<td>2000-01</td>
<td>92820</td>
<td>376736</td>
<td>4.1</td>
</tr>
<tr>
<td>2008-09</td>
<td>97209</td>
<td>510161</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Source: Directorate of Horticulture, Shimla, H.P.
The first apple orchard in the 19th century was established in Bundrole in Kullu tahsil of the same district by Capt. R.C. Lee. This fruit occupied only 10 percent (134 ha) of the total fruit area of the state in 1951, which was confined to a few pockets namely Mahasu, kullu, Mandi etc. from where it diffused to other parts of the state (Kaur, 2002).

After post independence period state has made considerable growth in apple production. It covered an area of 26735 hectare during 1970-71 which increased to 97209 hectare in 2008-09. The state has also experienced five time increase in apple production between 1970-71 to 2008-09 (Table 2). While in case of productivity Himachal Pradesh is not in better position, it has noticed an increase of only 1.3 metric tones per hectares during the period under reference. Kangra, Solan, Sirmaur and chamba have recorded decline in the productivity of apple during last three decades which is attributed to the changing climatic conditions of the area. Due to climate change production of apple in Himachal Pradesh in last two decades showed a declining trend. The global warming has caused loss of vigour, fruit bearing ability, reduction in size of fruits, less juice content, low colour, reduced shelf life and increasing attack of pests resulting low production and quality of apples (Hazarika, 2013). Rana et.al (2013) in their study stated that the changes in climate in the form of erratic precipitation, increase in temperature, lesser days serving as the chilling period have started affecting the mountain agricultural production systems.

2. Study Area

To understand the impact of climate change on apple at micro level Kotgarh village was selected to conduct field survey. Kotgarh is a village in Kumharsain tehsil of Shimla district in Himachal Pradesh. It is located between 31° 19' 0" North, 77° 29' 0" East. It is situated 82 km from Shimla on the old Hindustan-Tibet road. Located about 6,500 feet above sea level, it was famous for its apples and acres of apple orchards. Kotgarh is just 16 kilometers from National highway that heads into the valley through Kumarsain, Rampur and Kinnaur. It lies in the temperate climatic region of the state. Previously Kotgarh was known as Saibgarh due to the production of high quality apple.

But presently Kotgarh is experiencing decline in apple production. In past few decades the village has faced a strange phenomenon. Farmers in the Kotgarh have had to abandon apple farming due to certain climatic changes that eventually made it unsuitable to grow the apple crop. This change has consequently led to a continuous upward shift of the apple belt towards the north. This study takes the apple as an indicator crop to investigate the negative effect of climate change on spatial spread of
apple orchards and farm economy. It explores the impact it had on the apple economy of the hill farmers who were forced to abandon apple farming. Present study is an attempt to comprehend the impact of climate change on apple farming in the study area.

2. Material and methods

The study is based on primary as well as secondary data. The most important source of information for this study is farmers as they are the one who have been experiencing the strongest effects of climate change on apple. For this purpose, a structured questionnaire was prepared including questions on all relevant aspects of information necessary for this study. All farmers in the village were interviewed To know the changes in climate in the area and their impact on apple quality and productivity. Some questions related to changes in temperature and precipitation over the last 30 to 40 years were included in the climate change awareness baseline study. This is very important to know the farmers perception about climate change. These questions were asked specifically to those villagers above 40 years of age. The aim of this approach was to obtain a clear picture with respect to changes in these two key parameters of climate change.

Data related to area and production of apple in the country has been collected from the horticulture data base published by National Horticulture Board. To know the changes in area, production and productivity of apple in Himachal Pradesh unpublished data of directorate of Horticulture, H.P, Shimla has been used. To analyze the spatial-temporal changes of apple orchards in the state, data of unpublished revenue records of Directorate of Land Records, H.P. Shimla has been collected at tahsil level for two time periods i.e. 1974-84 and 2005-06.

To ascertain whether a warming in this region was actually taking place, it was first considered a priority to get data on temperature and precipitation for at least 30 years has been collected from the website of India water portal and analyzed. Unfortunately climatic data of exact location of the study area is not available so the data of Shimla district as a whole has been used to see the changes in temperature and precipitation. Primary data was analyzed using simple mathematical methods (percentage and averages) and part of its using statistical. Choropleth maps were prepared in GIS environment to know the spatial changes in area under apple in the state. Bar and line graphs have been prepared to analyze the climatic data.

3. Results and discussion

The data available on temperature in Himalayas indicate that warming during last 3-4 decades has been more than the global average of 0.75% over last century. Himalayas are getting warmer 5-6 times more than the global average .Temperature increases are more during winter and autumns than during summers, and they clearly increase with altitudinal rise (Liu and Chen 2000). Hence the high rised Himalayan mountains are more vulnerable to the climate change. In India apple is the most important commercial crop grown in the Himalayan region. But due to changing climatic conditions of this region apple farming has become an uphill task in many parts. Datta (2013) has also opined that because of climate change melting of ice cap in the Himalayan regions will reduce chilling effect required for the flowering of many of the horticultural crops like Apple, Saffron, Rhododendron, Orchid, etc. Horticultural plants specifically grown under open field conditions will be harshly affected. High temperature and moisture stress also increase sunburn and cracking in apples, apricot and cherries and increase in temperature at maturity will lead to fruit cracking and burning in litchi (Kumar and Kumar 2007). Panigragy et al. (2015) in their study also identified apple orchards as one of the most vulenerable crop to climate change in the Himalayan region. According to a report of State Council for Science Technology & Environment, Himachal Pradesh the air temperature in the state is one degree centigrade higher than in the year 1970. The average temperature of Shimla has increased by about 1°C during last 100 years. The average snowfall in the state decreased from 272.4 cm in the year 1976-80 to 77.20 cm in the year 2001-04. Basannagari and Kala (2013) in their study mentioned that the majority of farmers in Himachal Pradesh reported decrease in snowfall. According to horticulturists of the state, global warming has caused loss of vigour, fruit bearing ability, reduction in
size of fruit, less juice content, low colour, reduced shelf life and increasing attacks of pests resulting in the low production and poor quality crop.

Fig 1 Himachal Pradesh: Spatial Patterns of Apple (1974 to 1975)

Fig 2 Himachal Pradesh: Spatial Patterns of Apple (1974 to 1975)
3.1 Shifting apple belt of Himachal Pradesh

Apple is the major fruit crop of Himachal Pradesh. Since last five decades it has emerged as the formost cash crop in this hilly state. It can be witnessed by the fact that in Himachal Pradesh, the area under apple crop has increased from 3,025 hectares in 1960-61 to 1.04 lakh hectares in 2011-12 which is more than 48% of the total area under fruits. Likewise apple production has increased from 12,000 tonnes in 1960-61 to a record of 8.92 lakh tonnes in 2010-11. The apple industry contributes about Rs. 3600 crores annually to the state economy hence transforming the economic status of farmers (Thakur, 2015). Gautam et al. (2014) has also opined that in Himachal Pradesh apple is the major commercial crop occupied 1.05 lakh ha cultivated area, which obtained living for more than two lakh farmers. Since last three decades climatic conditions of many parts of Himachal Pradesh have been becoming unwelcoming for apple cultivation. Due to rising temperature and waning snowfall apple trees are not able to survive or becoming unproductive and apple belt of the state is shifting toward the higher riches. Rana et al. (2009) in their study stated that the majority of farmers in Kullu and Lahual & spitti are of the opinion that apple crop is shifting upward to higher elevation. As a result farmers of the affected areas are changing their cropping pattern and adopting other fruits and vegetables to sustain their farm income. It is evident from the figure1 & 2 that 9 tahsils, namely, Padhar, Sundernagar and Jogindernagar of Mandi district, Baijnaath tahsil in Kangra district, Bilaspur Sadar of Bilaspur district, Krishangarh, Solan and Kasauni tahsils of Solan district and Dadahu in the Sirmaur district have covered .1 to 40 percent of the total fruit area under apple during 1974-75 and in between 1974 to 2006 these tahsils have experienced decline in apple area, consequently in 2005-06 these tahsils covered 0 percent area under apple orchards.

Similarly three tahsils of Mandi district Aut, Mandi and Kotli were major apple producing areas of the state which occupied 40 to 90 percent of the total fruit area under apple cultivation in 1974-75 but after that these tahsils experienced sharp decline in apple area and at the end of the study period these tahsils almost negligible in apple production. Which is attributed to the rising temperature and declining snowfall in the areas since three decades. On the other hand Lahaul and Spiti and Kinnaur districts which lies in the Cold and Dry zone have noticed remarkable increase in area under apple between 1974-2006 which is attributed to the development in the infrastructural facilities and the climatic conditions which have become conducive for the cultivation of apples during the period under reference (Singh and Chand, 2011). It is clearly witnessed from the figure 1 & 2 that apple belt of Himachal Pradesh is shifting from High Hill Zone to Cold & Dry Zone. Gautam (2011) also stated that apple belt of Himachal Pradesh is shifting towards Kinnaur and Spiti areas which lies in the Cold & Dry Zone.

3.2 History of Apples in the Study Area

Kotgarh area of Shimla district of Himachal Pradesh has been taken for case study to understand the impact of climate change on apple cultivation. This place is the oldest node of diffusion of apple in Himachal Pradesh as well as in Jammu & Kashmir. Ones Kotgarh was known as the apple bowl of India and highest per capita income village of Asia because of its quality apple production. Saur quality of apples namely King pipen and Ras pipen were cultivated in the Kotgarh from very long time in history. These were the wild varieties of apple grown in the village before the introduction of delicious verities of apple by a Christian missionary Samuel Nicholas Stokes in early 20th century. He was an American Citizen came to India for spreading his religion in the country. During his visit to Kotgarh he found the climatic conditions of this area suitable for apple cultivation.

During 1920s, apple orchards were bearing fruit in the study area and the economy of the poor hill people started growing very fast. The first consignment of apple from Kotgarh marketed to Shimla in 1921. Majority of the people in Kotgarh started apple cultivation before 1940s and every land parcel which was suitable for cultivation was brought under apple orchards. According to the old farmers of the village during 1925-30 farmers of the village started the commercialization of apple plants; they developed their own nurseries and sold the plants to their neighboring villages and other parts of the state at the coast of 7 silver coins for one apple plant. So the farmers started earning money from fruit as well as from nursery which made them unbelievably rich. Satyanand Stokes opened a School named
Tara High School in 1940 at the name of his son. In this school students were taught about the cultivation of apples. Local people also get training in this school regarding the apple cultivation.

Decline of Apple Production and Factors affecting the apple economy

Between 1930 to 1980 there was boom in apple production in the study area but after 1980s Kotgarh started witnessing the wind of change. According to a respondent, in 1970-71 there was 6 feet snow in the area many trees were broken due to huge snow fall. After 1970s the decline in snowfall started but it was enough for the chilling of apples. In 1980-81 this area received more than 2 feet snowfall. But after 1980s amount of snowfall has started declining at very fast rate. Due to decline in snowfall the downfall of apple production also started.

Fig 4 Comparison of Apple Yield during Boom and Decline Period

As per the revenue record of village, 100 percent of the agricultural land is covered by apple orchards and dominated by small and marginal farmers. After analyzing the primary data it is observed that 100 percent of the sampled farmers experienced decrease in the productivity and area under apple orchards. They observed a 2/3 reduction in total apple productivity as compared to the boom period (Figure 1). According to a respondent during the boom period they get 40 to 50 boxes from a big apple tree but now it has reduced to 8 to 9 boxes. Small and marginal farmers are the most vulnerable to this change. They have small land holdings and small sized farm and not able to sustain their apple economy. Large farmers of the area have the capacity to handle this situation. They have enough money to buy an orchard in other parts where the climate is hospitable for the cultivation of apple. More than 40 percent of the large farmers of the study area have bought orchards in near by areas where climate is suitable for apple cultivation. While the small and marginal farmers still trying to resume their apple orchards and some of them have shifted partially towards vegetables and other fruits.

Table 3 Farmer’s observation of climate change impact on apple farming

(Percentage of Response)

| Farmers observation of climate change (increase in temperature, low and erratic rainfall, occurrence of bad weather conditions and decrease in snowfall) | 100% |
| Impact on fruit quality (size, weight, colour etc.) | 100% |
| • Small size, low weight, poor colour development |  |

Source: Field work

There is lot of change in household income contributed by apple before and after the phase out period. Apple contributed 100 percent to the house hold income for 30 percent of the farmers and around 90 percent of another 50 percent. For remaining 20 percent of the farmers apple contributed an average of 40 percent to their total income. The fact that 80 percent of the families were almost entirely dependent on apple before the phase out period.

After the phase out period proportion of apple in household economy declined drastically and 100 percent families are earning less than 40 percent of the total house hold income. More than 70 percent of the farmers are still trying to rejuvenate their apple orchards with new variety of apple but the maintenance cost for these orchards is very high and marginal and small farmers are struggling to
rejuvenate their orchards. Less than 20 percent of the small and marginal farmers are partially shifted towards the cultivation of vegetables and other fruits.

Apple require a chilling period of 90 days and least 4-5 inch of snow and moderate amount of rainfall during monsoon season to provide enough water for trees to grow. Otherwise the crop results are not satisfying and the colour of the apple is especially affected (Pratap, 2007). All farmers observed change in the climatic conditions in the area in the form of increase in temperature, low and erratic rainfall, occurrence of bad weather conditions and decrease in snowfall. This change also affected the size weight and colour of the fruit. Size and weight of fruits have been reduced and the colour development is also very poor. According to the respondents winter season became shorter and slightly warmer not fulfilling the chilling requirement of the apple. Snowfall has reduced during the winter season. It has reduced from 4-5 feet to 2-3 inch during previous four decades and summer season has also lengthened.

It is evident from the figures 2 and 3 that mean minimum temperature of the area during winters has increased to 1°C between 1970 to 2002. There is slight increase in mean maximum temperature during winters. While the figures 4 and 5 depicted the decline in precipitation during the winters and summer season. These all climatic factors impacted the size, shape, weight and colour of the apple in Kotgarh. Large apples with a symmetrical shape and full colour fetch a greater value in market. However the farmers of Kotgarh harvested were small apples, without the right shape and poor colour with little shine. Due to these reasons farmers are unable to profitably market their produce.

With climate change farmers faced increasing challenges as the climate became hospitable for new pests, diseases causing various problems such as root rot, buliya fid, canker, borer and drying trees. These all diseases affected the apple crops very harshly. To save their crops from these diseases...
100 percent of the respondent farmers started the use of fertilizers, pesticides and insecticides after 1980s. The use of these things increased the cost of production lowering the profit. Before the use of these substance farmers of the study area were spray of a liquid solution of diesel, sunlight soap, nilaththa and crude oil on their apple trees to protect from various diseases. But now it was difficult to control these diseases with this liquid solution and farmers had no other option to adopt these chemical fertilizers. For short time period these substance were useful, nourishing the crop, maintaining the quality and controlling the responsible pests and diseases. But in long run fertilizers degrade the fertility of soils. Responded farmers think that climate change is the major factor affecting the apple orchards in the area. But there are some other factors which are also responsible for the degradation of apple productivity. Many orchards have grown enough old to bear the fruits. But the main problem is that the new trees are also not able to survive in such climatic conditions. Farmers feel that migration of the educated people of the area to urban areas like Shimla, Chandigarh, Delhi etc. for the purpose of job is also responsible for decline in apple production. As the first school was opened in Kotgarh in 1873 and the education started here very early period as compare to other parts of the state. Because of increase in literacy level and control over birthrate families became nuclear, as a result manpower to maintain the orchards reduced. Educated generation refused to work in their orchards and they migrated towards the urban areas and gave the responsibility of maintaining their orchards to Nepali migrated labour. To maintain an apple orchard there is the need of skilled labour for spraying, pruning and other activities, but these migrated laborers were not skilled due to which faulty maintenance of orchards started in the study area which also contributed to degradation of apple.

Conclusion:

One time Kotgarh was known for best quality apple in the country but now apple have become uneconomical, nonviable, less profitable and even unproductive in such a short period. Over the years, fruit growers in the study area have observed significant variations in climate. This awareness of climate change is based mainly on the associated impacts on the apple crop especially on blossoming, fruit setting, yield and increased incidences of pests and diseases. Over all the climate is described as being much warmer and people perceive a definite reduction in snowfall over time. Not only has the actual amount of snowfall decreased but changes in timing of snowfall have also been noticed. Snowfall in December and January has become rare and the period of snowfall now extends through the months of February-March. As a result to maintain an apple orchard has been become an uphill task. New trees simply don’t survive and older ones are dying fast and the farmers are switching over to other fruits and vegetables. But large number of farmers is still trying to resume their apple orchards. But now it is clear that it is very difficult to resume apple economy in the area as the new trees are not able to survive in prevailing climatic conditions of the area. Farmers have noticed 2/3 decrease in apple productivity after the phase out period. Small and marginal farmers are most affected due to this change as they are not able to maintain their orchards due to high coast of maintenance. Rising temperature is the major factor for the degradation of apple productivity while other factors like lack of skilled labour, use of chemical fertilizers, old trees, and migration of the educated young generation are also partially responsible for this decline in productivity.

References:


