Impacts of Climate Change on Horticulture Crops in Uttarakhand: A Case Study of Apple Production from Nainital District

1. INTRODUCTION

1.1. Introduction

In 1992, United Nation Framework Convention on Climate Change (UNFCCC) stated that Climate change is a change in climate that is attributed by direct or indirect anthropogenic activities which modifies the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. Increase in greenhouse gases (GHGs) in the ambient air due to anthropogenic activities is responsible for changing climatic conditions. Climate change is one of the global challenges being faced by the world's population. The Intergovernmental Panel on Climate Change (IPCC) has estimated that the global mean surface temperature has risen up to 0·6 ±0·2°C since 1861, and predicts an increase of 2 to 4°C over the next 100 years. Implications of the changing climatic conditions would be felt differently by different regions ranging from glacier melt to sea level rise. The mountain ecosystems of the world cover 25 % of the world's land surface and provides habitat to 26 % of the global population (Beniston Martin, 2003). These vital sources of water, energy, mineral, forest, and agricultural products and are known as the storehouse of biodiversity (Singh et al., 2010).Himalayas are one of the most important mountain ecosystems in the world and are more vulnerable to climate change. As per IPCC (Intergovernmental Panel on Climate Change) - TAR5 (Third Assessment Report) the Himalayas are warming faster than the global average rate. The Himalayan mountain system cover an area of approximately 530,000 square or 16% of the geographical area of India (Singh & Chaturvedi,

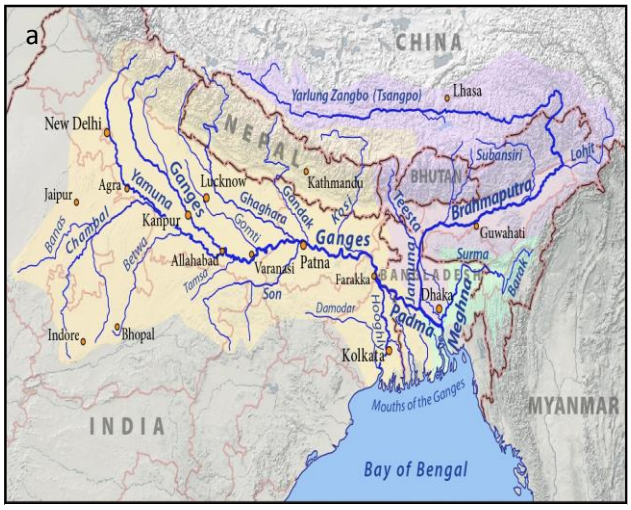

Fig.1 River System in Himalaya (Source: Google)

2011) .They are also a source of the 10 major rivers of Asia hence also referred as "Water tower of Asia" (Jianchu Xu et al., 2009).

The development of the monsoon rainfall pattern of the whole of Asia is caused by these mountains (Singh et al., 2015). For the Himalayan region the annual temperature has been forecast to increase from 0.9°C ± 0.6°C to 0.6°C ± 0.7°C in the 2030s. The net increase in temperature ranges from 1.7°C to 2.2°C with respect to the 1970s. The annual rainfall in the Himalayan region may vary between 1268 ± 225.2 mm and 1604 ± 175.2 mm. The precipitation that has been forecast shows a net increase in the 2030s with respect to the simulated rainfall of the 1970s in the Himalayan region by 60 to 206 mm. The increase in the annual rainfall in the 2030s with respect to that of the 1970s ranges from 5% to 13%[1]. Changes in weather patterns in Himalaya have serious implications not only for the Himalayas but also for adjoining regions and the world at large. The Himalayas are the makers of the climate of South and South-East Asia. The Himalayan glaciers are the source of some of the major river systems of the world, vital to food security and well being of a multitude of people both in the Himalayan region itself and those living downstream . The area under permanent and seasonal snow cover (17 and 30-40% respectively) forms an extensive water reservoir releasing 1,200,000 million m^3 yr^{-1}(meter cube per year) sustaining approximately 500 million people in the adjacent Gangetic plain (Baker & Moseley, 2007). Himalayas are also referred to as "Third Pole" or the "Water Towers of Asia". One of the most important impact of changing climate will be on forest ecosystems. Changes in phenology (periodic biological phenomena that are correlated with climatic conditions in plants or animals), upward march of species, shifting of tree line and spread of invasive species are some of the other observed impacts of climate change in the Indian Himalayan region. The importance of the Himalayas and the rapid rate of climate change being experienced in the region notwithstanding, very little is known about the nature of climate change in the Himalayas and its quantum. This is for various reasons. The aggregate

"It used to snow 2-3 feet earlier, now we wonder what snow is"

Sh. Bacchii Singh Bisht
69 yrs., Supi

models used for predicting climate change scenarios are unable to handle the diversity and complexity of the Himalayas. There are very few baseline studies to compare change with. Another important sector of concern is agriculture. Agriculture is the backbone of the Indian economy and offers food and livelihood security and support .However the contribution of agriculture in GDP (Gross Domestic Product) has declined over years to 14% in 2011 but it still a main source of livelihood of more than 50% of the population. In India the average size of the operational land holding declined to 1.16 ha in 2010-11 from 1.23 ha in 2005-06(Agriculture census data, 2012).Several factors such as increased competition for land, water and increasing climatic unpredictability are the major challenges that Indian agriculture is facing (Thadani et al., 2015).It has also been estimated that there is a possibility of 10–40% loss in crop production in India by 2080–2100 due to increase in temperature (Boomiraj et al., 2010).Uttarakhand a mountainous state of India is one of the most vulnerable states in view of climate change (UAPCC, 2015). Majority of the population depends on agriculture, is broadly defined to cover all land based activities such as cropping, animal husbandry, horticulture, forestry etc. for their sustainable livelihoods. Agriculture is intensely linked with weather and climate, the selection and production of crop is determined by the temperature and rainfall as most of the field in mountainous region is rain fed (Thadani et al., 2015).Total geographical area of Uttarakhand is 53.48 lakh ha, out of which 7.66 lakh ha is under agricultural land, of which 3.00 lakh ha is under horticulture (Department of Horticulture and Food Processing Uttarakhand, 2016). The net irrigated area of the state is 3.47 lakh ha (1999-2000) which is mostly confined to the plains (UAPCC, 2014).Agriculture's contribution to the state's GDP is about 11% and third fourth of the population depend on agriculture for their livelihood. The most important distinctive feature of agriculture in Uttarakhand is small size of average land holding of 0.95 ha which is against the national average of 1.57 ha. (CEDAR, 2015). Agro-horticultural practices are prevalent in Uttarakhand. Varieties of fruit yielding crops of economic importance are grown in the state such as apple, pear, peach, palm, apricot and cherry in abundant quantities. This sector has been of huge potential in improving rural livelihoods in the state. However, the changing climatic conditions have severely affected the sector by impacting the yield and quality of crops i.e. apple, pear, peach, plum, cherry, almonds, apricot and walnut. Winter chilling is essential for the growth of most of these temperate fruit crops. , warmer climate is affecting chilling requirements of these crops. Insufficient chilling greatly influences the flower initia-

tion and fruit colouration along with deterioration in fruit texture and taste (Rai et al, 2015).Additionally, the lack of proper winter chilling also causing serious problems like scab disease, premature leaf fall and infestation of red spider mite in apple (Rai et al, 2015). Apple is the most important commercial crop of the Himalayan region wherein India ranks 7thin the world with an average yield of about 7.24 t per ha (Basannagari & Kala, 2013). Jammu & Kashmir, Himachal Pradesh and Uttarakhand are the major apple producing states of India. Reports suggest that in the last three decades, apple crop is getting affected in all these mountainous states. Consequences of these climate changes are visible clearly in the shifting of apple cultivation from lower elevations to higher altitudes in Himachal Pradesh (Kuniyal & Hemlata, 2014).Under the current study I have focused on the state of Uttarakhand. Erratic weather conditions like irregular rainfall, low snowfall and temperature fluctuations are affecting the production of apple. There are a limited studies about the impact of climate change on apple cultivation in the state, whatever exists is related to Himachal Pradesh. The present study aims to understand the impact of climate change on apple production in Nainital District of Uttarakhand.

1.2 Rationale of the study

Horticulture is the main source of livelihood for farmers in Uttarakhand. Farmers are growing varieties of fruit and apple is one of the most important commercial fruit crops in the state. Studies that have been done in Himachal Pradesh on impacts of climate change on apple cultivation suggested that in last three decades the apple farming is getting affected and the production of apple has been declined in lower elevation and apple orchards are shifting towards higher elevation(Kuniyal & Hemlata., 2014). The data or studies regarding impact of climate change on fruit crops are very less in Uttarakhand. Therefore, it is important to consider the potential of impacts of climate change on apple farming that communities are facing in Nainital district.

1.3. Objectives

1. To Assess the Impact of Climate Change on horticultural crops in Western Himalayas.

Out of the total cultivated land of 7.66 lakh ha in Uttarakhand the area under horticulture crops is 3.00 lakh ha. Horticulture is primary occupation for most of the farmers along with agriculture. Studies suggest that changing climatic conditions in Himalayan region is affecting the production of many temperate fruit crops. There is paucity of data on impact of climate change on horticultural crop Himalayan regions. This study would help in assessing the impact of climate change on horticultural crops mainly apple.

2. To Understand Underlying Reasons behind Decline in Apple Cultivation in the study area.

Studies from Himalayan region suggest that the production of apple is declining. Each crop has a climatic conditions to grow. Apple requires 1000-1500 hours of chilling, chilling hours depends on the type of cultivar. There is a need to understand the specific climatic factors that are responsible for the declining rate and poor quality of apple production. This study would help in understanding the causes of decline in production of apple.

3. To Assess the Potential of other Horticultural Crops under Changing Climatic Conditions.

Under changing climatic conditions certain species will take advantage or would be pre ferred over other. This study would investigate which fruit crops are becoming more favourable and for what reason. Horticulture is a climate sensitive sector largely practiced by rural communities. Changing climatic conditions is likely to have severe impact on these communities. This study would help in understanding what coping mechanisms exist for the people and what government or community level efforts have been made so far

4. To Understand the Adaptation Strategies Adopted by the Communities in view of Horticulture

Horticulture is a climate sensitive sector largely practiced by rural communities. Changing climatic conditions is likely to have severe impact on these communities. This study would help in understanding what coping mechanisms exist for the people and what government or community level efforts have been made so far.

1.4 Hypothesis

The state of art information suggests that there is a gradual decline in production and quantity of apple in the Western Himalayan region due to climate change. I hypothesise that decline in apple production would lead to cultivation of more climate resilient species of fruits to manage the village economy.

2. Literature Review

Previously very few studies have documented impact of climate change on apple production from Uttarakhand. Recent and rapid changes in Climate systems are becoming vital issues of social, economic, political, and scientific discussion. Climatic changes are already affecting ecological and human systems, such that they are now seen as the most important environmental threat to social ecological systems. The effects are greatest in highly Climate sensitive environments like the Himalayas. **Vitousek, P.M, 1994 in** his paper "Beyond Global Warming: Ecology and Global Change" summarize three components of global environmental change, their adjacent causes have been identified clearly and all have direct casual connections to global climate change and /or the loss of biological diversity. The three components that have been selected for this study are (1) Increasing concentration of carbon dioxide (2) Alteration of the global nitrogen cycle (3) Change in land cover and / or land used. The paper describes the consequences of these changes and how they derive global changes in climate and biological diversity. And also briefly discuss the proximate and ultimate causes of change and finally suggests several steps that can be taken to influence the way of global climate change. **Adger et.al, 2003** in his paper "Adaptation to Climate Change in the Developing World" documented that the world's climate is changing and will continue to change into the coming century and the risks associated with these changes are highly uncertain and may intensify ongoing social and economic challenges, particularly those part of societies that dependent on resources. Risks are apparent in agriculture, fisheries and many other components that constitute the livelihood of rural population in developing countries. This paper explores the nature of risk and vulnerability in the context of climate change and review the evidences on present day adaptation in developing countries and on coordinated international action on future adaptation.

XU et al., 2009 in his paper "The Melting Himalayas: Cascading Effects of Climate Change on Water, Biodiversity and Livelihoods" studied that rapid reduction in the volume of Himalayan glaciers due to climate change is taking place. Himalayas hold the largest mass of ice outside the Polar Regions and are the source of major rivers in Asia. The cascading effects of rising temperature and loss of ice and snow in the region are affecting water amounts & seasonality, biodiversity and also results in loss of carbon and shifts in tree line and monsoon pattern. To identify the mitigation and adaptation strategies, a common understanding of climate change needs to be developed through regional and local scale research. **Singh et al., 2010** draws the attention towards impact of warming on Himalayas and ecosystems in both upstream and downstream regions and proposes that Himalayas are warming at more than the global average rate. Alpine ecosystems are particularly vulnerable to warming because species on mountains top have no space to move. Leaf phenology and the regeneration of dominant forest species can adversely affect due to rise in water stress because of warmer temperature and suggests that carbon forestry and manure management by local communities could be seen as both mitigation and adaptation strategies.

Munismay et al., 2012 studied the impact of climate change on rain fed agriculture in Dharwad and this study reveals that climatic variations such as drought have significant impact on production of rain fed crops. The small and medium rain fed farmers are highly vulnerable to climate change and they are the ones who adopted coping mechanisms for climate change as compared to large farmers. Farmers are adopted both positive such as technological coping mechanism as well as negative through shifting to other profession. The study also suggests that as the impact of climate change is increasing day by day it should be addressed by policy viewpoint at the earliest to avoid the short term and long term effects such as yield and income loss and quitting agriculture profession by the rain fed farmers etc.

S. Datta., 2013 documented that commercial horticultural crops will perform poorly due to climate change. Melting of ice caps in the Himalayan region will reduce chilling effect required for the flowering of many horticultural crops like apple, saffron, rhododendron, orchid etc. and high temperature will lead more prominent physiological disorders in the horticultural crops. Conservation of natural resources (forest, water, land etc.) and development of new cultivars that are tolerant to high temperature, resist to pest and disease, producing good yield under stress condition and wise management of land use resources are some solutions that will

minimise the effect of climate change. **T.K. Hazarika,2013** in his paper "Climate Change and Indian Horticulture: Opportunities, Challenges and Mitigation Strategies" documented that climate change has arisen as a serious global environmental issue and results in increased temperature, more demand of water and increase in abiotic and biotic stress, has direct impact on agriculture and horticulture. Due to changing climate low production of horticultural crop is bring out such as production of apple production in Himachal Pradesh showed a decreasing trend and same with other fruit crops. Global warming has caused reduction in size, less juice content, low colour and increasing attack of pests resulting in low production and quality of apples. Appropriate strategies such as development of new cultivars tolerant to high temperature and producing good yield under stress conditions have to be developed by horticulturalist for saving horticulture crops.

S K Malhotra.,(2016) documented that horticultural crops have a much bigger role to play in answering the negative consequences of climate change by providing a better carbon trade and carbon sink. One of the most threatening physiological responses that increase in response to climate change is the shortened growing period, causing characteristic reduction in production of fruits and vegetables. These responses will leave negative impact on growth and development of horticultural crops due to incurable heat stress and poor soil water availability. Interventions seeking climate-smart horticulture are, therefore, felt an unnecessary need integrating location-specific and knowledge-intensive basis for improving production under such challenging environment. Crop-based adaptation strategies are needed keeping in view the nature of crop, its sensitivity level and the agro-ecological region. Simultaneously, keeping an eye on carbon sink potential of different horticultural crops regarding annual field crops will further help in developing a blue print for redressal of climate change related issues.

Pippal et al., (2016) in his paper Impact on Horticulture in India due to Climate Change documented that Global warming and climate change is the chief concern of mankind in this century. The traditional commercial varieties of fruits, vegetables and flowers will perform poorly in an unpredictable manner due to irregularity of climate. Commercial production of horticultural plants particularly grown under open field conditions will be severely affected. Due to high temperature, physiological disorder of horticultural crops will be more evident e.g. spongy tissue of mango, fruit cracking of litchi, flower and fruit abscission in vegetables, etc. Hence there is a need to protect these valuable crops for sustainability against the climate change sce-

nario. The most effective way is to adopt conservation agriculture, using renewable energy, forest and water conservation, reforestation etc. To sustain the productivity, modification of present horticultural practices and greater use of greenhouse technology are some of the solutions to minimize the effect of climate change. Development of new cultivars of horticultural crops tolerant to high temperature, resistant to pests and diseases, short duration and producing good yield under stress conditions, as well as adoption of hi–tech horticulture and judicious management of natural resources will be the main strategies to meet this challenge.

Rai et al., (2015) in his paper "Implications of Changing Climate on Productivity of Temperate Fruit Crops with Special Reference to Apple" documented that winter chill is essential for most of the plants that undergoes dormancy in the winter and climate change is likely to affect chilling requirement of temperate fruit crops significantly, hence the opportunity to meet this requirement will be reduced as the climate becomes warmer. The resultant of these climate changes are clearly apparent in the shifting of apple cultivation from lower elevations to higher elevations in India. This paper also reveals that there is paucity of data on impact of climate change on temperate fruit crops. **Basannagari & Kala., 2013** studied the perception of farmers on the effects of climate change on apple farming along the altitudinal gradient in an Indian Himalayan State, Himachal Pradesh and documented that apple cultivation shifts from low hills to middle and high hills due to increase in temperature. Apart from temperature hailstorms, decrease in snowfall and pest attack also attributed to decline in apple at low hills. The change in land use practices was attributed to climate change and in many areas the land under apple farming was replaced for production of coarse grains, seasonal vegetables and other horticulture species such as peach. According to an article published in **"Tribune News Service", December 21, Jotirmay Thapliyal** stated that climate change such as less snowfall and temperature fluctuations are affecting apple production in Uttarakhand, leading to financial insecurity among the growers. Farmers at higher elevation are shifting to other fruits such as peach and plum that requires lesser cold conditions. In the apple famous Ramgarh belt of Nainital district, the crop has been successfully replaced by peach, which is fetching good prices in the markets of Delhi and Mumbai. Development of small weather stations, suitable varieties and climate resilient technologies for horticulture are some solutions to mitigate the impact of climate change so that Uttarakhand can contribute a lot more by adopting these strategies. An article **"Climate Change Impacts Apple Cultivation"** published in **"The Hindu",** on 25 April,

2015 documented that farmers of the states like Himachal Pradesh and Uttarakhand are cultivating early maturing and low chilling varieties due to less snow and precipitation in lower elevation regions and cultivation of traditional varieties are slowly shifting to higher reaches. Dr. Nazeer Ahmad, director of Central Institute of Temperate Horticulture(CITH),Srinagar stated that these new varieties which matures early and has low chilling hours requirement can help us to mitigate the impact of climate change on apple.

3. Materials and Methods

3.1. Study site

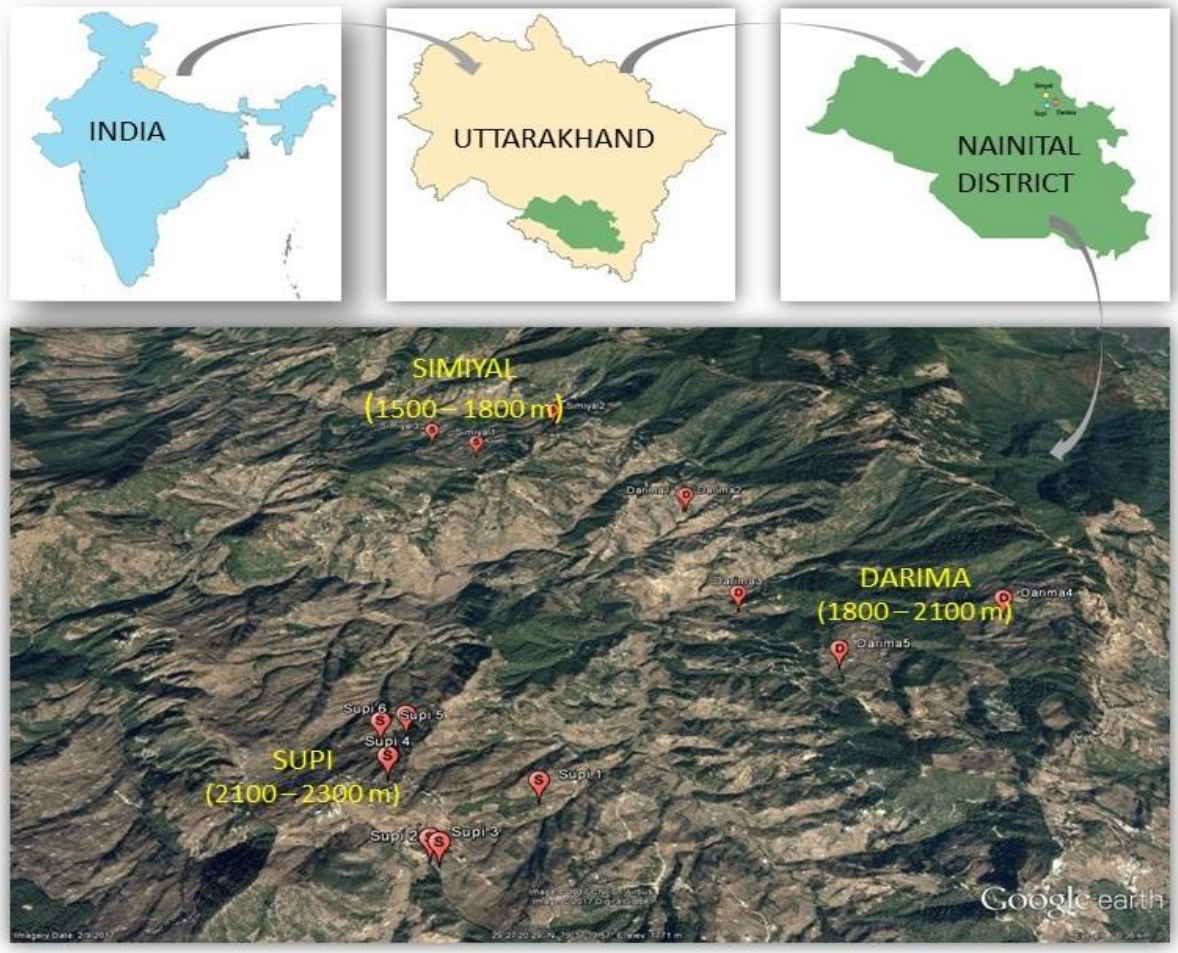

Fig.2 Location Map of Study Site

Source: Google earth

The present study was conducted in Nainital district of Uttarakhand, which is located in the Northern India. Ramgarh-Mukteshwar belt of Nainital district is famous for its Apple orchards. Ramgarh block is one of the 9 blocks in Nainital district, and is geographically located at 29.45°N 79.55°E. The block is divided into two parts- Talla (lower part) and the Malla (Upper part). It has an average elevation of 1,518 metre and altitude ranges from 1,400 metres in the Talla (Lower) Ramgarh valley to 1,900 metres in Malla (Upper) Ramgarh. The block is also known as "Fruit Bowl of Kumaon" owing to its luxuriant orchards of peach, apricots, pears & apples. Following are the three villages of Ramgarh block, Nainital District that have been undertaken for the study along the altitudinal gradient:

S.no	Name of the village	Elevation (m)	Total Population	No of household
1	Simyal	1500-1800	568	127
2	Darima	1800-2100	3158	485
3	Supi	2100-2300	3411	637

Table 1: Some Characteristics of Sample Village

3.2. Materials

Software: Arc Gis , Ms Office tools (Excel, Word and Power Point) used for representing my dissertation.

Instrument: GPS was used to record the elevational point for the formation of location map of the study site

3.3 Research Methodology

The study is based on primary as well as secondary data. The sampling technique that I have used for this study is simple random sampling - is a subset of individuals chosen from the larger set (Population) and is the best sampling method for research. It is easy to use and each individual of the population has the same probability to be chosen. The most important source of information for this study are farmers as they are the ones who have been experiencing the

strongest effects of climate change on apple. Below is the detailed explanation of the methodology which is tremendously important and necessary.

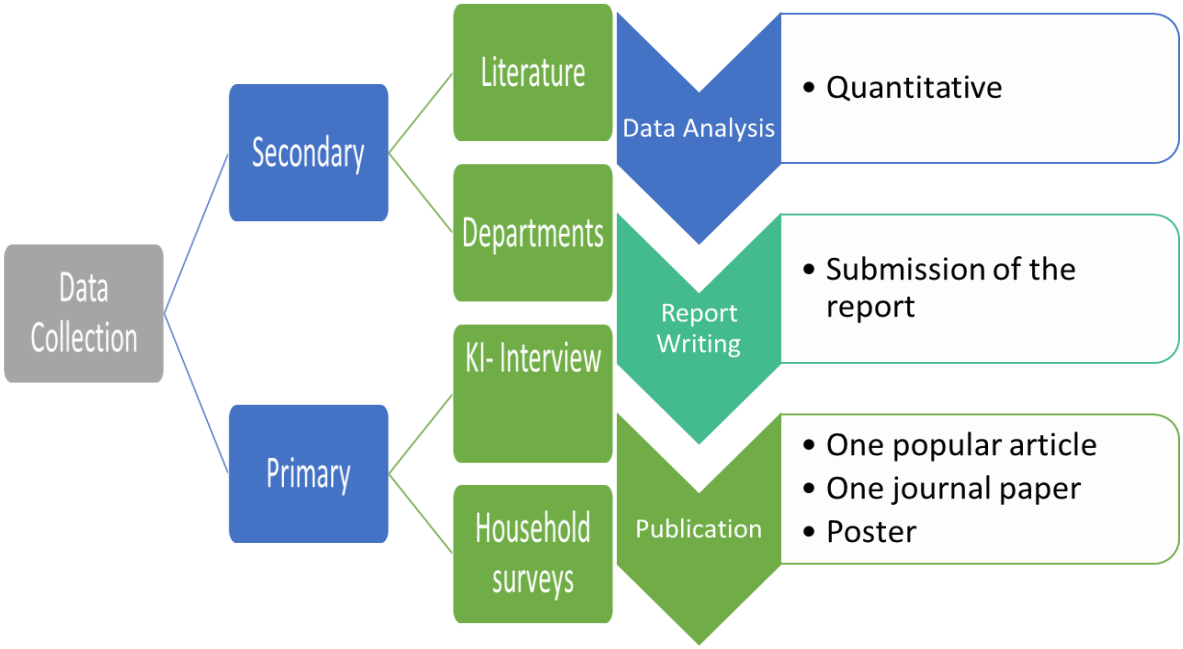

Fig.3 Schematic representation of work

3.3.1. Field Surveys

During my preliminary field visit I have collected basic information of the area and the current situation and views regarding horticulture crops by farmers in Ramgarh block

Fig.4 Household Survey in different villages

Primary data has been obtained with the help of semi-structured questionnaire survey. A total of 45 household have been surveyed, 15 from each village along the altitudinal gradient such as Simyal (1500-1800m),Darima(1800-2100m) and Supi (2100-2300m) in Nainital district as well as key informant interview was conducted and information was collected on different parameters and perception of farmers based on the effect of changing climate on apple farming.

3.3.2. Secondary data collection

Secondary data was collected from different published journals on the parameters related to the study. Different departments such as State Horticulture Board, State forest department, Watershed development department, local horticulture department and NGO were approached for collection of present and past information related to apple farming in the state of Uttarakhand.

Fig. 5 Different departments approached

3.3.3. Expert Opinion

Due to the lack of literature on the proposed study, opinions and advice has been taken from the expert of different fields to get more reliable data to support the findings of the study.

S. No.	Name	Designation
1	Prof. S.P. Singh	Renowned Ecologist
2	Dr. Ashish Tiwari	Plant Physiologist
3	Dr. Subrat Sharma	Climate Change
4	Dr. Narayan Singh	Horticulturist

Table 2. Name and Designation of the experts

3.3.4. SWOT ANALYSIS

On the basis of both the primary and secondary information SWOT analysis has been done. It is a structured planning tool to evaluate the strengths, weaknesses, opportunities and threats involved in a project or in a sector. SWOT analysis is very useful tool for community vision and development (Singh, 2010). In this project this analysis has been done to analyse the internal (Strengths & Weaknesses) and external (Opportunities & Threats) factors to conclude that, what are the opportunities to increase the area and production under apple cultivation.

Fig.6 Pictures of apple from field

4. Results and Discussions

Of the total people surveyed majority of the farmers admitted horticulture as a primary occupation. Most of the area under horticulture in Uttarakhand is occupied by fruit crops, but in last 15 years it has been declined. In 2001-02 the total area under fruits was 190100 ha which has been declined to 175329.9 ha in 2015-16(Fig.7).

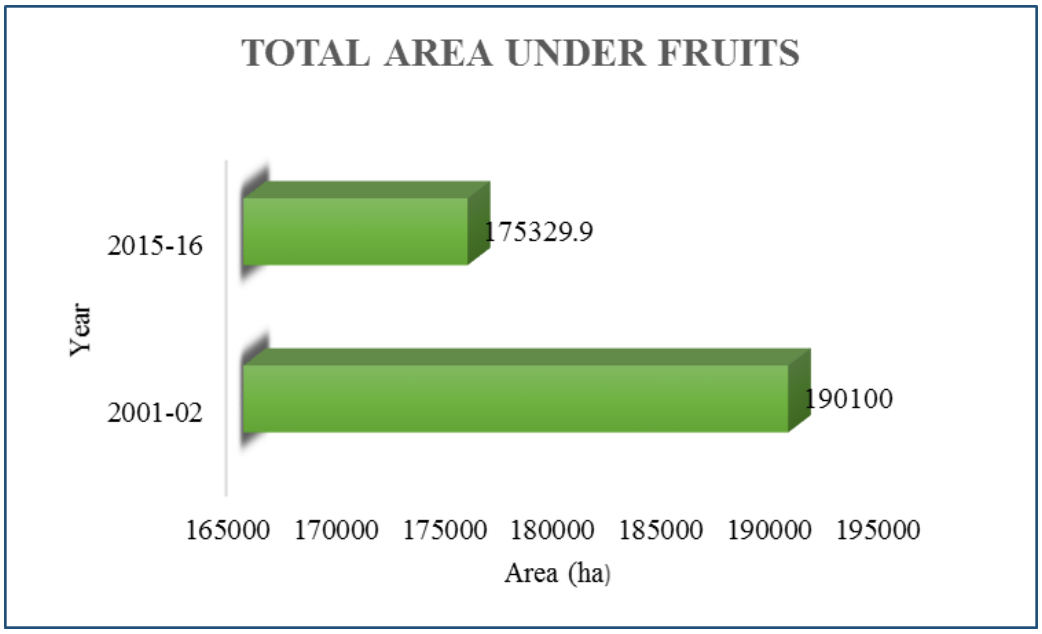

Fig 7. Change in total area under fruits in last 15 years
Source: Uttarakhand Development Report & Horticulture Department of Uttarakhand

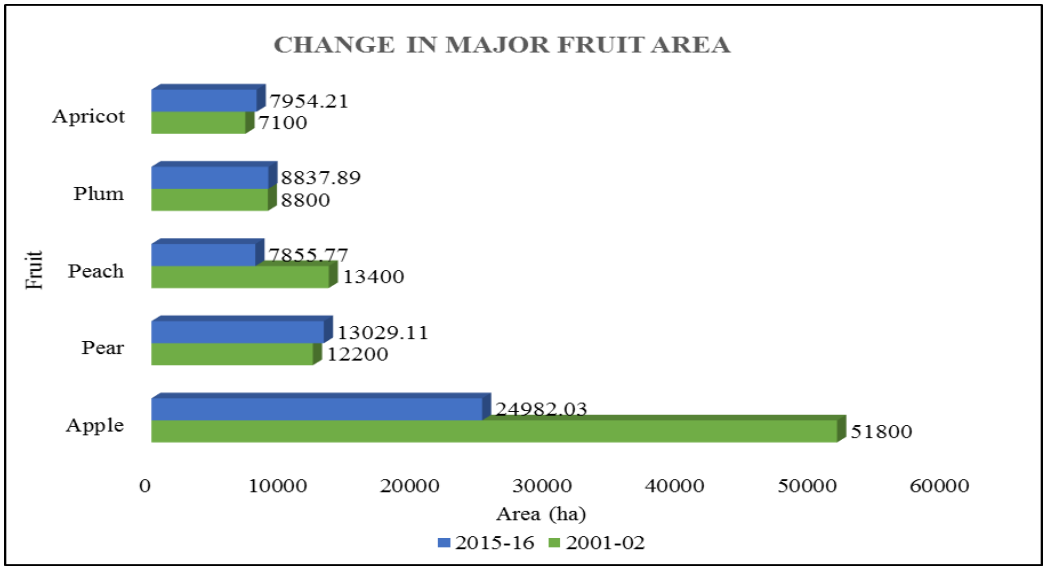

Fig.8 Change in area under major fruits in Uttarakhand

Source: Uttarakhand Development Report & Horticulture Department of Uttarakhand, Dehradun

According to data obtained from horticulture department and Uttarakhand development commission the area under apple and peach cultivation have been declined whereas the area under apricot and pear has increased and plum is showing no change in area (Fig.8).

The graph is showing annual rainfall trend from 1970 to 2016 in the Nainital district (Fig 9). As we can see from this graph there is fluctuations in precipitation pattern in last 30 yrs. From 2009 rainfall started increasing and in 2016 there is decline in rainfall.

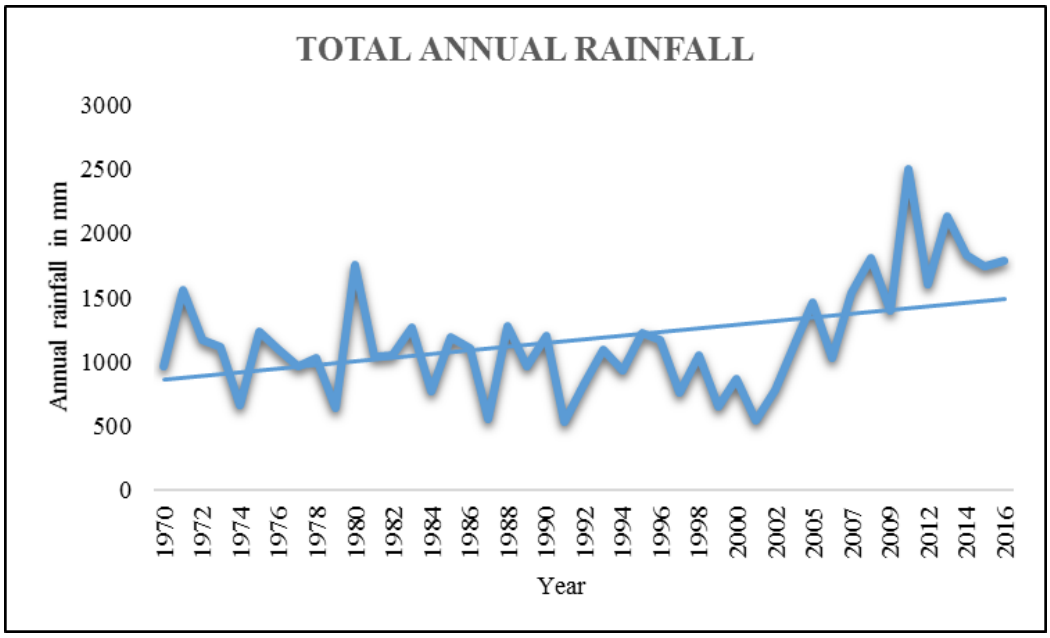

Fig 9. Annual rainfall in the Nainital District (1970- 2016)

Source: Indian water portal & Indian Meteorological Department

Fig 9 is showing annual average temperature in the Nainital District. The temperature has been increased in past years. From the graph we can conclude that in 1999 the temperature has reached to its peak and this is the time from when apple has started declining and farmers started peach cultivation at large scale. Apple requires cold condition for its growth and needs temperature below 7 degree Celsius. But due to increasing temperature apple is not getting sufficient chilling hours which is necessary to go under dormancy.

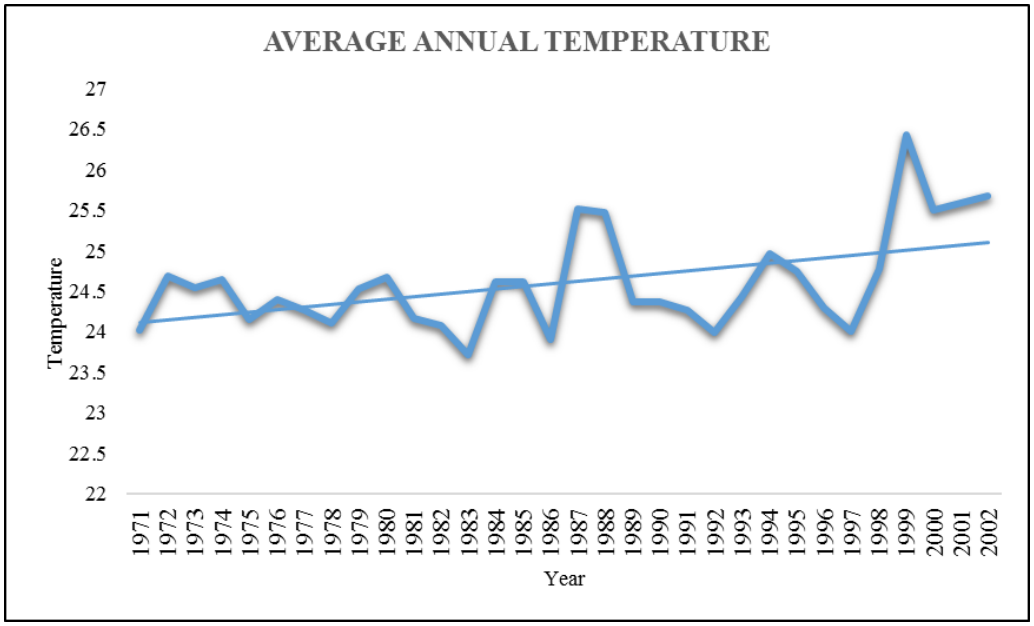

Fig 10. Annual average temperature trend in Nainital district (1971-2002)

Source: Indian water portal

The graph (Fig 11) is showing overall perception of the 45 respondents. 36 out of 45 farmers reported less and erratic rainfall is major reason for decline in apple cultivation followed by increase in temperature (29) and decline in snowfall (24). Very few perceived hailstorms (7) and frost (only 6) as the reason for decline in apple cultivation.18 farmers out of 45 reported increase in pest and disease is also one of the reason for decline in area under apple orchards.

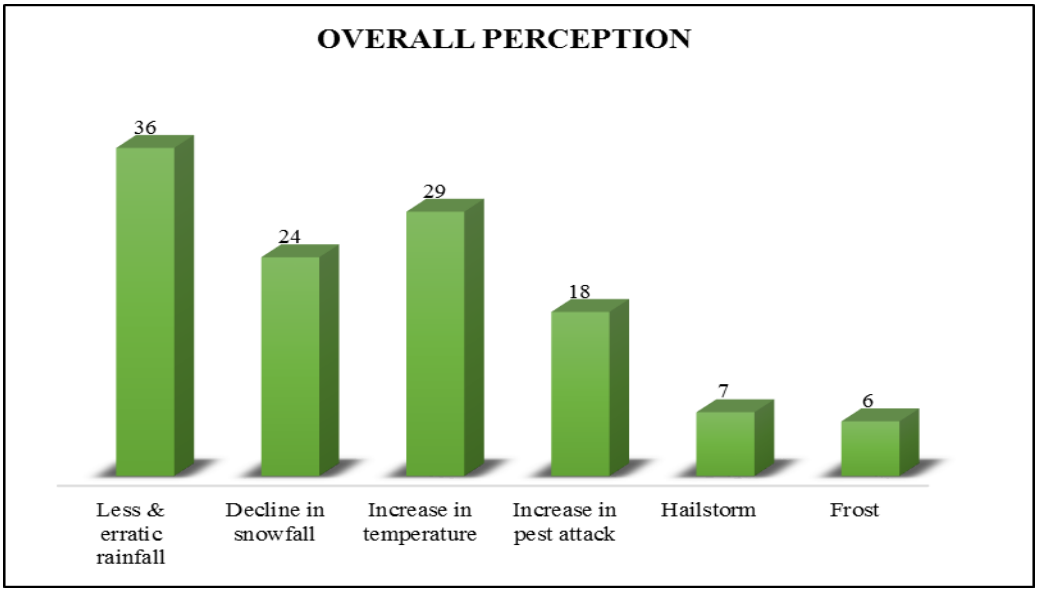

Fig.11 Overall perception of the farmers on factors attributed to decline in apple

The farmers reported many indicators of climate change that impact apple farming along altitudinal gradient. Less and erratic rainfall, increase in temperature, and decline in snowfall are the major indicators of climate change responsible for decline in apple production. Based upon the altitudinal gradient maximum people in all three altitudinal zones attributed Less and Erratic Rainfall to be the major reason however with rise in altitute the number of respondents attributing this as major reason declined. A similar pattern was observed for Increase in temperature, as for Decline in snowfall is concerned maximum people between (1800-2100 m altitute) it as the major reason followed by 2100-2300m atitude. As percieved between 1500-1800m the insect and pest attack was given higer value in comparison to other two zones. At mid and high elevations hailstorm and frost are reported as the reason for degradation of the quality of fruits.

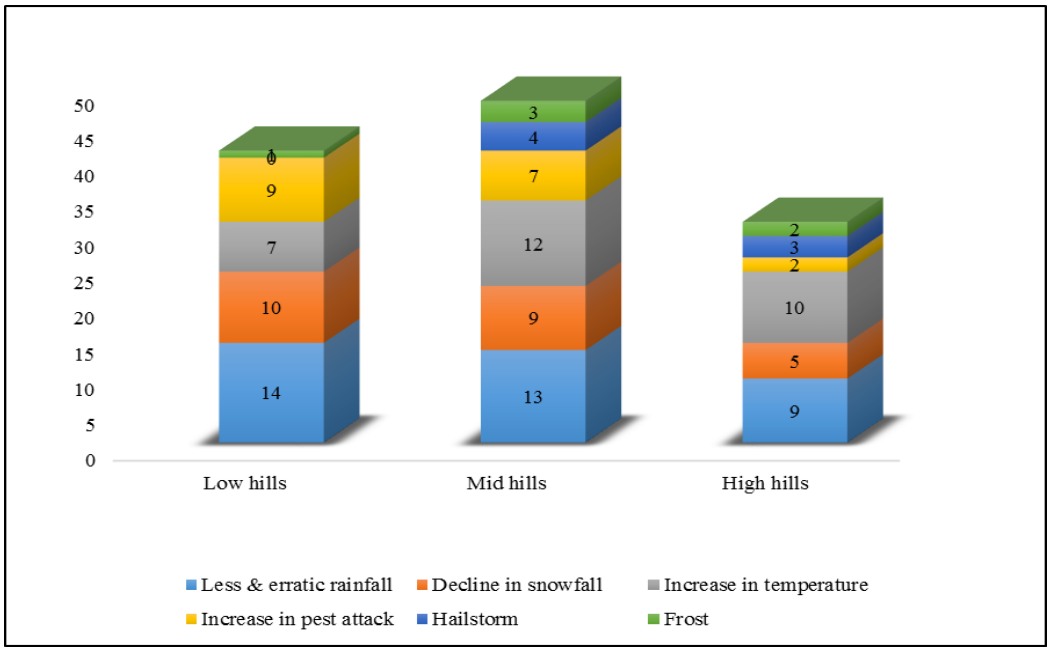

Fig 12. Perception of respondents on climatic factors at different elevation

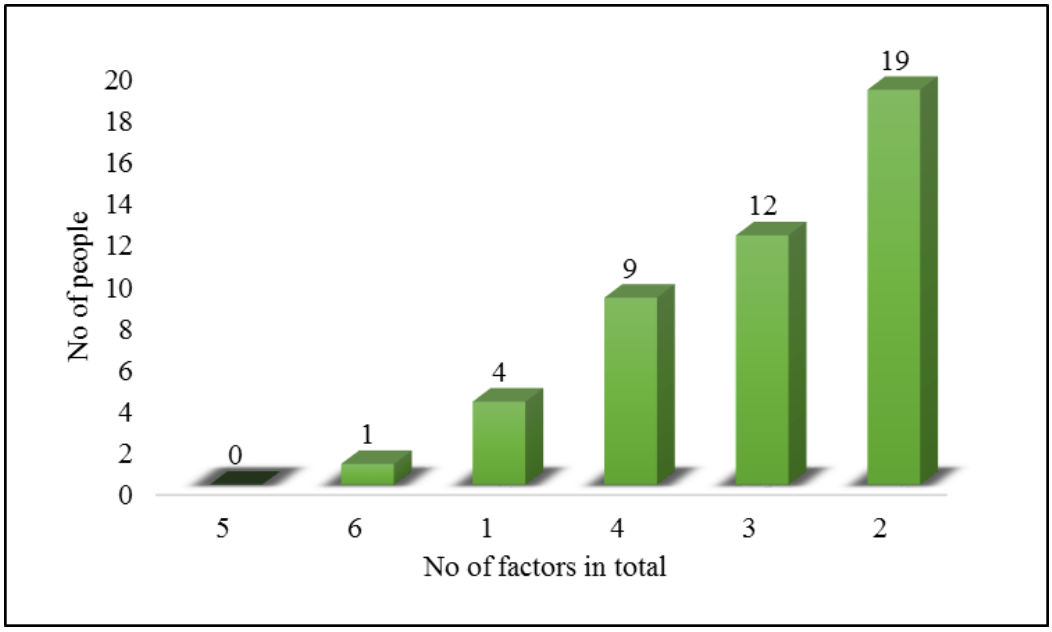

Fig 13. Perception of respondents on climatic factors

Out of the total 45 Interviews maximum no of people attributted 2 reasons for decline in apple cultivation (19) and only one respondent attributed 6 reason for the decline(Fig 13). The three most common responses were

1. Less and Erratic Rainfall
2. Increase in Temperature
3. Decline in Snowfall (Fig.12)

Most of the farmers in the study area indicated that because of climate change the land use practices were also changed and apple farming is replaced by farming of other fruit crops and vegetables. At low altitude all the farmers surveyed admitted that there is huge decline in the area (Fig. 14) and production (15) of apple and they are shifted to peach cultivation. At mid and high altitude majority of farmers also reported decline in area and production but very few stated either increase or no change in area as well as production of apple.

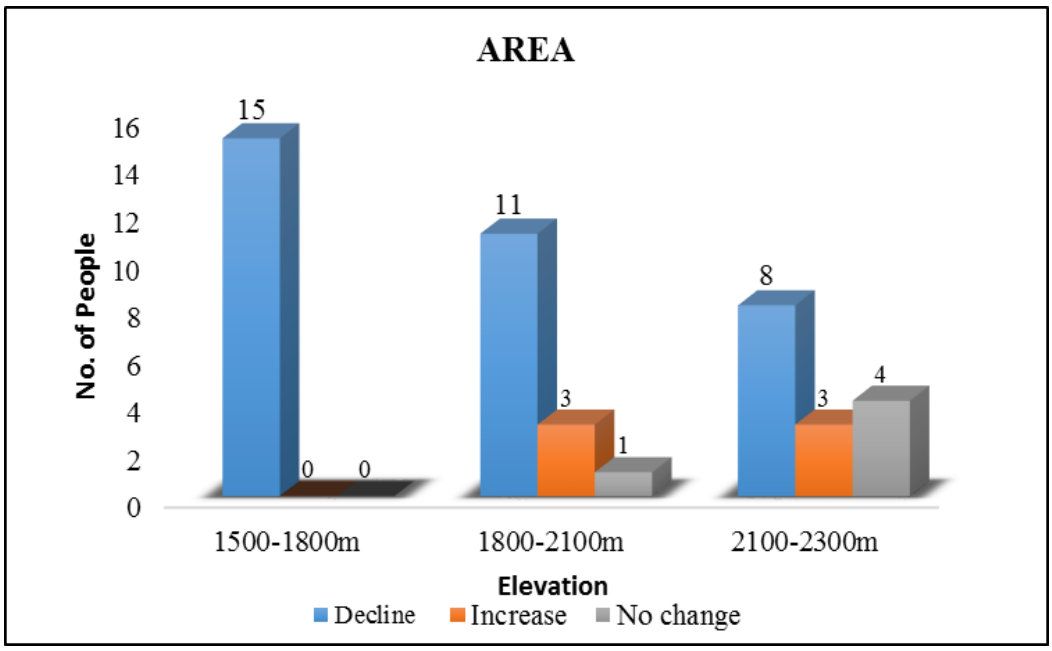

Fig 14. Perception of the farmers on change in area under apple cultivation in last 15-20 yrs.

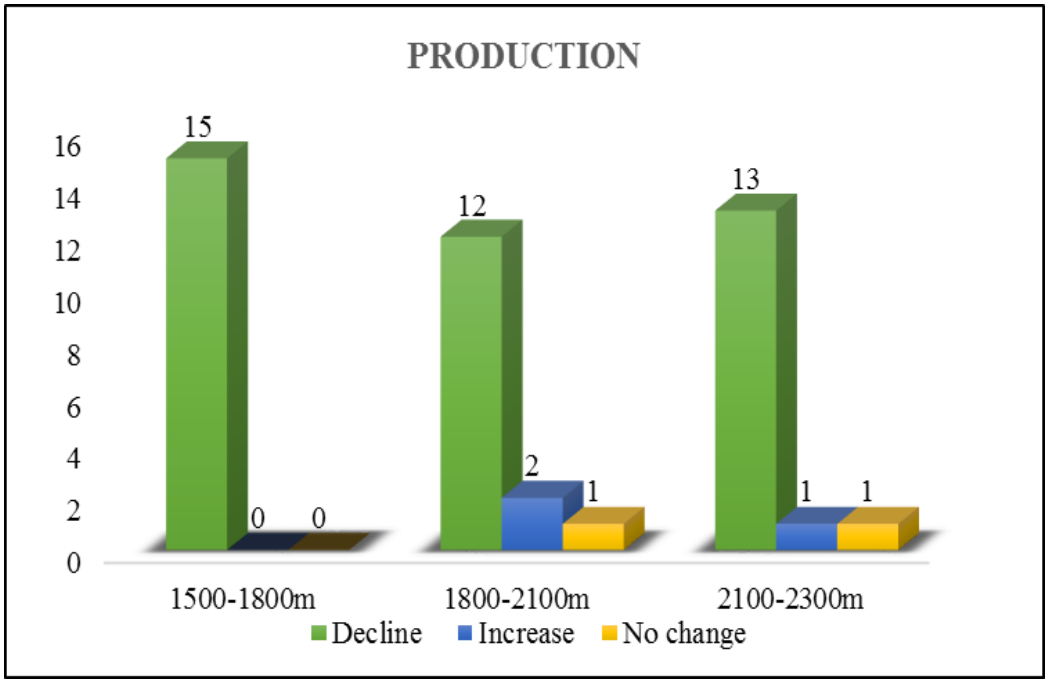

Fig. 15 Perceptions of the farmers on change in production under apple cultivation in last 15-20 yrs.

Though farmers are growing apple at mid and high elevation but the overall area and production has been declined. At low elevation 15 out of 15 farmers admitted decline in both the area

as well as production of apple. In mid-11 and in high elevation 8 farmers admitted that there is decline in area same in case of production 12 farmers at mid and 13 at high elevation admitted decline in production.

Discussion

Due to changes in climate, the patterns of horticulture have also changed in the last 15-20 years. The orchards that were dominated by apple trees in Ramgarh block are now experiencing a huge decline in both area as well as production of apple. Apple requires 1000-1500 hours of chilling, loamy soil and temperature below 7 degree Celsius for its growth. In this study based on climate change perception to understand the factors in decline in apple production, major reasons attributed to this decline were indicated by the farmers themselves. Increasing temperature, decline in rainfall, snowfall and erratic weather patterns both for rainfall and snowfall caused due to climate change were the main causes noted. Other factors included infestation of pest and disease, land use changes characterized by replacement of apple orchards to peach and plum, changing preferences of farmers towards other crops such as fruits (peach, plum,& apricot) and vegetables (pea, potato, cabbage), and poor linkages between farmers, government agencies and other institutions. Different changes at different elevations have been observed in fruit crop cultivation. In the lower elevation, apples have almost disappeared and have been replaced by peach. As per data obtained from Horticulture Department now the area under horticulture crops is maximum for peach 38% followed by apple 26% and minimum under walnut 3% (Fig 15). According to CEO of Uttarakhand Horticulture Department the production of apple is declining due to decline in snowfall, it used to 3-3.5 feet snowfall earlier but now the snow has been declined to 5-6 inches.

> ***"Aadu har saal phal deta hai aur iss climate mai acha ho raha hai."***
>
> ***Narendra Raikwal***
> ***46 yrs., Simyal***

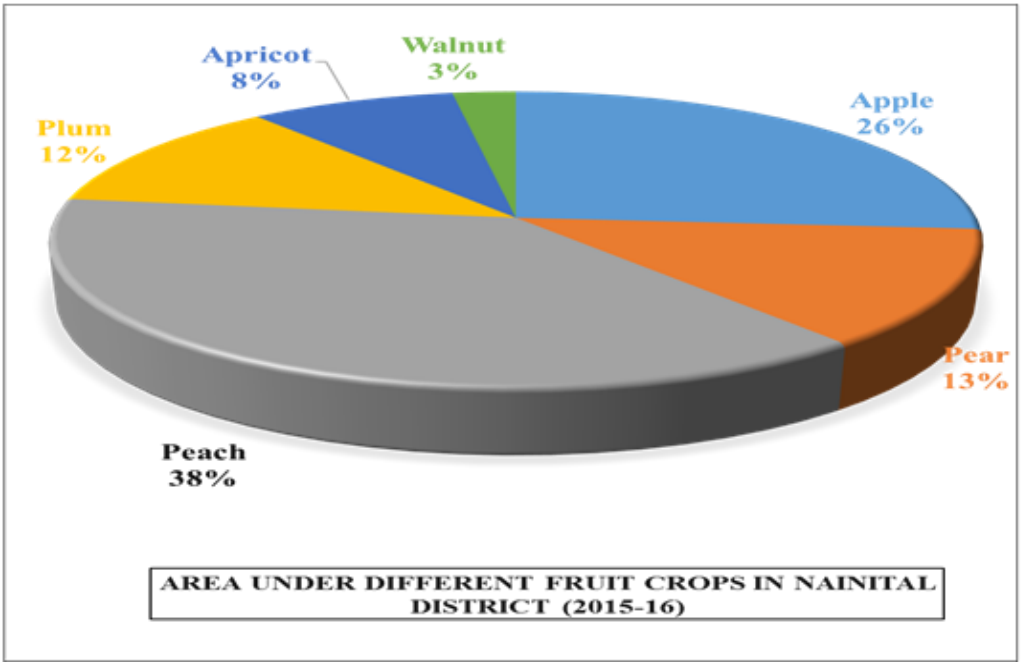

Fig 16. Area under major fruit crops in the Nainital District

Source: Horticulture Department, Uttarakhand

At mid and high elevation farmers are growing apple but the overall area and production both have been declined and the old varieties of apple such as **Rymer, Delicious, Ambri, Macintosh, Benoni, No. 103, Jonathan, Laalmeetha etc.** have been replaced by a new variety named DK(Local name: ***Bhoora delicious***) ,which is locally prepared. DK has good market value and demand, it starts fruiting after 3-4 years of plantation as compared to old varieties which take 10-15 years to start fruiting. Farmers in Ramgarh Block are preferring these new varieties of fruits as they start fruiting early, don't require hard work, fetch good market price and are more resilient to the changing climate. A member, Horticulture Department, Nathuakhan said we are providing plants, corrugated boxes, tools for orchard management and chemical fertilisers etc. to the farmers, whereas the perception of farmers differs from the Horticulture Department according to them only dominated people or big farmers are getting benefits from these schemes. **Dr. Surabhi Pandey**, Coordinator, Horticulture Department, Uttarakhand considers that apple has started declining from 2003 and **Prof S.P Singh** a Renowned ecologist believes that failure of government in Uttarakhand is the major reason for decline in apple cultivation whereas climate change has very less impacts on the decline in apple farming. According to R.C. Srivastava and Dr. Surbhi Pandey (Horticulture Department, Uttarakhand) no

study has been done on impacts of climate change on apple cultivation from horticulture department but recently government has initiated a scheme "Apple Mission" to support the farmers. In this scheme 10 farmers have been selected and govt. will provide 80% subsidy as 10 lakh rupees and 2 lakh rupees will be invested by farmers to grow low chilling height specific spur varieties in one acre of land area to increase the yield of the apple so that farmers will get benefit from this scheme. Other institutions such as **"Aanchal Dairy"** and Local NGO **"CHIRAG"** are helping farmers in marketing by buy fruits from them at good price and further sale these fruits in markets of Haldwani, Delhi and Mumbai.

4.1 Swot Analysis

On the basis of primary and secondary information SWOT analysis has been done. This analysis will be helpful to know the strengths of the study area that makes it different from others, weaknesses that need to be overcome and the threats as well as opportunities to increase the area and production of apple.

Strengths for apple cultivation

- Diverse agro climatic conditions for cultivation of high value seasonal and off season fruits, vegetables etc.
- Good market facilities e.g. Haldwani, Delhi and Mumbai.
- Higher market price of apple
- Health benefits
- Long storage life

Weaknesses of apple cultivation

- Apple orchards are replaced by peach
- Preferences of farmers are changing towards other fruits and vegetables
- Farmers are losing interest in apple farming

- Less desirable efforts for apple sector development in the state
- Poor linkages between farmers, government agencies and other institutions
- Deterioration of fruit quality due to increasing intensity of hailstorm and frost

Opportunities for apple cultivation

- Longer term studies required
- Development of low chilling, region specific spur varieties
- Well established marketing infrastructure but need to be strengthen and transparent
- Value addition to fruits
- Rejuvenation of old orchards by scientific management
- Organic farming to improve the soil quality
- Establishment of cold storage plant so that apple can be stored for longer period
- Degraded fruits can be used for jellies, jam and candies etc.

Threats of apple cultivation

- Impacts of adverse weather conditions such as inadequate rainfall, fluctuations in temperature and decline in snowfall etc. on apple cultivation.
- Infestation of pest and diseases
- Crop intensification leads to degradation of soil in hills
- Human-wildlife conflicts
- Scarcity of resources to fund agriculture research and extensioN

5. Conclusion

Due to adverse weather conditions and changing preferences of farmers towards other fruit crops the horticulture as well as agriculture pattern in Nainital district has been changed and in apple famous Ramgarh belt the crop has been successfully replaced by peach. Less and erratic rainfall, decline in snowfall, increasing temperature and increasing intensity of hailstorm and frost and infestation of pests and diseases attributed to decline in area as well as production of apple cultivation.

Under changing climatic conditions peach is taking advantage and are preferring over apple because peach can be cultivated in a wide range of climatic conditions, starts fruting in 3-4 years after plantation, tolerant to warmer conditions, requires 200-1200 hours of chilling whereas apple requires 1000-1500 chilling hours, doesn't require hard work, less prone to disease and pest and vegetables can thrive best as inter crop but this can be done pre fruit bearing stage.

Horticulture is a most sensitive sector in view of climate change and is the main occupation of the rural communities in hills so the changing climatic conditions have severe impact on these communities. The adaptation strategies adopted by the communities to cope with existing climatic conditions are diversification of crops such as peach is replacing apple, they are using anti hail net to prevent hail damage in a broad variety of crops, preferring livestock farming because it has less climatic risk and other fruit crops which starts early fruiting and doesn't require hard work. Farmers are losing interest in apple farming the major reason is poor government policy implementation, as govt. is not playing any significant role in view of declining apple production in Nainital District.

6. Recommendations

To increase the area and production under horticulture crops following recommendations are proposed:

1. Longer term studies required

Very few studies have focused on the impact of climate change on fruit crops in Uttarakhand, apple is one of the most important commercial fruits and because of climate change the area and production under apple cultivation has declined so studies need to be done on focusing decline in apple cultivation

2. Climate resilient varieties need to be introduced

New low chilling, region specific and early maturing varieties of fruit are being introduced in the apple producing areas of the state like Uttarakhand as cultivation of traditional types is gradually declining or shifting to higher altitudes.

3. Focus on storage and market linkages

Farmers in the study area wanting cold stores so that they can store their fruits for longer time. Due to lack of storage facility and infrastructure the market is dominated by middle man (Baniya) and because of them farmers are not getting maximum benefit and there is need to release farmers from danger of middle man so as they could decide at their own in the market.

4. Creating opportunities for farmers

Government should provide opportunities and encourage educated youth towards agriculture and allied activities because they are losing interest in it. The provision of training and workshop must be provided for the farmers to develop their skills and knowledge.

5. Better implementation of schemes by government

Farmers are not getting benefit of the schemes provided by government for the betterment of agriculture because of weak implementation policy. Government should revise their policy structure for successful implementation of the facilities so that each farmer will get maximum benefit.

7. Limitations of the Study

Although the research has reached its aims, there were some unavoidable limitations. Following are the limitations of my study:

1. Because of the time limit this research was conducted only on a small size of population, I only got a week to do field work.
2. Limited access to secondary data.
3. The farmers were devoted most of their time in the farming activities so it was difficult to communicate with them.

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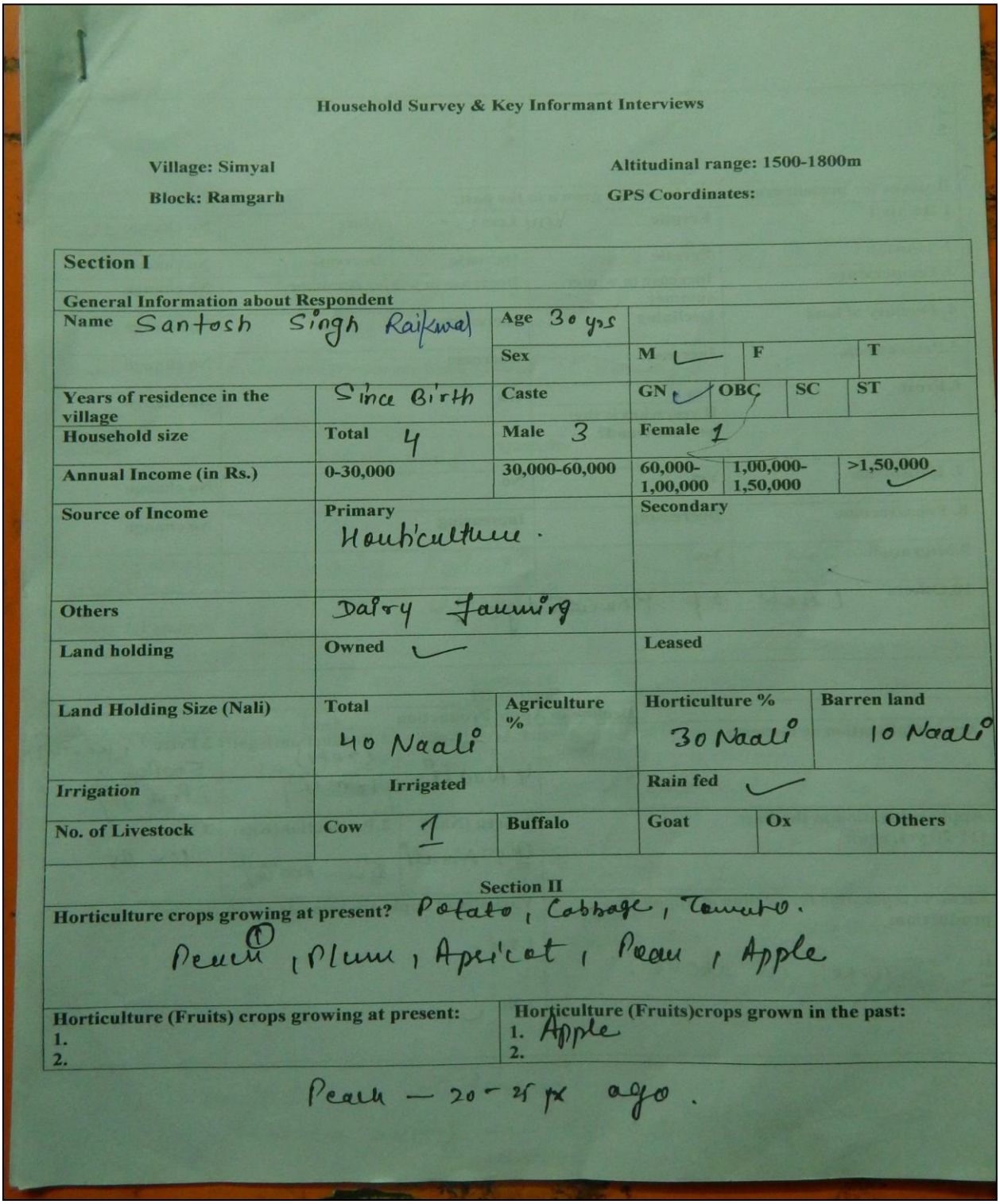
ANNEXURE 1

Questionnaire of the study



Household Survey & Key Informant Interviews

Village: Simyal — **Altitudinal range:** 1500-1800m

Block: Ramgarh — **GPS Coordinates:**

Section I

General Information about Respondent

Name Santosh Singh Raikwal		**Age** 30 yrs				
		Sex	**M** ✓	**F**		**T**
Years of residence in the village	Since Birth	**Caste**	**GN** ✓	**OBC**	**SC**	**ST**
Household size	**Total** 4	**Male** 3	**Female** 1			
Annual Income (in Rs.)	**0-30,000**	**30,000-60,000**	**60,000-1,00,000**	**1,00,000-1,50,000**	**>1,50,000** ✓	
Source of Income	**Primary** Horticulture.		**Secondary**			
Others	Dairy Farming					
Land holding	**Owned** ✓		**Leased**			
Land Holding Size (Nali)	**Total** 40 Naali	**Agriculture %**	**Horticulture %** 30 Naali	**Barren land** 10 Naali		
Irrigation	**Irrigated**		**Rain fed** ✓			
No. of Livestock	**Cow** 1	**Buffalo**	**Goat**	**Ox**	**Others**	

Section II

Horticulture crops growing at present? Potato, Cabbage, Tomato. Peach, Plum, Apricot, Pear, Apple

Horticulture (Fruits) crops growing at present: 1. 2.	**Horticulture (Fruits)crops grown in the past:** 1. Apple 2.

Peach — 20-25 yr ago.

3. 4. 5.		3. 4. 5.		
Reasons for present crops replacing crops grown in the past:				
1.Rainfall	**Erratic** Very	**Less** ✓	**More**	**No change**
2.Snowfall	**Erratic**	**Increase**	**Decrease**	**No change**
3.Temperature	**Increase in winter/ summer** ✓	**Decrease in winter /summer**		**No change**
4. Fertility of land	**Declining**	**Increasing**		**No change**
5.Pests attack	**Increase** ✓	**Decrease**		**No change**
6.Frost	**Yes** **If yes, what is the current trend?**	**No**		**No change**
7. Hailstorms	**Yes**	**No**		**No change**
8. Price/Income	**Decreasing**	**Increasing**		**No change**
9.Migration	**Yes**	**No**		
10.Others Lack of Knowledge.				

Section III

Decline in Apple Production (8-9 yrs.)

Apple Cultivation at Present:	**1.Area (Nali)** 4 Naali	**2.Production(Kgs)** (20kg) 100 पेटी	**3.Price** (100 पेटी) 500Rs Per पेटी
Apple cultivation in the Past (15-20 yrs. ago):	**1.Area (Nali)** 25 Naali	**2.Production(Kgs)** 500-600 पेटी	**3.Price** 100 Rs
Factors responsible for decline in apple production: 1. Same as above. 2. 3. 4.		**Varieties of apple are same as 15-20 yrs ago?** **1.Yes** **2.No** ✓	

New Varieties (Why only these varieties) DK → good price Fenny. → early fruiting.	**Old Varieties** Red delicious, Rich 12, Rymers, No. 103,
Since how many years current varieties are being grown? 15 yrs ago	
Changes that have been observed in apple?	
Quality DK — Taste is not good.	**Quantity**

Phenology of new variety? Flowering fruit setting walnut size (one month).					
Variety 1(Past)	April → if climate is thanda.				
Variety 1(Present)	March				

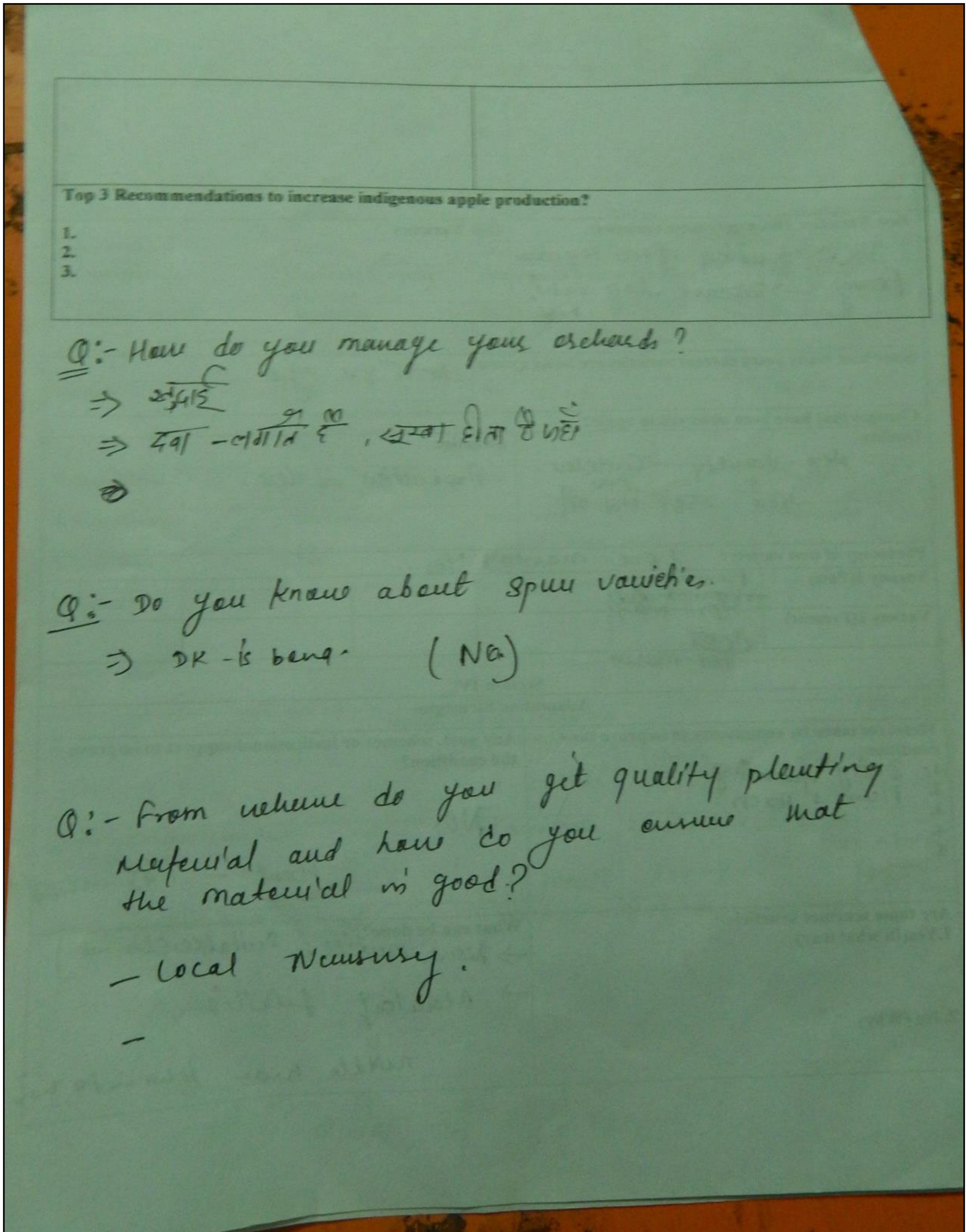
Section-IV

Adaptation Strategies

Measures taken by community to improve the condition: 1. Peach replacing apple. 2. Cash crops — 1995 3. 4. 5.	**Any govt. schemes or institutional support to improve the condition?** ☆ Horticulture ne insurance kiya but paisa nahi mila. ☆ Mandi Samiti — 15 Jy (1-2) 21 → Delicious
Are those schemes beneficial: **1.Yes(In what way)** **2. No (Why)**	**What can be done?** → Training — Nainital ke kisano ko variety lagni chaiye.

Market — Haldwani

Mother dairy — Peach, Plum, Fenny, Apricot.



Top 3 Recommendations to increase indigenous apple production?

1.
2.
3.

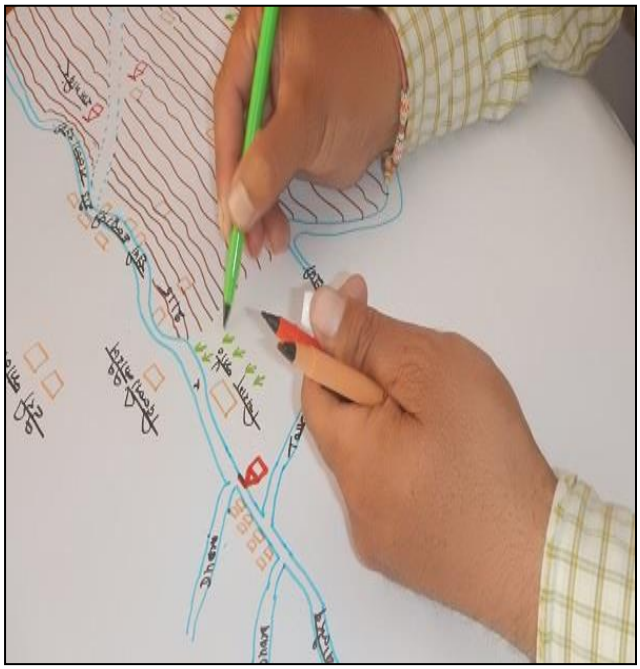
Q:- How do you manage your orchards?
⇒ गुड़ाई
⇒ दवा - लगाते हैं, खर्चा होता है यहाँ
⇒

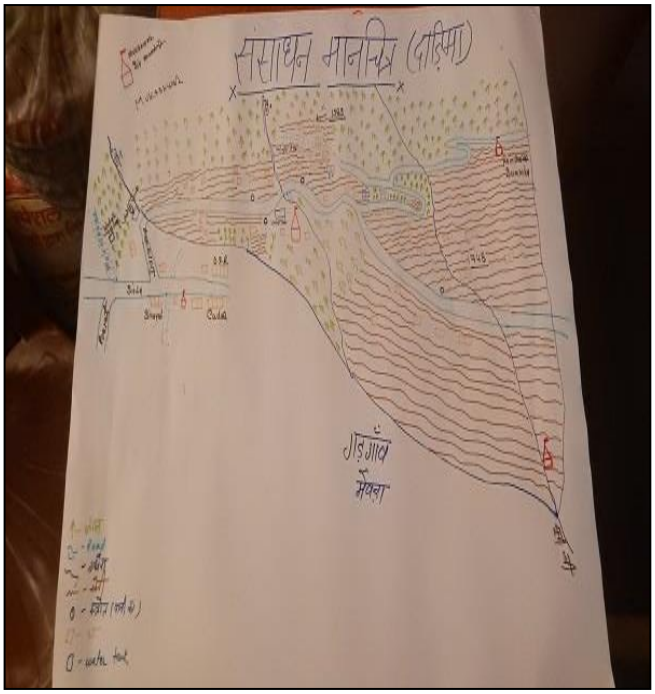
Q:- Do you know about Spur varieties.
⇒ DK - is bang. (No)

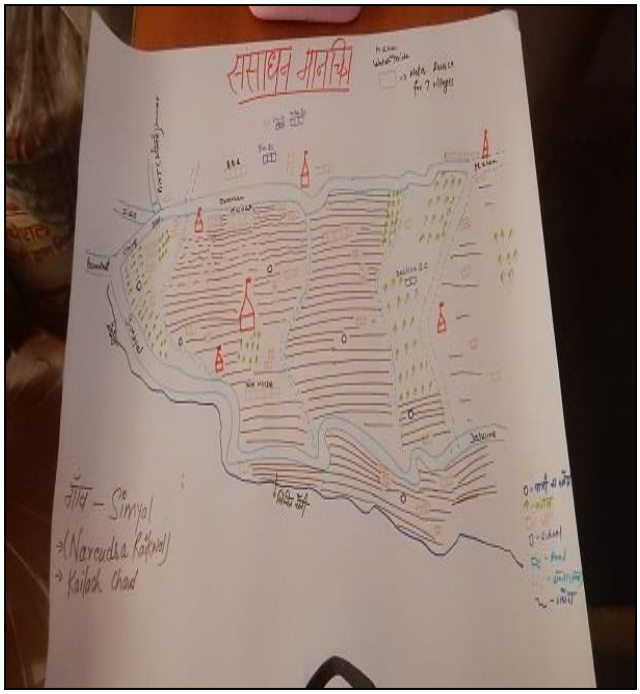
Q:- From where do you get quality planting material and how do you ensure that the material is good?
– Local Nursery.
–

ANNEXURE 2

Resource Mapping by Villagers







ANNEXURE 3

What people had to say?

"Hum logo Ki galti hai, jungle khatam ho gaye
Isliye janwar bahar aa rahe hai
Kisi ne ek pedh (tree) kaata hai to,
Dus lagane bhi chahiye
Hum logo ka to hojaiga,
Par baccho ke liye aage hona chahiye"

"It is our fault, the forests are declining,
hence the wildlife is coming closer to the society
"If you fell a tree, plant 10 trees as compensation.
Our lives are over but what about the future
genertion"

Smt. Basanti Pandey
Age: 48 yrs.
Village: Supi

"Pehle Himalaya yahi lagta tha,

Itni barf padti thi"

"We could experience the snow clad Himalayas here

Itself"

Sh. Pal Singh Mehta
Age: 55 years
Village: Supi

Sh. Jeevan Singh
Age: 63 yrs.
Village: Supi

"Jansankhya badh gayi, Kheti sikud gayi"

"The population is increasing,
the agriculture is declining"

Sh. Bacchii Singh Bisht
Age: 69 yrs, Village: Supi

"Pehle 2-3 feet barf girtithi,
Ab hum bhi sochte hai barf hoti kaisi hai"

"It used to snow 2-3 feet earlier,
now we wonder what snow is"

ANNEXURE 4

Snapshots from the field

"Grafting ***in Pear"***

"Grafting In apple"

"Apple after hailstorm"

"***Dk variety of apple, locally prepared"***

(Local name- Boora Delicious)

"Anti -hail net, protect crop from hailstorms"

"Impact of hailstorm on plum"

"Peach"

"Disease in Dk variety of fruit"

"Apricot"

"Riped plum"

"Preparing wheat for household consumption"

"Apricot"

"Peach"

"Gulel- A device used by farmers to keep away monkeys from their farm"

"Farmers sowing cabbage in their field"

"Pahadi Daal"

"Impact of hailstorm on Peach"

"Apple"