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Research Article

Assessment of the Impact of Climate Change on Large Cardamom (*Amomum subulatum roxb*.) Cultivation in Sankhuwasabha, Nepal

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Abstract

The study was conducted in March, 2021 to assess the impacts of Climate Change on the production of Large Cardamom in Sankhuwasabha district of Nepal. The main purpose of the study was to know the impact of climate change on production of Large Cardamom. Primary data were collected by face to face interaction with 80 farmers with prepared questionnaire. The data were statistically analyzed and processed by using MS-Excel through descriptive and inferential method. The results showed that majority of the respondents were male, janajati, literate and mainly depends upon agriculture occupation as their major source of income. They were familiar about Climate Change scenario revealed that increase in overall temperature, deficit in rainfall during flowering and fruiting has negative impact in crop yield. Occurrence of disease pest like wilt, leaf and root rot, Gabaro, Caterpillar and Chirkey, Furkey has heavily affected Large Cardamom orchard. Secondary data of past 10 year were collected from MoALD, AKC, DHM, World Weather Online etc. Secondary data were analyzed by using regression model and found that average seasonal maximum and minimum temperature was decreased by -0.0137ºC and -0.0045ºC respectively and annual rainfall was increased by 1.2326 mm and productivity decreased by 0.0026 ton/ha annually. Increase in temperature, drought, and lack of better irrigation facility, disease and pest problem, unavailability of quality planting materials were the major constraints faced by the Large Cardamom farmers.

Keywords: Climate Change; Large Cardamom; Rainfall; Temperature; Yield.

Introduction

Nepal is a landlocked country located in the central Himalaya region consists of three different ecological zone Mountain, Hills and Terai, and is prone to various types of natural disasters and climatic change due to its geographical structure i.e. characterized by very high peaks to low land, complex geology, active tectonic plates, unplanned settlement, variable climatic condition and weak economic and political condition (Maharjan & Hanaoka, 2017). In Nepal, agriculture provides 66% job opportunity to the total population and contribute 36% in GDP (Chaudhary, 2018).

Global Climate change refers to a change in the long-term weather pattern that is characterized in the region of the world and the term weather refers to the short-term (daily basis) changes in temperature, precipitation, or change in the wind of a region (Varga, 2021).Climate change is mainly caused by the emission of greenhouse gases i.e.

methane gas (CH_4), Carbon dioxide (CO_2), Nitrous oxide (N_2O) gases into the atmosphere results in global warming that directly affects the agriculture parameter like soil, air temperature, precipitation, sea level, etc. Methane gas has the highest potential of global warming i.e. 300 times the potential of CO_2, and 20 times that of N_2O (Aydinalp & Cresser, 2008).

Large Cardamom (*Amomum subulatum Roxb*.) is a perennial herbaceous crop species that belongs to the *Zingiberaceae* family. Globally Cardamom is known as the "queen of all spices" or "black gold" which value rank in the third position only after Saffron and Vanilla in terms of price per volume (Acharya *et al*., 2021). Large Cardamom is also known as Black Cardamom, or Nepalese Cardamom, or Greater Indian Cardamom, or '*Alaichi'* in Nepali (Kalauni *et al*., 2019), It is a native crop that mostly grows in the sub-Himalayan region having cold humid conditions with an altitude of 600-2000 meters above sea level and 2800 to 3500 mm annual rainfall (Singh & Pothula, 2013).

In Nepal the total area under cultivation of Large Cardamom is 15055 ha, and production is 7954 tons with a productivity of 0.53 ton/ha (MoALD, 2020). In the world market, Nepal is the largest producer of large cardamom which contributes more than 53% share and followed by India i.e. 37% (Bhutia *et al*., 2018). (Khatiwada *et al*., 2020) (Kattel *et al*., 2020) reported Terahthum, Sankhuwasabha, Panchthar, and Illam as the four major Cardamom producing districts of Nepal. Taplejung produces most of the large cardamom i.e. 2,490 tons/ha followed by Sankhuwasabha 1129 tons/ha (Khatiwada *et al*., 2020). Inspite of having high production potential, the yield is not constant in every year. This might happen due to rainfall variation, increase in temperature etc. The main objective of this survey is to investigate or lead to a low yield of Large Cardamom.

Materials and Methodology

Selection of Survey Site

The study was conducted in Sankhuwasabha district, Eastern Nepal. The total area of this district is 3,480 km^2 and the total population is 158,742 (CBS, 2011). The district lies between 27°21'59.99" N and 87°12' 60.00" E (CBS, 2012). The landscape altitude ranges from 457 m to 8,463 m above sea level. It is the zone area for Large Cardamom production in Nepal.

Sample Size

The farmers of Khadbari Municipality, Chainpur Municipality, Madi Municipality, Sabhapokhari Municipality, Panchkhapan Municipality, Dharmadevi Municipality, Bhotkhola Rural Municipality, Makalu Rural Municipality, SilichongRural Municipality and Chichila Rural Municipality were targeted. A total of 80 households were selected for the survey.

Sampling Procedure

Large Cardamom farming households were surveyed and samples were selected based on purposive random sampling method.

Selection of the Respondents

Farmers who were cultivating large Cardamom for at least 10 years were selected for the study for getting the useful and accurate information regarding the impact of Climate Change in Large Cardamom production and productivity.

Primary Source of Data

The primary data were collected from the farmers of the study area by face to face interaction with prepared questionnaire in order to get the correct information regarding the changes seen in climatic variable and its impacts on Large Cardamom production.

Secondary Source of Data

The secondary data were collected from different organizations, institutions and publications related to agriculture such as Krishi diary, Ministry of Agriculture and Livestock Development (MoALD), Central Bureau Statistics (CBS), Agriculture knowledge Center (AKC). The data related to seasonal climatic variables of past 10 years were collected from Department of Hydrology and Meteorology (DHM) and World Weather Online.

Technique of Date Collection

The questionnaire was prepared and Large Cardamom farmers were interviewed face to face to collect the primary data for the study. Information was collected from the farmer`s perception.

Regression Analysis

Regression formula is given as:

$\Delta yield = a + b\Delta T\ max + b2\Delta T\ min + b3\Delta\ rainfall + c$

Where,

a = Intercept

b, b2, b3 = Regression Coefficient

ΔT max = Interannual change in seasonal average maximum temperature

ΔT min = Interannual change in seasonal average minimum temperature

Δrainfall = Interannual change in seasonal total rainfall

C = Residual error

Processing of Temperature Data

The data of seasonal monthly temperature of the district was collected and was processed. Monthly temperature for each month was calculated as:

Temperature (T_{mean}) = (T_{max}+T_{min})/2

Where,

T_{max}= Average seasonal maximum temperature of a particular month

T_{min}= Average seasonal minimum temperature of a particular month

Processing Rainfall Data

The data of seasonal rainfall was collected and was processed as:

$R = R_1+R_2+R_3+……..+R_n$

Where,

R= Total seasonal rainfall

Ranking of the Multiple Option

The preference of the respondents as ranked with the use of index. In scaling technique, the reasons for choosing Large Cardamom farming by the respondent problems seen due to climate change were ranked by using four point scaling technique comparing as most, considerable, moderate and least important reasons using scores of 1, 0.75, 0.5 and 0.25 respectively. The index value was computed by using formula:

Index value (I_v)= $\Sigma \frac{Si.Fi}{N}$

Where,

Σ = Summation

Si = Scale value of i^{th} response

Fi =Frequency of i^{th} response

N= Total number of respondents

The reasons were ranked based on the index value; higher index value represents higher reasons.

Results

Socio-Economic and Demographic Characterization

The total population of the 80 household was 479 out of which 15% were female and 85% were male respondents (Fig. 1). The economically active population on cardamom production was higher (62%) between age 15-60 yrs followed by (27%) below 15yrs and (11%) above 60 yrs (Fig. 2). From the survey, it was found that the literacy rate of the respondent household was 93.75% which was higher than the national literacy rate (66.22%) and literacy rate of Sankhuwasabha district is 56% (CBS,2012). 11.25% of the respondents had completed bachelors and above. The percentage of the respondents having primary, secondary and higher secondary education were 15.50%, 26.25% and 27.50% respectively whereas the national literacy rate of primary, secondary, higher secondary and bachelors were 40.63%, 21.83%, 12.28 and 1.56% respectively. Out of total surveyed population only 6.25% were illiterate and 13.75% were literate (Fig. 3). In ethnic composition of respondents, majority were Janajati 58 (73%) followed by Chhetri 21 (26%), Brahmin 1(1%) (Fig. 4) which is very different from the district ethnic composition Brahmin 5%, Chhetri 18%, Janajati 43%, Dalit 5% and Other 29% (CBS 2012).

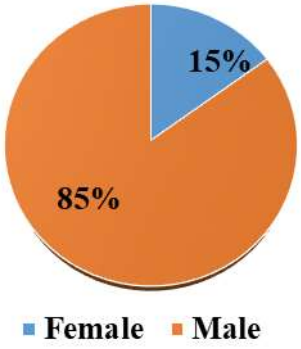

Fig. 1: Gender Percentage of Respondents in the Study Area. Source: Field Survey 2021.

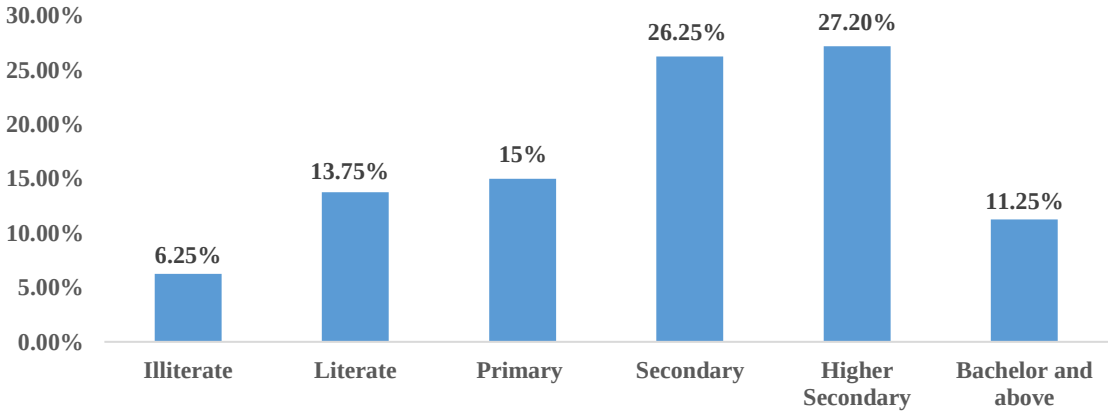

Fig. 2: Education Level of Respondents in the Study Area. Source: Field Survey, 2021.

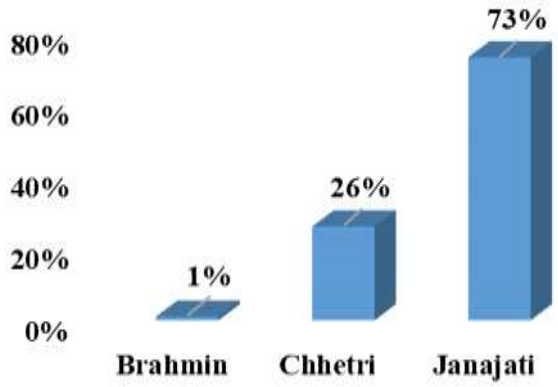

Fig. 3: Ethnic Composition of Respondents in the Study Area. Source: Field Survey, 2021.

Table 1: Reason for choosing Large Cardamom cultivation in Sankhuwasabha District, 2021.

Reasons	Index Value	Rank
Higher Income than other Horticultural crops	0.9	1
Easy cultivation than other Horticultural Crops	0.76	2
Marginal Land can be utilized	0.59	3
Following the Tradition	0.49	4
Other Reason	0.26	5

Source: Field Survey, 2021.

Reasons for Choosing Large Cardamom Cultivation with Rank

There were many reasons for the cultivation of Large Cardamom. Among them, some reasons were the utilization of marginal land, following the tradition, easier cultivation than other horticultural crops, higher income generating crops than other horticultural crops and other reasons. From the survey, it was found that the first reason for selecting Large Cardamom cultivation was higher income than other horticultural crops followed by cultivation is easier than other horticultural crops, marginal land can be utilized, following the traditions respectively. The least selected reasons were other reasons of Large Cardamom farming respectively (Table 1).

Farmer's perception on the weather in past 10 years (Since 2010)

Temperature

It was found that there was increase in overall temperature and summer temperature and also increase in winter temperature since 2011 in Sankhuwasabha district. Out of the 80 (100%) respondents, most of the respondents 77 (96.25%) perceived increase in overall temperature. Also 77 respondents perceived increase in summer temperature and 49 respondents perceived increase in winter temperature. Similar data were observed in other districts of Nepal like Kailali (Maharjan *et al*., 2015), Chitwan, Rampur (Paudel *et al*., 2014), Banke and Dang (Devkota, 2014).

Rainfall

Among the 80 respondents, 46 perceived increased in overall rainfall. Decreased in amount of overall rainfall was felt less by 28 respondents and 6 had no idea about the amount of overall rainfall in the study area since 2011. Similarly, 35, 39, 3 and 3 respondents had perceived increase, decrease, no idea and same in rainfall frequency respectively since 2011. Also, 34, 32, 3 and 11 respondents had perceived increase, decrease, no idea and same in rainfall intensity respectively since 2011. Likewise, 48, 26, 11 and 4 respondents perceived increase, decrease, no idea and same monsoon rainfall respectively. 10, 65 and 5 respondents had perceived increase, decrease and same winter rainfall respectively since 2011 (Fig. 5).

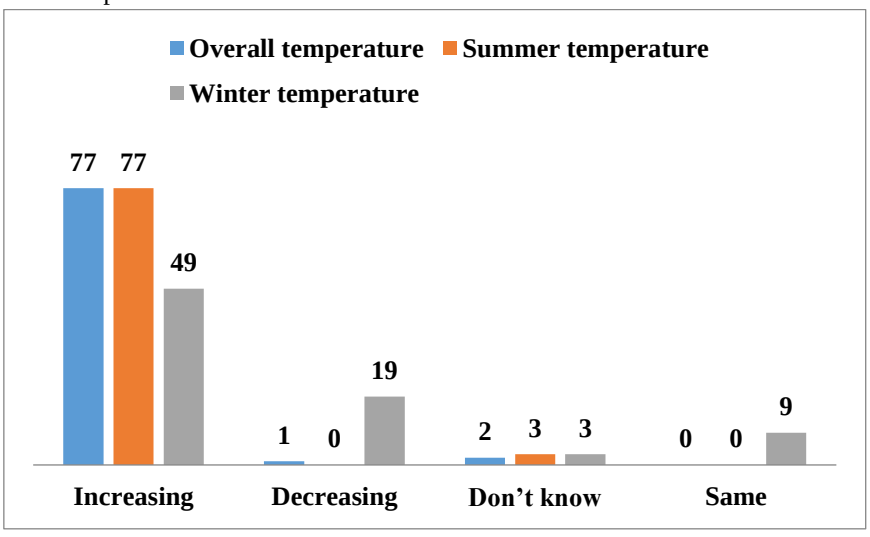

Fig. 1: Farmer's perception about temperature in the Study Area. Source: Field survey 2021.

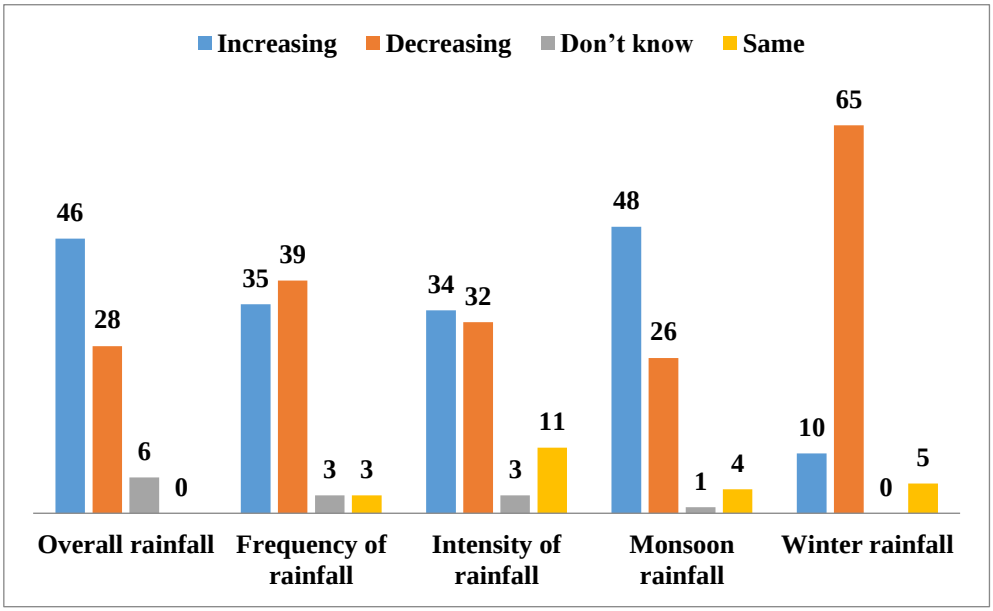

Fig. 2: Farmer's perception about rainfall pattern in the Study Area. Source: Field survey 2021.

Farmers' Perception on Large Cardamom Yield

Farmers perceived lower yield of Large Cardamom since 2011 in the study area. 85% of respondents observed decrease in Large Cardamom yield whereas 9% and 6% of respondents observed increase (Fig. 6).

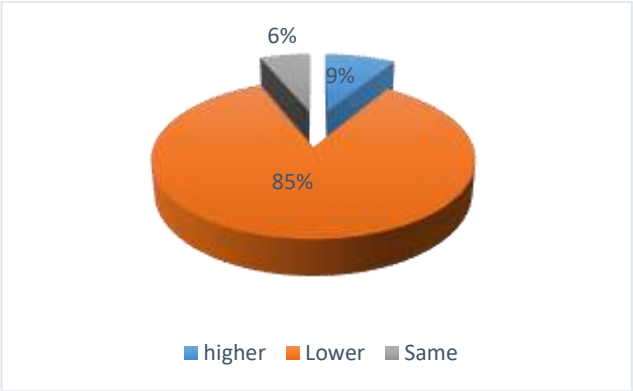

Fig. 3: perception about Large Cardamom yield in the Study Area. Source: Field Survey 2021.

Farmers' Perception on Occurrence of Disease and Pest

Majority of respondents felt high occurrence of disease pest since 2011. Occurrence of disease like Wilt, Leaf and root rot were increased whereas leaf streak, sooty mold were decreased. Occurrence of pest like Gabaro, Caterpillar and Aphids were increased whereas Thrips was heavily decreased. One of the major problems in Large Cardamom is Chirkey, Furkey viral disease. According to the respondents, activities of this viral disease were very high in past 10 years.

Production and Productivity Trend of Large Cardamom in Sankhuwasabha District in Past 10 Years

The trend of production and productivity of Large Cardamom were fluctuating every year. Productive area and production were increased up to 2014/15 and productivity was increased and reaches highest 0.53 ton/ha in 2015/16. Then after, total area and productive area were decreased and production and productivity slightly increased. According to the respondents, this slight increase in production and productivity were only due to their intensive care. The production was highest during year 2019/20 and productivity was highest during fiscal year of 2015/16 and 2018/19 (Fig. 8).

Regression Analysis of Secondary Data over Last 10 Years

Secondary data for the regression analysis were dependent variable (Large Cardamom yield) and independent variable (Temperature and Rainfall).The results of regression model shows that there is no relation between the dependent and independent variables i.e. seasonal average minimum temperature since the p-value of all the variables are more than 0.05. But seasonal average maximum temperature and total seasonal rainfall has shown some relation. Hence, Climatic variables i.e. seasonal average minimum temperature do not influence the Large Cardamom yield and seasonal average maximum temperature and total seasonal rainfall influence the Large Cardamom yield significantly (Table 2).

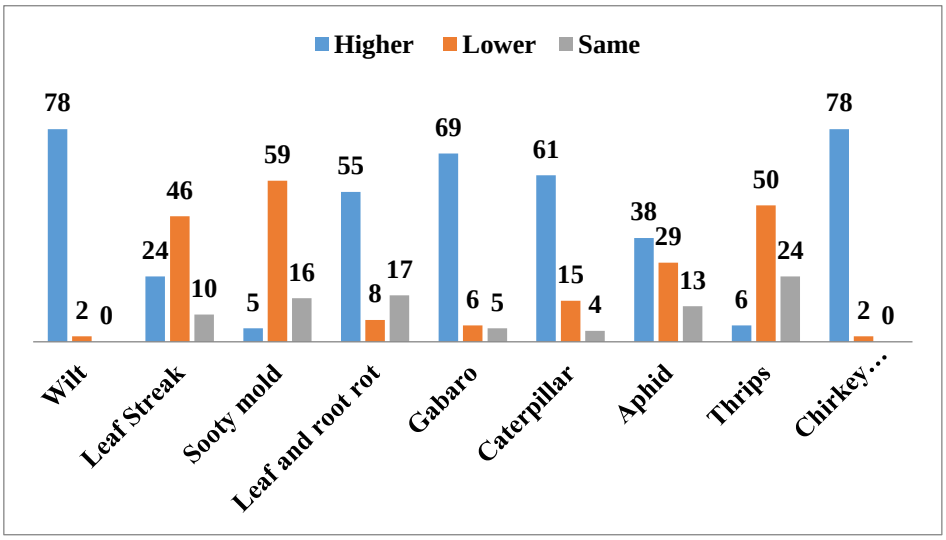

Fig. 4: Farmers perceptions on occurrence of the disease and pest in the Study Area. Source: Field Survey 2021.

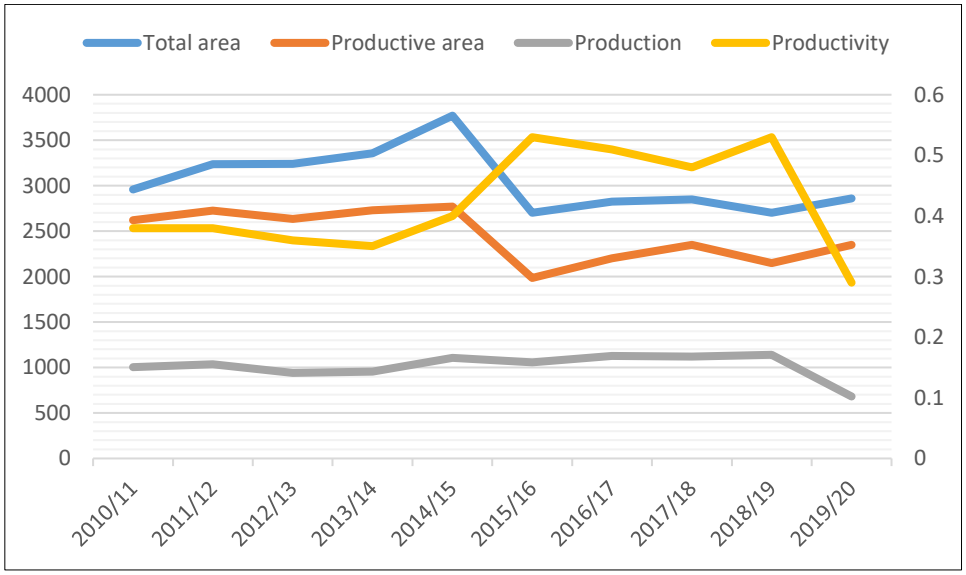

Fig. 5: Production and Productivity trend of Large Cardamom in Sankhuwasabha district in past 10 years duration. Source: MoAD and AKC 2021.

Table 2: Regression Analysis of Secondary Data of Large Cardamom Yield, Temperature and Rainfall of Sankhuwasabha district over last 10 year.

Climatic Variables	Coefficients	P-value
Intercept	0.360012	-20.434
Seasonal average maximum temperature	0.001324	-66.4743
Seasonal average minimum temperature	0.439402	-0.06241
Total seasonal rainfall	0.04554	0.05445

Source: MoALD and World Weather Online.

Trend Analysis of Annual Climatic Variables

Trend analysis showed that the average annual maximum temperature was decreased by -0.0137°C and average annual minimum temperature was decreased by -0.0045°C. Total annual rainfall was increased by 1.2326 mm per year over last 10 years. The results of trend analysis and farmers perception about maximum and minimum temperature showed different result and similar result about rainfall. Trend analysis showed that the productivity of Large Cardamom is decreasing by 0.0026 ton/ha per year. The decrease in productivity may be due to seasonal average maximum temperature and other factors like disease pest occurrence, cultivation practices etc.

Table 3: Result of Trend of Annual Temperature and Rainfall in Sankhuwasabha District, 2021.

Annual Climatic Variables	Average	SD	Annual Change
Average maximum temperature (°C)	0.158	2.6392	-0.0137
Average minimum temperaure (°C)	-0.117	1.3659	-0.0045
Total Rainfall (mm)	83.585	1175.9580	1.2326

Source: MoALD and World Weather Online.

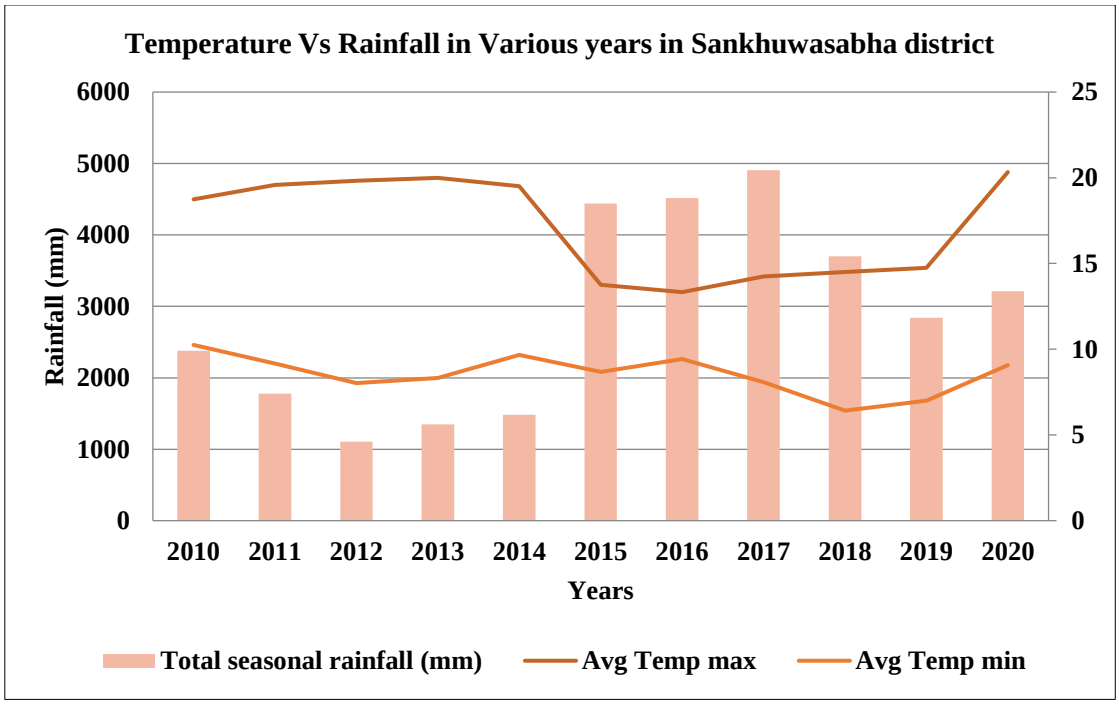

Fig. 6: Trend analysis of annual temperature and rainfall. Source: World Weather Online.

Discussion

From the above results, it is revealed that production of Large Cardamom was varied in Sankhuwasabha district. The production of Large Cardamom data was collected from 2010 to 2020 from (MoALD, 2020) and the trend of Large Cardamom production and productivity were in increasing rate from year 2010/11 to 2015/16 from 1005 ton to 1058 ton and 0.38 ton/ha to 0.53 ton/ha. Then after, the production and productivity were in decreasing order and found lowest 681.5 ton and 0.29 ton/ha in 2019/20. From the trend analysis it was also found that Large Cardamom productivity was decreased by 0.0026 ton/ha every year. Similar result has shown by(Adhikari *et al*., 2020).From the study we observed, decrease in production and productivity and this trend has been followed from many years. The reason behind this might be due to climatic and non-climatic factors. Similar results are found in (Sharma *et al*., 2016).

From the trend analysis, average seasonal maximum and minimum temperature were decreased by -0.0137°C and -0.0045°C respectively and total annual rainfall was increased by 1.2326 mm per year. The regression analysis of these secondary data showed decreased in seasonal average maximum temperature and increased in total seasonal rainfall and trend was found to be significant ($p<0.05$) at Sankhuwasabha district. The trend in minimum temperature was decreased and found to be insignificant ($p>0.05$). Similar result has shown by(Adhikari *et al*., 2020b).

Relationship between climatic condition and Large Cardamom production were also studied. Study showed, there was clear significant correlation between annual average maximum temperature and total seasonal rainfall and production and no significant correlation between average annual minimum temperature and yield. It also showed that with increase in average maximum temperature and total seasonal rainfall yield increased and with decrease in average maximum temperature and total seasonal rainfall yield also decreased but yield was not affected by annual minimum temperature. Similar finding has been observed by (Sharma *et al*., 2016), (Chapagain, 2011) and (Adhikari *et al*., 2020a).

Some findings reveled that with relatively small change in temperature and precipitation would have large effects on soil moisture status and the volume and timing of runoff of water as Nepal is highly vulnerable to climate change (Rijal, 2014). This deficit in water availability decreases the yield of Large Cardamom. A major problem faced by the Large Cardamom farmers was also disease-pest problems and then

drought and then fruit ripening problem and so on. Similar findings were obtained by (Adhikari *et al*., 2020a). Viral diseases like Chirkey and Forkey, fungal disease like Wilt and Leaf and Root rot and insect pest- Gabaro and Caterpillar were the most devastating disease pest of Large Cardamom orchard and this statement was supported by (Rijal, 2014).

Conclusion

The Climate Change has affected almost all the places in the world. Climate change possesses significant risk to future crop productivity as increase in disease-pest occurrence, change in rainfall patterns and increase in temperature. The study revealed that all of the respondents in the study area felt the change in climate. Due to the change in climate, there was decreasing trend of production and productivity in Large Cardamom. From the study, it was found that majority of the respondents were male, economically active, literate, Janajati and their major source of income was agriculture. The majority of respondents produced Large Cardamom and for alternative source of income they cultivated Maize, Paddy, Millet, etc.

Almost all the respondents said that the overall temperature was increased from past ten years. Majority of respondent revealed that overall rainfall was increased but the production was decreased due to lack of irrigation facilities and drought during flowering and fruit settings periods (April-May). From the study, it was also found that natural disaster like frost; hailstone had no major role in Large Cardamom production and productivity. The occurrence of diseases like Wilt, Leaf and Root rot, Chirkey and Furkey and pest like Gabaro, Caterpillar and Aphid had increased from the past ten years that had heavily decreased the production and productivity of Large Cardamom. Since 2010, the Large Cardamom productivity was decreasing by 0.0026 ton/ha and reason for decreasing trend in productivity was due to seasonal average maximum temperature and total seasonal rainfall. The other factors for decrease in the production and productivity may be due to disease pest occurrence, less care for orchard management, Nobel Corona Virus (Covid-19) etc.

Authors' Contribution

P. Swar & S. Bohara_designed the research plan; A. Sah performed experimental works & collected the required data. U. Timilsina, S. Bohara A. Shrestha & S. Chaudhary analysed the data; P. Swar prepared the manuscript. A. Sah & A. Shrestha critical revised and finalized the manuscript. Final form of manuscript was approved by all authors.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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