

Climate Change and its Impact on Fruits and Vegetable Production in Nepal

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Abstract

Climate change, the global phenomenon, have both positive and negative effects in growth and development of fruits and vegetables through rise and fall in temperature, shifting of climatic zone, disease/pest outbreak etc. This review paper aim to describe the recent climate change pattern and its impact on fruits and vegetables production in Nepal. Due to climatic zone shifting, tropical fruits and vegetables grown in higher altitudes attribute significant effects on various growth stages as delayed maturity, delayed ripening; poor quality fruit, poor color development, sunburn of fruit, poor flower emergence, improper pollination etc. Researches reveal that with the exposure to extreme temperatures, insects as adaptive mechanism may produce heat shock proteins, cryoprotectants and osmolyte compounds within their bodies to survive extreme condition. Higher temperature has been reported to induce early flowering resulting in poor fruit-set because of abnormalities arising from prevailing low night temperatures. In vegetables, tomato plants reported to have increased incidence of various diseases such as late blight, leaf curl and black spot with sudden onset of climatic fluctuations. Hence, the review suggests that organizations related to fruit and vegetables research, education and development in Nepal have to get organized and strive hard to bring new genetic advancements such as biotechnology, tissue culture and/or initiatives that adapt/mitigate the adverse effect of climate such as high density planting, develop high yielding and stress tolerant varieties and thrive for enhanced production contributing to food security and livelihood of burgeoning population in Nepal.

Keywords: Climate change, Fruits and vegetables, Global warming, Sustainable agriculture

Introduction

Background

Nepal is a mountainous country with diverse agro-climatic zones, which has opened up the opportunity to grow diverse fruits and vegetables. The hills among Terai and Mountains are the dominant land type where perennial fruits can be grown in sloppy terraces with minimum soil erosion while vegetables can be grown near major cities and market centers concentrating on Terai and low to mid hills (Baniya, 2008). The main climatic zones of Nepal are tropical, sub-tropical, mild-temperate and temperate (S. Subedi, 2019). The major fruits grown in Nepal are Mango, Banana, Guava, Apple, Citrus, Pear, Peach, Papaya, Pineapple, Litchi (Atreya & Kaphle, 2020; G. D. Subedi et al., 2020; S. Subedi, 2019) and vegetables are tomato, potato, cauliflower, cucumber, green leafy vegetables, onion, broccoli, cabbage, pea, carrot, radish etc. which have their own growing environment i.e. temperature, humidity, precipitation, solar radiation etc. (Bhattarai & Subedi, n.d.; Gyawali et al., 2022; I.R. Pandey et al., 2022).

Fruit and vegetables contribute more than two-third in total of agriculture GDP which is 27.59% (Jha et al., 2021; Paudel, 2016). The share of Nepal in global production of fruit is very low i.e. 0.16% (1177640MT) in 2018-19 which has increased from 0.1% (686213MT) in 2008-09. Similarly, the production of vegetables in Nepal has increased from 0.3% (2.61MMT) in 2008-09 to 0.36% (3.97MMT) in 2018-19. The increase in rate of production of both fruits and vegetables is very low and unable to meet the requirements of people. So, fruits and vegetables are mostly imported from nearest neighbors China and India. The global production of vegetables has reached to 1088.9MMT in 2018-19 which is slightly lesser than 2017-18 (Jha et al., 2021). WHO recommends the daily

consumption of >400gm/person/day of fruits and vegetables for physical and mental wellbeing while our consumption is lesser than 300gm/person/day (Joshia et al., 2022; Nepali et al., 2020). Hence, the demand of fresh fruits and vegetables in daily consumption is very high. The domestic production has been decreasing with time due to serious damaging diseases, pest, lack of proper management practices, uneven precipitation as a consequence of climate change (C.L. Pandey, 2012). It is growing everyday as a serious challenge which is mainly due to emission of greenhouse gases from industries, deforestation and urbanization resulting changes in solar energy, temperature and rainfall intensity (Iderawumi, 2022). Global warming causes rise in temperature, which leads to rapid shifting in climatic zones. This shifting causes serious problem in fruit and vegetable production. Other serious problems of climate change are disease pest outbreak, drought, landslides, flood, erosion etc. (S. Subedi, 2019). The production of temperate fruits is decreasing due to rise in temperature and lack of proper chilling temperature for physiological growth and breaking of dormancy (Rai et al., 2015; Mahmood et al., 2000).

Rationale of Study

In this prospect, the study about climate change is very important for fruits and vegetables production these days. A good knowledge of climatic zones and their shifting pattern in response to climate change for the better production of fruits and vegetables is important. There are fewer researches carried out in Nepal about the effect of climate change on fruit and vegetable production since they are perennial. Most of the researches related to climate change are targeted to annual crops like cereals and pulses. The perennial nature of fruit trees makes it difficult to do research on them. Researches on fruit trees should be done for 5-8 years for the more relevant data.

Objective of the study

The main objectives of this study is to assess the pattern of climate change and its causes in fruit and vegetable production. This will also recommend the adaptive measures to minimize the impacts of climate change and cope up with this ongoing global phenomenon.

Materials and Methods

This paper is prepared based on review from both published and unpublished printed materials consulting relevant books, research papers, reports of different organizations as well as web sites. Discussion was done with horticulturists, farmers, lecturers/professors of universities and indigenous communities involved in fruit and vegetable production in Nepal.

Results and Discussion

The amount of greenhouse gases on earth surface is increasing day by day. These greenhouse gases like carbon dioxide (CO₂), Methane (CH₄), Nitrous oxide (N₂O), water vapour (H₂O) absorb infrared radiation (heat) emitted from surface of earth. The more the emission and absorption of these greenhouse gases, the more it causes the earth to warm up quickly resulting in global warming and climate change. Since 1900, the global average temperature of earth increased by 0.8°C (1.4° F) (Bisbis et al., 2018). Researches reveal that the average temperature in Nepal is increasing in faster rate than the global average. This rate is even higher in Himalayan region as compared to Hills and Terai (Gentle et al., 2014). Due to this climatic change, precipitation is becoming unpredictable and uneven, resulting in extreme environmental conditions. Change in rainfall pattern from November to April with either excessive or scanty rain adversely affects the winter and spring crops production (Palazzoli et al., 2015). Climate change has hardest hit mostly to poor people in their economy and livelihoods (Poudel et al., 2017) (Gentle et al., 2014). Nepal with impacts like depletion of snow cover, glacier retreat and flood outburst from glacial lake is one of the most vulnerable countries of the world towards changing climate. It associates other consequences like erratic rainfall, water stress and vector borne diseases are affecting at the community level. Early flowering and ripening of fruits or crops and shifting seasonal weather pattern are the major impacts on agriculture sector (Dahal, 2006). The earth is warming continuously due to which climatic zones are shifting. The effect of global warming can be seen on higher Himalayas of Nepal in terms of glacier retreat and significant increase in size and volume of glacial lakes, more prone to outburst flooding (Nie et al., 2021; Shrestha & Aryal, 2011). In vegetables, tomato plants reported to have increased incidence of various diseases such as late blight, leaf curl and black spot with sudden onset of climatic fluctuations (Mothapo et al., 2022). This type of flooding mainly affects the agriculture sector by degrading

agricultural land (Agrawala et al., 2003). Extreme climatic events increase the process of soil erosion (Bhattacharyya et al., 2015). Although Nepal does not produce much of greenhouse gases as compared to industrialized countries, it has been facing serious consequences of climate change. Exploitation of natural resources, deforestation, population growth are the major causes of climatic degradation in Nepal which lead to pollution, declination water quality, drought, landslide, flood, land degradation and other environmental problems. These events lead to losses in agricultural productivity (Lohani, 2007).

Due to climate change, temperature and precipitation pattern have changed which will result in changes in water regimes and land ultimately affecting the agricultural productivity. The tropical regions of the poorest countries are affected more than the other parts with low level of technologies, wide pest range, weeds, diseases; land degradation, rapid population growth etc. (Liliane & Charles, 2020; (S. Subedi, 2019). For the mitigation of climate change; some adaptation measures like improving water management practices, modernization of agriculture, utilizing new techniques like changing crop types and location etc. should be carried out (Kurukulasuriya & Rosenthal, 2003).

The availability of water is expected to decline whereas water use in the agriculture sector is predicted to increase by 19% in 2050 due to climate change, (Ranabhat et al., 2023). In South Asia, the annual average maximum temperature is predicted to increase by 1.4-1.8°C in 2030 and 2.1-2.6°C in 2050 leading to an increment in the heat-stressed area in the region by 12% in 2030 and 21% in 2050 (Tesfaye et al., 2017). And, South Asia could lose about 1.8% of its annual gross domestic product by 2050 and 8.8% by 2100 (Ahmed & Suphachalasai, 2014). Erratic patterns of rainfall have been experienced that lead to irregular monsoon patterns, droughts and floods (Malla, 2008).

The extreme climates prevailing at different time intervals in the crop cycle decrease productivity (Beillouin et al., 2020). An increase in carbon dioxide gas has caused the reduction of elements such as iron, zinc, manganese and sulfur in potatoes (Malla, 2008) while has positive effects with increased approximately 5% vitamin C in citrus. Climate change causes the shifting in climatic zones, disease pest outbreaks, drought, landslides, flood erosion, etc. Previously citrus psylla were only found below 1000 masl, but now they can survive in mid hill up to 1500 masl (Atreya & Kaphle, 2020). Climate change has caused insects to produce heat shock proteins, cryoprotectants and osmolyte compounds within their bodies as adaptive mechanism to survive an increase in insects and pests in vegetable production and has also increased their resistance to pesticides due to which farmers are using pesticides in vegetables haphazardly (Parajuli et al., 2020). Cauliflower grown in Dhading showed pesticide levels of the organophosphate family that were more than 45 percent above the allowable limit (GC & Palikhe, 2021).

A long drought period followed by strong hailstorms during the flowering and fruiting season causes the bloom and fruit to drop. The higher temperature in papaya has led to flower drop in female and hermaphrodite, sex changes in hermaphrodite and male plants and promoted sterility (Paudyal et al., 2016). Due to the lack of rainfall in Solukhumbu, there was a heavy loss in potato production; about 90% of potatoes were destroyed as the people of this district depend on rainfall for irrigation (Nasir & Toth, 2022); (Mainali & Pricope, 2017). Climate change has been arising as one of the significant factors for causing biodiversity loss over the next 100 years which brings the change in species distribution, phenology and ecological interaction, affecting the pollination of fruits and vegetables as many crops of fruit and vegetable are pollinated by the insects (Bhandari & Thapa, 2018). The wind has become one of the major threats to banana growers (Joshi et al., 2020).

Climate change has affected apple production hampering the yield and quality (size, color and taste) of apples as well as pollination. Due to climate change, there is less snowing which might be the reason behind the losing reddish hue and taste of apples and also flowers are blooming before normal dates. Early flowering has been observed in olive, apple and pear and Flower size and pedicel lengths in cherry were also found reduced as a result of less chilling (Subedi, 2019; Medda et al., 2022). The increased soil temperature induced by global warming activates the population of soil microbes causes a decrease in the amount of soil organic carbon and micronutrients and an acceleration of decomposition (Atreya & Kaphle, 2020).

Horticultural crops are more sensitive to climatic variability as they heavily rely on adequate water supply and proper amount of daily energy like temperature, solar radiation, relative humidity, precipitation. That's why, a small rise in temperature may cause serious damage to horticultural crops like fruits and vegetable. The most significant

effect of the climate change on fruit crops is shifting of climatic zone (S. Subedi, 2019). Due to climatic zone shift, the climatic suitability changes. The percentage change in climatic suitability is not same in the case of all fruits (Baniya, 2008). Bananas among the fruits show higher percentage of decrease in suitable cropping area (68%) and also the high negative change in climatic suitability over a period of time (1961-1999) followed by apple (58%), oranges (47%) and coconut (40%). Mango showed the lower variation in climatic suitability change with more positive effect along with low decrease in suitable cropping area (28%) (S. Subedi, 2019).

Recommendations

- Assessment of the vulnerability and climate risks associated with fruit and vegetable production in all agro ecological regions of Nepal (Karki et al., 2020).
- Assessment of present issues of climate change in fruit and vegetable sector via rigorous research (Aryal et al., 2020).
- Develop smart Information Communication and Technology (ICT) system to transfer climate change adaptation methods and technologies at farmer's field to cope up with the issues of climate change (Balogun et al., 2020).
- Conduct awareness program such as seminar, workshops and training regarding climate change and its effect in fruit and vegetable production (Aggarwal et al., 2018)
- Learning and capacity building programs for Nepalese researcher and development workers from the international seminar/conference/dialogue about greenhouse gas emissions management and global warming with respect to fruit and vegetable production (Atreya & Kaphle, 2020).
- Strengthen Horticulture Research Station and Commodity Programs to run effective researches in country
- In vitro preservation of genetic materials to reduce extinction of biodiversity due to climate change and work on genetic enhancement for tolerance to biotic and abiotic stress in coordination with the national agriculture research center (Mothapo et al., 2022).
- Promotion of fruit crop insurances program for social security and food security targeting commercial fruit growers.
- Change in national policies that emphasizes incentives to the farmers for agricultural inputs in fruit production (Mothapo et al., 2022).
- Evaluate varieties and rootstocks to minimize of climate change hazard.
- Integrated nutrient management, Integrated pest management, Integrated weed management, development of water harvesting techniques to cope up with the climate change in fruit species (Atreya et al., 2019).
- Agronomic management strategies such as Agri-silvicultural system, Agri-horticulture system, Agri-horti-silvicultural system, Horti-pastoral system, Inter cropping of annual crops under fruit trees, Integrated Farming system should be adopted (Montes et al., 2019)
- Proper management of irrigation infrastructure in both rural and urban area of fruit pocket to reduce drought hazards is essential
- Develop climate-forecasting system for reducing hazards.
- Need to build capacity of government officials at central ministry, provincial ministry and local government levels to communicate and response to climate concerns (Khatri et al., 2022).
- It would be better to use machines operated from renewable energy during plantation, intercultural operation as well as harvesting and processing
- Effective adaptation techniques such as cultivation in a greenhouse, variety selection, mulching techniques and planting time modification (Aryal et al., 2020).
- Tree planting and hedge row planting in a semi-arid region, while cover crops and counter plowing in humid and coastal regions are practiced to reduce soil erosion (Aryal et al., 2020).
- Alternative use of water is another approach for adoption to water stress. Water harvesting has been practiced long ago in India (Satapathy et al., 2011) and also in rural Bangladesh by approximately 35% of the coastal area households (Gitz et al., 2016) which helps to reduce the surface runoff and maintain the groundwater table as well (Rai et al., 2015).

Conclusion

Fruits and vegetables play a unique role in Nepalese economy by improving the income of the rural people. Diverse fruits and vegetables are grown from tropical to temperate region of Nepal. Cultivation of fruits and vegetables play a vital role in the prosperity of the nation and is directly linked with the health and happiness of the people. Fruits and vegetables are also rich source of vitamins, minerals, proteins and carbohydrates etc. which are essential in human nutrition. The knowledge about the impact of climate change on fruit and vegetable production is limited. Consequences of climate change are global warming, change of seasonal pattern, excessive or intermittent rain, melting of glaciers, flood, rising sea level, drought etc. leading to extremity to fruit and vegetable production. Climate change has been potentially impacting fruit and vegetable production through: Changes in the distribution of existing pests, diseases and weeds and an increased threat of new incursions, Increased incidence of physiological disorders such as tip burn and blossom end rot, Greater potential for downgrading product quality, Increases in pollination failures if heat stress days occur during flowering, Increased risk of spread and proliferation of soil borne diseases as a result of more intense rainfall events along with warmer temperature, Increased irrigation demand especially during dry periods of the year, Increased risk of soil erosion and off farm effects of nutrients and pesticides, from extreme rainfall events, Increased input cost especially fuel, fertilizers and pesticides while the Increased atmospheric CO₂ concentrations will benefit productivity of most fruit crops, although the extent of this benefit is unknown. The addressing of the consequences of climate change requires integrated efforts with thorough analysis, advance planning and improved management. Climate change poses serious challenges to human and places unprecedented pressure on the sustainability of fruit industry. Hence, there is a need to protect these valuable crops for sustainability against the climate change scenario. The most effective way is to adopt conservation agriculture; using renewable energy, forest and water conservation, afforestation 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. Experiments on varietal evaluation should be conducted under natural conditions at different altitudes/conditions with natural variations in temperature and moisture falling under various agro-climatic zones of the countries. 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.

Fruit production is a long-term investment as compared to vegetables and cereals. Adaptation measures towards climatic change should focus on improvement of existing technologies for creating appropriate production environment for current as well as future conditions. Fruit trees have some advantage of being more resilient to climatic variation. Choice of variety is one of the important processes while establishing new orchard because a variety suitable for current climatic condition might not be suitable for the future climatic condition in long term. Thus, farmers need those crop varieties which can tolerate greater stress like heat, drought as well as light and thermo insensitive varieties. Understanding these impacts, we should adopt some improved production techniques for the fruit and vegetable production that can cope with the effects of climate change.

Declaration of the conflict of interest

The authors declare for this article that they have no actual, potential or perceived conflict of interests.

Ethical approval/declaration

Not applicable

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