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Research Article

Farmer's Perception on Impact of Climate Change on Mandarin (*Citrus reticulata* Blanco.) Production in Syangja, Nepal

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Abstract

Research on "Farmer's Perception on Impact of Climate Change on Mandarin (*Citrus Reticulata Blanco.*) Production In Syangja, Nepal" was conducted in 2024, under the guidance of PMAMP, Syangja. Altogether 120 households from Bhirkot and Putalibazzar municipalities were selected randomly for the study. Primary data were obtained from face-to-face interview schedule, Focus Group Discussion, Key Informant Interview and secondary data from Department of Hydrology and Meterology (DHM), Kathmandu, and several publications. Majority of the farmers perceived the change in climatic condition in terms of increase in temperature and decrease in rainfall which brings a prolonged drought leads to loss in production. Analysis of the climatic data (last 30 years for rainfall and temperature) showed the increasing trend for maximum and minimum 0.0768°C per year and 0.003°C per year respectively and decreasing trend of mean annual precipitation is -0.1762 mm per year. The major natural hazards for mandarin production were prolonged drought during flowering and fruit setting time, followed by heavy hailstorm, storm, soil-erosion, frost, and landslide respectively, resulting downward trend in mandarin yield in study area. Farmers in the study area are mostly practiced mulching as an adaptation strategy to combat impacts of climate change against drought. The study concluded that farmers experienced the climate change, and its negative impact too, but haven't taken any adaptation measures to mitigate its effect. So, there is immediate need of effective adaptation mechanisms to make country self-sufficient in Mandarin production.

Keywords: Production, Climate change, Adaptation, Perception, Rainfall.

Introduction

Agriculture is the major economic sector in Nepal. In fiscal year 2021/22, contribution of agriculture sector to GDP was estimated to be 23.9% (MoF, 2021). Within agriculture, fruits were one of the important sub-sectors. Varied topography and diverse micro-climatic condition of Nepal allows cultivation of all types of fruit species ranging from tropical to subtropical to temperate. Citrus is major cultivated fruits in Nepal covering 29% [128,733ha] of total fruit growing area (MoALD, 2022). In Nepal, citrus development programs were started along with the establishment of department of Agriculture in 1982 B**S.** Citrus can be grown in different climatic zone ranging from tropical, subtropical, and arid and semi-arid in a range of temperature between 12 to 37 degrees Celsius. poor access to transportation, storage facilities and processing are bottleneck for the development of citrus industry (Chaulagai & Shrestha, 2022). Nepal is considered as one of the top ten countries most likely to be impacted by global climate change (WFP, 2009). Eastern Terai faced rain deficit in the year 2005/06 by early monsoon and crop production reduced by 12.5% on national basis. (Malla, 2009). Farmer perceived that Climate change affects growth and productivity of citrus varieties particularly seedless varieties, different environment factors like high temperature, hot waves, drought, cool temperature, and frost, has an impressive effect on growth and productivity of citrus. The optimum temperature for citrus growth and productivity ranged from 12.8 to 37 degree Celsius. Low temperature minimized metabolism activity, whereas chilling and frost for long period could destroy the whole trees, from another side rising carbon dioxide had positive effects on growth of citrus seedling and productive trees (W.F.Abobatta, 2019). Citrus had a phenological life cycle of the whole year, starting from February to next year January. Flowering started during February–March in subtropical regions and is generally considered a critical period for citrus production. An increase in temperature and water stress after pollination inhibits ovule fertilization, which in return reduced tree fruit set, increased June fruit drop and reduced tree yield. Fruit growth phases from button size to mature fruit were more sensitive to heat stress and deficit irrigation. Citrus under water deficit conditions faces reduced fruit growth and ripening, which is associated with a decreased in fruit size, an increase in fruit acidity, and low tree yield. Water stress at the pre-harvest stage in oranges develops fruit peel wrinkled. An increased in optimum temperature at fruit ripening causes pre-harvest fruit to drop and reduced yield. (Shafqat *et al.*, 2021).The contents of Vitamin C, naringin and hesperidin decreased significantly, while chlorogenic acid and caffeic acid increased during frozen temperatures. The highest content of peel was observed from October to March and the Vitamin C content decreased during the ripening process. Additionally, essential oils vary in content in different months. Therefore, the study is necessary to reveal the impact of future climate change on citrus (Wang *et al.*, 2022) . Farmer perceived that rainfall during September-October had an obvious effect on total soluble solid while low rainfall at that time increased the soluble solids (Subedi, 2019). An increase in summer temperature over the past few years has decreased the growth of Mandarin. Changed in temperature and weather patterns which impact on mandarin production. The climate change makes mandarin trees more vulnerable to pests and diseases. The low productivity of the mandarin over the past few years was mainly due to the rise in temperature. Most of the farmer experienced those difficulties in managing water resources, such as irrigation, due to changing climate conditions. Erratic rainfall due to climate change is also affecting the flowering and fruiting of mandarin orchards**.** (Nidup *et al.*, 2023). Climate change directly affected the reproduction, development, survival, and dispersal of pests and indirectly impact the interactions between and within insect species, including predators, competitors, and mutualists, and interactions with their environment and introduction of invasive pests too (Subedi *et al.*, 2023). Mandarin growers of Syangja districts also experienced high economic losses due to the negative of climate change. Government should focus in developing and strengthening institutional mechanisms that support the farmers to adapt to climate change through proper analysis of their perception about climate change (Regmi *et al.*, 2017).

Research Methodology

The research was conducted in Putalibazzar and Bhirkot municipalities of Syangja district. These areas were purposively selected as they were the common area of PMAMP mandarin super zone, with highest production potential in the district. In consultation with Prime Minister Agriculture Modernization Project, Citrus Super zone, Syangja, 2123 farmers were identified as Mandarin farmers in the study area, out of which 120 households were selected by purposive simple random sampling technique for the household survey. The sample size was calculated using Rao-soft software by keeping 5% error and 95% level of confidence. Household survey was conducted by face-to-face interview schedule technique among 120 farmers using pretested semi-structured questionnaire. Climatic data of past 30years was obtained by the Department of Hydrology and Meterology.

Data analysis was done by using XLSTATA and Microsoft Excel. Both descriptive and inferential analysis were done to conclude and generalize the result. The trend of change in climatic variables was studied by estimating trend line through Microsoft excel. Major climatic variables (i.e., Temperature, precipitation, drought, frost/dew, cloudy weather) area and yield data was analyzed by using Microsoft excel. The monthly average temperature for each month was calculated as (T) = (Tmax+Tmin)/2. The same method was employed to calculate the annual average temperature, taking data from January to December. The processing of rainfall data was done in the required form. Collected daily and monthly rainfall data was processed to find annual rainfall (R).

$$R = R1 + R2 + R3 + R4 + ...+R12$$

where, R1, R2, R3, R4, ...,R12 refers to the rainfall from January to December.

Likert- type scale was used for the ranking of climatic hazards. Indexing was computed by using the following formula:

$$I_{imp}=\sum(S_i*f_i/N)$$

Result and Discussion

Farmer's Perception on Climate Change

Based on study only 1% of respondents have comprehensive knowledge of climate change while 37% have clear understanding, 55% knew a little bit and 7% of respondents have no clue about it. On the other hand, maximum proportion of farmers i.e., 88.3%, can feel the impact of climate change through their self-experiences. Besides self-experiences,7.5% learn through the media, 3.17% through various climate related organizations and very few (1%) of farmers through discussing with their community members.

Ranking of Major Hazards Based on Farmer's Perception

Based on farmers experience, the major natural hazards for mandarin production were prolonged drought during flowering and fruit setting time, followed by heavy hailstorm which caused the destruction of flower and fruit. Apart from these, storm, soil-erosion, frost, and landslide hold the third, fourth, fifth and sixth position respectively as shown in the Table 1. Changes recorded for various parameters are shown in Table 2 to 5.

Table 1: Ranking of major hazards based on farmer's perception

Major Hazards	Total	Rank
Drought	0.99	I
Hailstorm	0.82	II
Storm	0.59	III
Soil-erosion	0.48	IV
Frost/Dew	0.36	V
Landslide	0.28	VI

Table 2: Change in Planting Time (Farmer's adaptation)

Change in Planting Time	Frequency	Percentage (%)
Earlier	20	16.67
Later	71	59.17
No change	29	24.17

Table 3: Change in Flowering Time

Change in Flowering Time	Frequency	Percentage (%)
Earlier	11	9.17
Later	68	56.67
No change	41	34.17

Table 4: Change in Fruit Setting Time

Change in Fruit Setting Time	Frequency	Percentage (%)
Earlier	1	0.83
Later	67	55.83
No change	42	43.33

Table 5: Change in Harvesting Time

Change in Harvesting Time	Frequency	Percentage (%)
Earlier	1	0.83
Later	104	86.67
No change	15	12.5

Difference Between Farmer's Perceived and Actual Changes in Climatic Variables as Recorded by The Department of Hydrology and Meteorology

According to all households, variation in temperature has been occurring as compared to past. It was reported that it was becoming very hot during summer and less cold during winter than before which is shown in the Fig. 1 and 2 respectively.

Result shows, 88.30% of the farmers experienced increased in summer temperature over the last 10 years compared to before, 3.30% respondent experienced decreased in summer temperature and 8.4% of respondents experienced no change in temperature.

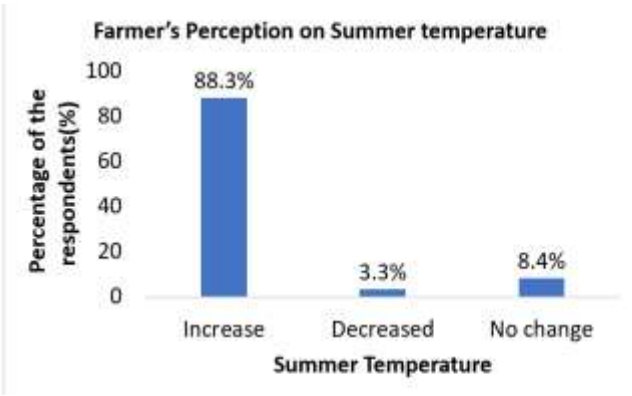

Fig.1: Farmer's Perception on Summer temperature

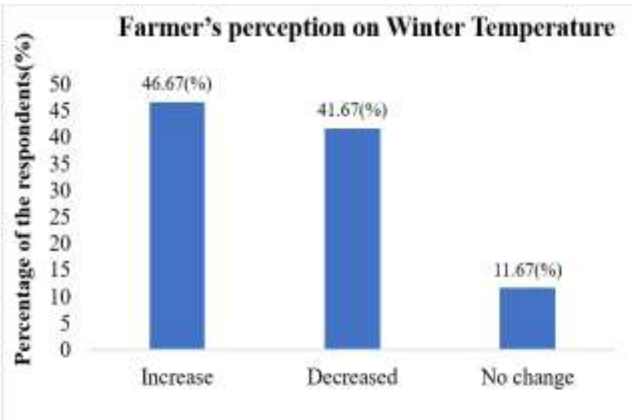

Fig. 2: Farmer's perception on Winter Temperature

On the other hand, 46.6% experienced increased in winter temperature over the last 10 years as compared to before,41.6% perceived decreased in winter temperature and 11.67% of respondents said that there was not any change in winter temperature. The temperature and precipitation data obtained from Department of Hydrology and Meteorology (DHM) is shown in Fig. 3, 4 & 5. By analyzing the obtained data, it can be concluded that that maximum annual temperature of temperature is increasing at the rate of 0.0768◦C and minimum annual temperature is increasing at the rate of 0.003◦C per year respectively which directly validated the farmer's perception of increasing temperature.

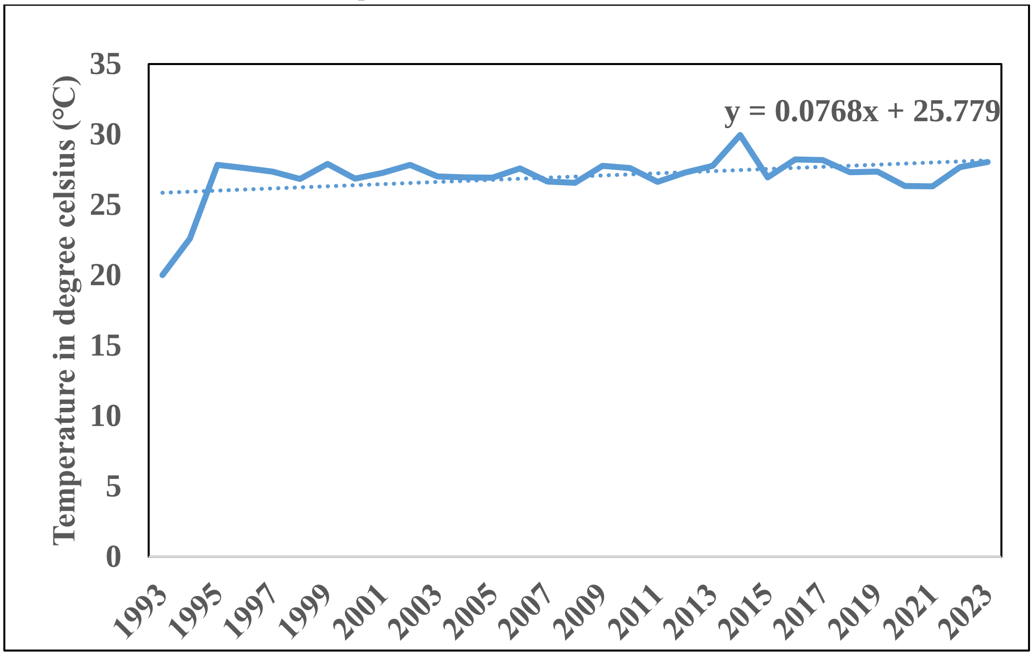

Fig. 3: Maximum annual average temperature trend (1993-2023)

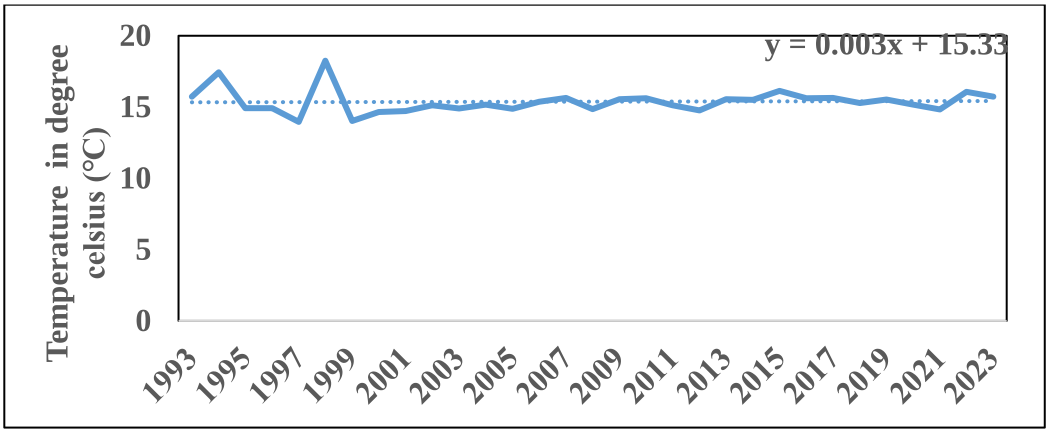

Fig. 4: Minimum annual average Temperature Trend (1993-2023)

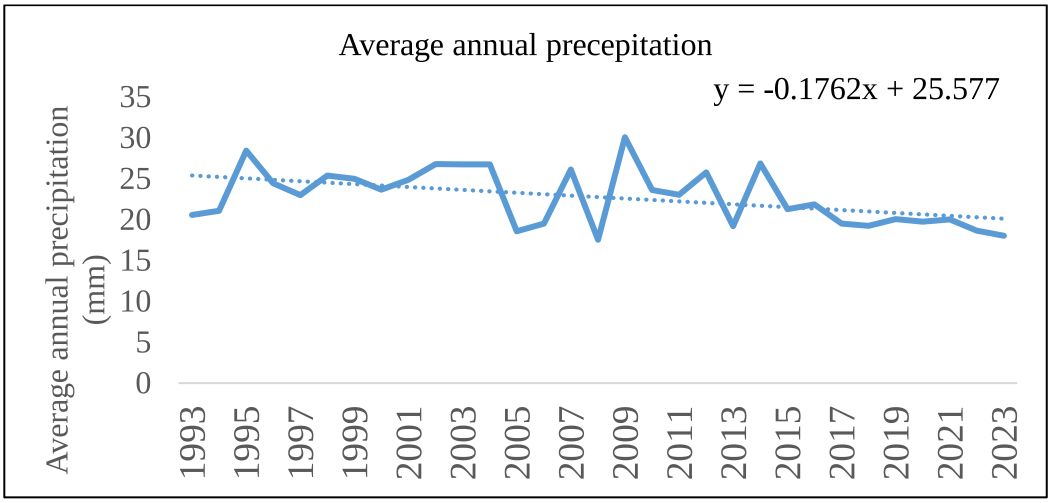

Fig. 5: Average annual Precipitation Trend (1993-2023)

Area and Production Trend of Mandarin

With the change in planting, flowering, fruiting, and harvesting time of mandarin, there has been changed in production, area, and productivity of Mandarin in last 5 years as shown in Fig. 6. The productivity of mandarin show trend line with slope y=-0.803x+14.963. This shows that the productivity of mandarin has been declined from BS2076 to BS2080.

Data taken from MoALD source when put in line graph as shown in Fig. 7, a normal trend line with slope y=-1.849x+3943.7 is obtained which clearly indicates that the productivity of Mandarin have been decreasing in last 5 years which verify the farmer's perception. Add ths provided sentence after precipitation. Similarly, variation in precipitation have been noticed in comparison with past. There has been changed in amount and intensity of rainfall. 100% responded felt that there has been decreased in duration of rainfall. The trend analysis of precipitation obtained from Department of Hydrology and Meteorology (DHM) is also placed under the trend analysis which shows that the annual precipitation is decreasing at the rate of -0.1762 mm per year during rainy season which directly valid the farmer's perception.

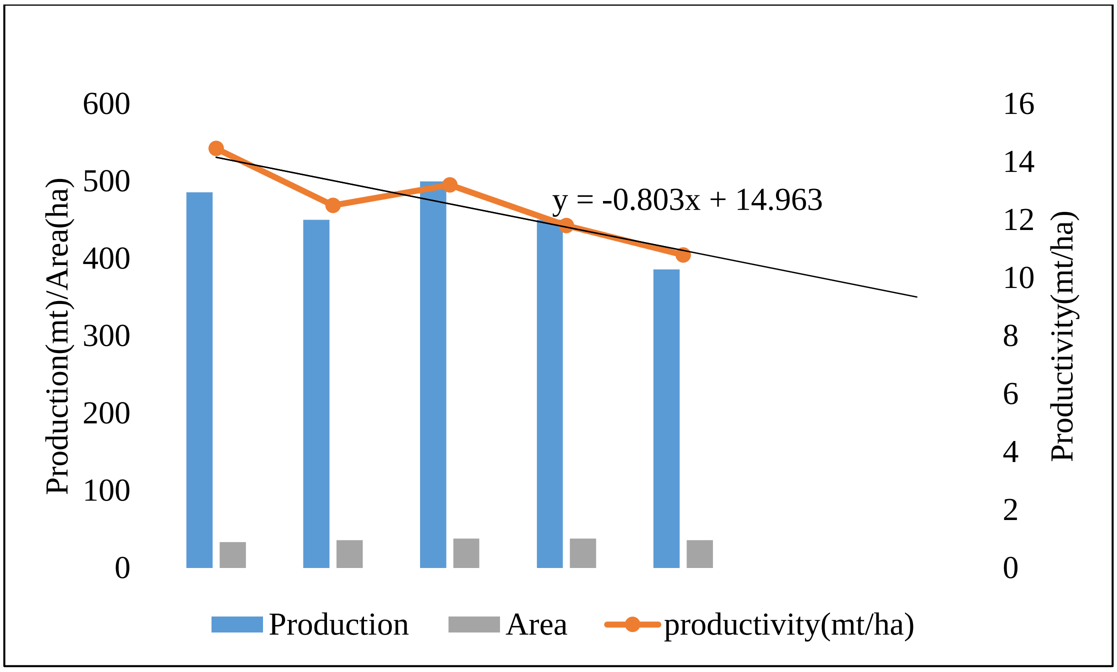

Fig. 1: Production, Productivity and Area under cultivation from 2018-2022

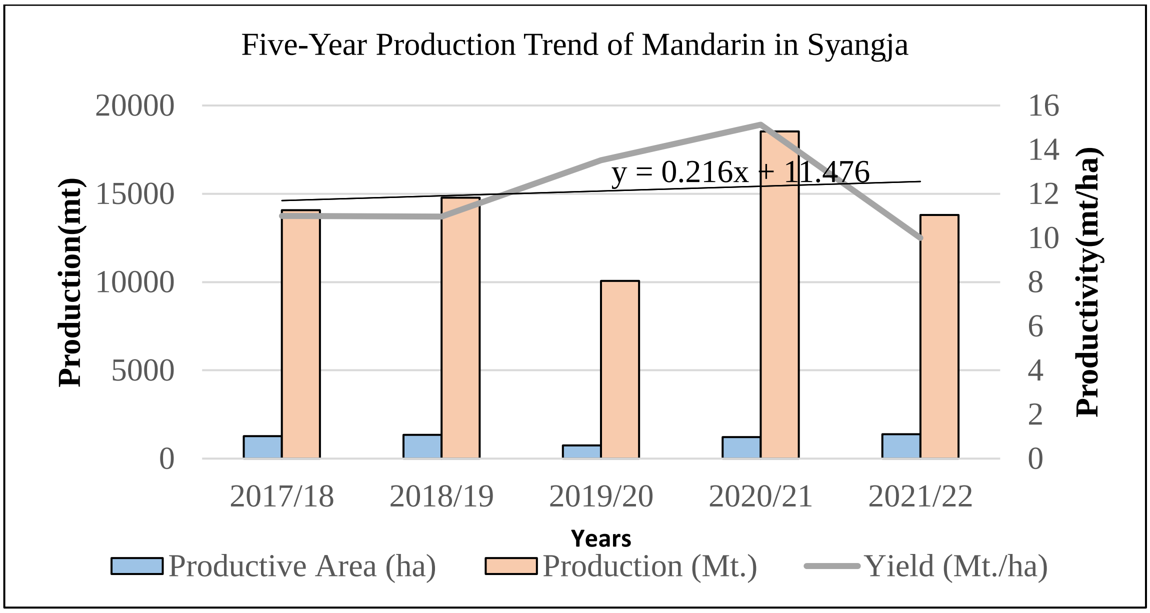

Fig. 7: Five years production trend of mandarin in Syangja.

Adaptation Strategies of Farmers Minimize Negative Impact of Climate Change

It was observed that majority of farmers preferred mulching (33.33%) over other strategies which was followed by inter-cropping (25%), high density planting (23.33%) and pipeline irrigation (18.33%) as shown in Table 6.

Table 6: Adaptation strategies to minimize impact of climate change

Adaptation Measures	Frequency	Percent
Mulching	40	33.33
Inter-cropping	30	25
High Density Planting	28	23.33
Pipeline Irrigation	22	18.33

Source: Field Survey, 2024

Discussion

Majority of respondents (55%) known a little bit about climate change. Majority of them experienced change in planting flowering, fruiting, and harvesting time. Due to climate change planting, flowering, fruiting, and harvesting time has been shifted later. Farmers experienced decreased in area, production, and productivity of mandarin in recent five years. It means that the productivity of mandarin has been declined over a period. Report from MoALD also suggest the same. Majority of respondents experienced increased in summer and winter temperature (88.3%) and (46.6%) respectively. Maximum and minimum temperature are found increasing at the rate of 0.0768°C and 0.003°C per year respectively (Source: DHM Syangja station). Due to increase in summer temperature the yield of mandarin has been declined. It may be due to increase in heat stress in April and May when fruit are small, which causes the fruit drop. Extreme temperature during flowering can affect pollination and fruit sets. High temperature may lead to flower drop. Mandarin plant required low temperature for flower initiation as increased in winter temperature effect on the flowering of plant. It may lead to delay in flowering and effect on yield of Mandarin. Majority of respondents experienced (58%) decreased in rainfall and annual mean precipitation decreasing at the rate of -0.1762 mm per year (Source: DHM Syangja station). Due to decreased rainfall during flowering and fruiting time, (98%) respondents experienced decreased production. Lack of rainfall caused more demand of water by the plants as there is less water available in the soil (Gao *et al.*, 2022). Hailstorm during flowering and fruiting time decreased production experienced by majority of farmers (53%). Hailstorm is a natural hazard which affect both quality and appealing of mandarin. It causes flower and fruit drop, leaves damage and mostly the tender seedling of mandarin at two leaf stage were highly damaged leading to drying and dying. So overall productivity is declined. Beside these, majority of farmers experienced prolonged drought especially during flowering time which leads to100% decreased in production of mandarin. Mandarin fruit required more water during fruit expansion than maturity so if drought occurred during fruit expansion period than there will be poor sized of fruit which ultimately affect yield. Majority of respondents experienced decreased in frost /dew (73.33%), increased in cloudy weather (57.5%) and decreased in landslide (85.83%). Landslide is decreased due to high density planting of mandarin. High density planting technique conserved the soil moisture, properly utilized the space and high yield per unit area (Ladaniya *et al.*, 2021). Farmers experienced if increased in frost/dew, cloudy weather, and landslide there will be great loss in production. Increased in frost/dew caused the economic losses, when the temperature falls below -4 degree ○C even for several hours in a year, frost damage can kill the mandarin plant (Yalaki, 2023). It is also experienced by the farmer which ultimately affect their production.

Drought is major hazard (100%), followed by hailstorm (98.33%), storm (75.5%), soil-erosion (73.3%) and landslide (10.83) in study area based on farmers perceptions. Drought, hailstorm, soil-erosion, frost/dew, and landslide are ranked I (0.99), II (0.82), III (0.59), IV (0.48), V (0.36) and VI (0.28) respectively.

Most of the farmers adopted mulching (33.33%) to protect the soil from drought which helps to conserve soil moisture and add organic materials to the soil. It also prevent the surface run off and soil erosion (Gao *et al.*, 2022). Similarly intercropping is practiced by 25% to prevent from soil erosion. Some literatures suggest that intercropping with maize, potato etc help to reduce the surface run off velocity, reduce soil moisture evaporation and improved water use efficiency. The citrus orchard with intercropped have less soil eroded(14.47%) as compare to orchard without intercropping (Pilon *et al.*, 2022). High density planting by (23.33%) to minimize landslide and high yield per unit area (Ladaniya *et al.*, 2021).

Farmers practices pipeline irrigation (18.33%) to protect from the drought. Irrigation during drought helps to meet the water demand of plant and helps to increase the yield (Proloy *et al.*, 2022).

Conclusion

This study finds out the changing scenario of temperature and precipitation in Syangja district through farmers perception as well as trend analysis of weather data obtained from 2018AD to 2022AD. Result clearly showed that this region experienced increased in both summer and winter temperature. According to study maximum and minimum temperature are increasing at the rate of 0.0768°C and 0.003°C per year respectively. Whereas precipitation is found reducing at the rate of -0.1762 mm per year. As a result, occurrence of prolonged drought and occurrence of heavy hailstorms during flowering and fruiting time and lateral shift in planting, flowering, fruiting, and harvesting time which ultimately lead to decline in productivity at the rate of -0.803 mt/ha. Most people were aware of the term "Climate Change", but they were unaware of the adaptation measures that were required. The government hasn't taken any significant action to address the issue. It came to light that the effects of climate change on apple production had received very little, if any, attention over the course of this study. Thus, there is an immediate need to develop adaptation strategies, but farmers' perceptions and their experiences should be considered while designing plans and policies so that they will help enhance farmers' knowledge about climate change and lessen their vulnerability to the adverse impacts of climate change

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Authors' Contribution

Mamita KC is the Primary author who designed the research, collected, and analyzed the data. Asst. Prof. Ganesh Lamsal is the major supervisor of the study who helped Mamita KC in writing proposal, methodology selection, data analysis and final report writing throughout the research. Subarna KC and Bibas Chaulagai helped Mamita KC in data collection, data entry and proof reading. All the authors have read the final version of this manuscript and approved for the publication.

Conflict of Interest

Authors declare that there is no financial or other any type of conflict of interest with the present study.

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