Economic Affairs, Vol. 67, No. 04, pp. 385-392, September 2022
DOI: 10.46852/0424-2513.4.2022.2

AESSRA

Research Paper

Production of Large Cardamom under Climate Change Scenario- Findings from Sikkim

S.M. Feroze[1]*, Nivetina Laitonjam[1], Ram Singh[2] and Abujam Anuradha Devi[1]

[1]Department of Agricultural Economics, College of Agriculture, Central Agricultural University, Imphal, Manipur, India
[2]Department of Agricultural Economics, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University, Imphal, Manipur, India

*Corresponding author: ferozendri@gmail.com (**ORCID ID:** 0000-0002-2425-9530)

Received: 10-05-2022 **Revised:** 27-08-2022 **Accepted:** 05-09-2022

ABSTRACT

Large cardamom is an important cash crop for the farmers of Sikkim. This paper estimated the trend, growth, and instability in large cardamom production in Sikkim. The paper also forecasts the area, production,and yields of the crop for the period 2003-2019. The study revealed that there is a positive significant linear trend in the production and yield of large cardamom. The annual growth was also positive for production and yield of large cardamom. The study forecasted that the area under cardamom is to decline by 2030 while the production and yield of the crop was estimated to increase in future. Correlation and regression technique was used to study the effect of climate change on the production of large cardamom during the same period. The study showed that annual rainfall had positive and significant influence on production of the crop. Hence, assured irrigation during the critical phase of crop growth will ensure steady production of the crop.

HIGHLIGHTS

- The study revealed that production and yield of large cardamom grew at the rate of 2.94 percent and 2.09 percent, respectively in the State.
- The correlation and regression result showed positive and significant influence of annual rainfall on production of large cardamom.

Keywords: Large cardamom, climate, forecasting, instability

Large cardamom (*Amomum subulatum*) is a perennial herbaceous plant which is popularly known as 'Queen of Spice' and is the second most important spice crop in the world, next to black pepper. Large cardamom is native to Eastern Himalayan region and believed to be first cultivated by the indigenous Lepcha tribe and later on by the Bhutias and Nepalies of Sikkim and then spread to its neighboring countries like Southern Bhutan and Eastern Nepal (Sharma *et al.* 2007). It is one of the most important cash crops of the Himalayan region which include Sikkim, the Indian hills of Darjeeling, southern Bhutan and eastern part of Nepal (Sharma *et al.* 2000). In India, the total area under large cardamom is 44.70 thousand ha with a total production of 8803 MT during 2020-21. The area under large cardamom was highest in Sikkim (23312 ha), followed by Arunachal Pradesh (11403 ha) and Nagaland (6499 ha) (GoI, 2021a). India is also a major exporter of large cardamom in the world. During 2019-20, a total quantity of 1310 MT of large cardamom was exported with a total value of ₹ 7090.17 lakh in return (GoI, 2021b).

Cardamom is a climate sensitive and grown as rain fed crop (Murugan *et al*. 2007). Temperatures above 25°C accelerate the ripening of cardamom capsule and offend lead to early maturity. However, continuous exposure to high day temperature of above 32°C leads to withering of leaves and

How to cite this article: Feroze, S.M., Laitonjam, N., Singh, R. and Devi, A.A. (2022). Production of Large Cardamom under Climate Change Scenario- Findings from Sikkim. *Econ. Aff.*, **67**(04): 385-392.

Source of Support: None; **Conflict of Interest:** None

young tillers. A high temperature in association with continuous dry spell during flowering season (April-May) may reduce pollination and also cause abortion of cardamom flowers (Murugan *et al*. 2009). Rainfall also plays an important role in increasing cardamom productivity as the crop is sensitive to both excess rainfall and drought. A well distributed annual rainfall of 1500-4000 mm is favorable for cardamom (Ajmera *et al*. 2018) and 2000-4000 mm for large cardamom production (Sharma *et al*. 2016). On the other hand, frost, hailstorm, snowfall, storm, water logging due to continuous rain, disease and pest affect large cardamom production negatively (Chapagain, 2011).

Sharma *et al*. (2016) reported that altered season, erratic or scanty rainfall, prolong dry spells, increased temperature, loss in soil moisture and increasing instances of pest and disease attack were the major factors responsible for declining large cardamom production in Sikkim. Earlier studies used simulation models to study the potential impact of climate change on natural and managed ecosystem (Tao *et al*. 2000; Parry *et al*. 2004). One way to estimate the effect of climate change variability on yield of crop is through historical records (Thompson 1975, 1986; Changnon and Winstanley, 2000). Therefore, the present study estimated the trend, growth and instability in large cardamom forecasted the area, production and yield and estimated the effect of climatic variables on yield of large cardamom.

MATERIALS AND METHODS

Time series data on daily rainfall (2003-2019) and daily temperature were extracted from high resolution 0.25° × 0.25° and 1° × 1° daily gridded data, respectively obtained from India Meteorological Department (IMD), Pune. For the present study, 8 rainfall stations and 1 temperature stations which were between 88.25°E to 88.5°E longitude and 27.25°N to 28°N latitude were considered. The individual station data were used to arrive at state average. The temporal data on area, production and yield of large cardamom (2003-2020) was collected from the Directorate of Economics and Statistics, Government of Sikkim. Statistical tools like Compound Annual Growth Rate and Cuddy-Della Valle Index (CDVI) were utilized to work out the growth rate and instability in area, production and yield of large cardamom in the state, respectively.

Compound Annual Growth Rate

The formula used for calculating CAGR is given below:

$$y = ab^t e \quad \ldots(i)$$

Equation (i) is converted to logarithmic form as below:

$$lnY = lna + tlnb + e \quad \ldots(ii)$$

where '*Y*' is area / production/ yield; '*t*' is the number of years; '*a*' is the constant; '*b*' = (1 + *r*) is the slope coefficient that measures relative change in *Y* for absolute change in explanatory variable; '*r*' is growth rate; '*ln*' is the natural logarithm and '*e*' is error term.

The CAGR is estimated by using the following equation:

$$CAGR = [antilog\,(b) - 1] * 100 \quad \ldots(iii)$$

Measuring instability

Cuddy Della Valle Instability index (CDVI) accommodated trend present in the time series data (Cuddy and Della Valle 1978) and superior over standard deviation which is the scale dependent measure. The CDVI is estimated using the following formula:

$$CDVI = CV \times \sqrt{1 - \overline{R}^2} \quad \ldots(iv)$$

Where, *CV* is the coefficient of variation, and $\overline{R}$ is the coefficient of determination from a time-trend regression adjusted for its degrees of freedom. Higher value of the index shows higher instability and *vice-versa*. CDVI range is categorized into low (0 < CDVI > = 15), medium (15 < CDVI > = 30) and high (CDVI > 30) instability (Sihmar, 2014).

Ordinary Least Squares Method

Ordinary Least Squares (OLS) technique was used to determine the effect of rainfall and temperature on production of large cardamom. Production of

large cardamom was regressed on annual rainfall, annual minimum and maximum temperature for the period of 2003-2019. Linear regression model used in the present study is as follows:

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + e$$

Where, Y = Production of large cardamom (MT); a = intercept; b_1, b_2, and b_3 are the regression coefficients; x_1, x_2 and x_3 are the annual rainfall, annual maximum and minimum temperature, respectively and e = residual of regression.

RESULTS AND DISCUSSION

Trend growth and instability in large cardamom production

The total area under large cardamom in the state was 21.78 thousand ha with a total production of 5.23 MT and average yield of 0.24 MT/ha as in 2015-16in Sikkim (Table 1) which increased to 23.31 thousand ha of area under large cardamom but the production decreased to 4.78 MT with yield level of 0.21 MT in 2020-21. All though the crop was cultivated in all the four districts, the area under large cardamom was highest in North Sikkim (6.53 thousand ha) which was 29.98 percent of the total area under the crop in the state, contributing about 30.02 per cent to the total production of 1.57 MT. East Sikkim's share in total state's production was 27.34 per cent from 27.41 per cent of total area under large cardamom. Off-late the farmers of West Sikkim district have started large cardamom cultivation seriously and may probably overtake East Sikkim and North Sikkim districts in terms of area and production. The contribution of South Sikkim in total production of large cardamom was the least in the state. The production of large cardamom in different districts were dependent on area under the crop as yields of large cardamom in different districts were estimated to be almost equal (0.24 MT/ha).

The linear trend for area under large cardamom during 2003-2020 is positive but insignificant, on the other hand, the linear trends for production ($\beta = 0.11$, $p<0.01$) and yield ($\beta = 0.003$, $p<0.05$) of large cardamom are positive and significant in the state, which can also be observed in the time series lines depicted in Fig. 1. In the state, the production of large cardamom grew by 2.94 per cent annually

Table 1: Area, production and yield of large cardamom in Sikkim in 2017-18

Sl. No.	District	Area ('000ha)	Production (MT)	Yield (MT/ha)
1	North Sikkim	6.53 (29.98)	1.57 (30.02)	0.24
2	East Sikkim	5.97 (27.41)	1.43 (27.34)	0.24
3	South Sikkim	4.34 (19.93)	1.04 (19.89)	0.24
4	West Sikkim	4.96 (22.77)	1.19 (22.75)	0.24
	Total	21.78	5.23	0.24#

Source: *GoS, 2018.*

Note: *The figures in parenthesis are percentage to total and # indicates state average.*

Table 2: Trend, growth and instability in large cardamom production in Sikkim during 2003-2020

Sl. No.	Particulars	Area ('000ha)	Production (000'MT)	Yield (MT/ha)
1	Mean	18.84	3.90	0.21
2	Linear trend (b)	0.13 (p=0.49)	0.11 (p<0.01)	0.003 (p<0.05)
	R^2	0.23	0.76	0.34
3	CAGR (%)	0.83	2.94	2.09
4	Instability			
(a)	STD	3.88	0.70	0.04
(b)	CV (%)	20.62	18.03	18.79
(c)	Skewness	0.16	0.36	-1.02
(d)	Kurtosis	-1.45	-1.10	-1.02
(e)	CDVI	3.57	15.71	10.96

[Original].

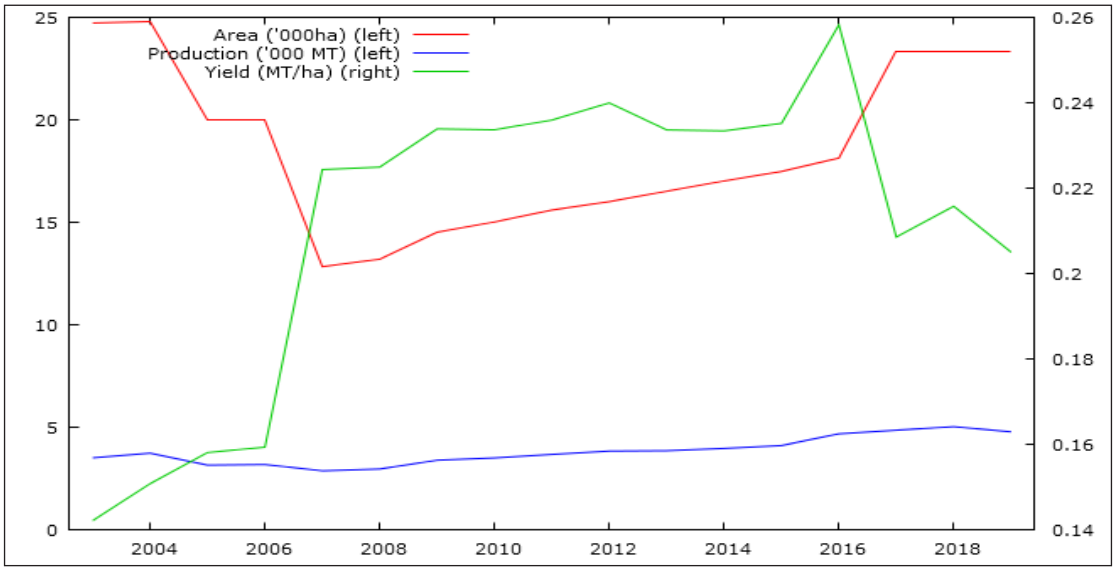


Fig. 1: Trend in area, production and yield of large cardamom in Sikkim during 2003-2016

which is due to 2.09 per cent of annual growth in yield and 0.83 per cent of annual growth in area under large cardamom in during 2003-2020.

In Sikkim, the area under large cardamom was only 19.91 thousand ha in 1999, which increased to 22.71 thousand ha in 2003 but as a result of long dry spells accompanied with disease infestations during the year 2004–2007, the area and yield decreased each year, with a sharp drop of 37 per cent in area under large cardamom during 2006 to 2007 (Sharma *et al.* 2016). Fig. 1 shows that the time series lines are not smooth indicating inter year variations in area, production and yield of large cardamom in the state. The percentage variation from the mean was highest in case of area (20.62%), followed by yield (18.79%) and production (18.03%). The estimated values of skewness for area and production of large cardamom were positive indicating that in most of the years the area under and production of large cardamom were low and lay nearer to the lower limit (Table 2). The average area under large cardamom in the state was 18.84 thousand ha but the area under cardamom was below average for ten years during 2007-2016. Likewise, the average production of large cardamom was 3.90 thousand MT during 2003-2020, however the production was below the average for eleven years i.e., 2003-2013. On the other hand, skewness for yield of large cardamom was negative indicating that in most of the years yield of large cardamom was high and was nearer to upper limit. The average yield of cardamom in Sikkim was 0.21 MT/ha but only during 2003-2006, the yield was below average. The kurtosis values for area, production and yield of large cardamom were negative in the state during 2003-2020. The CDVI for area under and yield of cardamom were 3.57 and 10.96 showing low instability while the CDVI was 15.71 in production indicating medium instability.

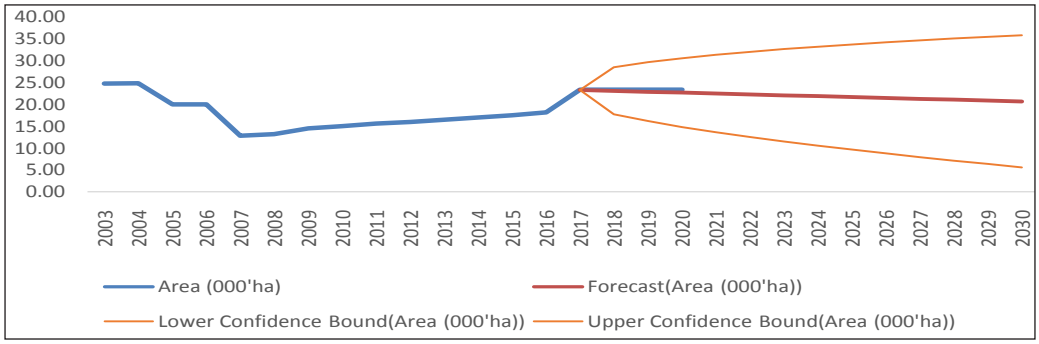
Table 3: Forecasted value of area, production and yield of large cardamom in Sikkim

Year	Area ('000ha)	Production (000' MT)	Yield (MT/ha)
2022	22.31	6.17	0.24
2023	22.10	6.44	0.25
2024	21.90	6.70	0.25
2025	21.70	6.96	0.26
2026	21.50	7.22	0.27
2027	21.30	7.49	0.27
2028	21.10	7.75	0.28
2029	20.90	8.01	0.29
2030	20.69	8.27	0.29

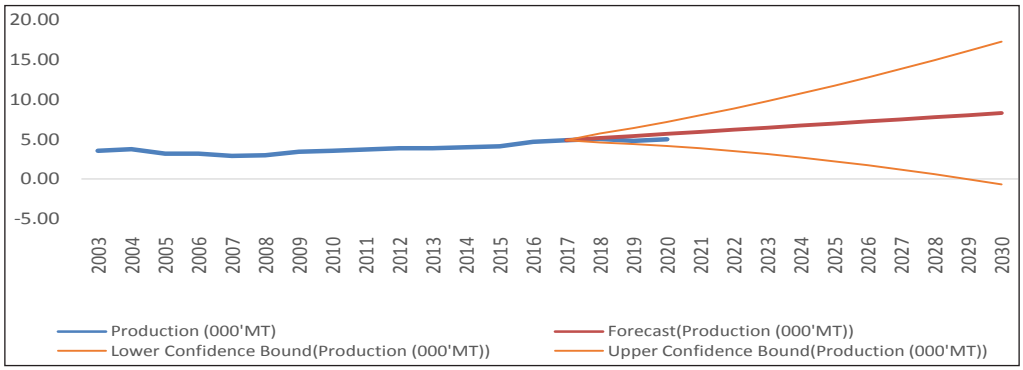
[Original].

Forecasting of large cardamom area, production and yield

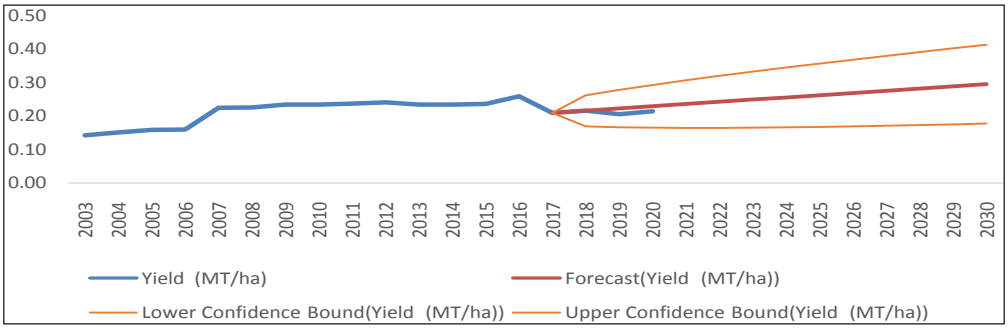
The area under large cardamom during 2022 was estimated to be 22.31 thousand ha but it was projected to further decline to 20.69 thousand ha during 2030. Although the area under large cardamom was forecasted to decline, its production and yield was estimated to increase in the next



(a) Area under large cardamom



(b) Production of large cardamom



(c) Yield of large cardamom

Fig. 2: Forecasting of area, production and yield of large cardamom in Sikkim

decade. The projected production and yield of large cardamom during 2022 was 6.17 thousand MT and 0.24 MT/ha which will further rise to 8.27 thousand MT and 0.29 MT/ha, respectively.

Effect of climatic variables on large cardamom production

Sikkim received average annual rainfall of 2636.47 mm during 2003-2019 with maximum annual rainfall of 3310.08 mm in 2018 and minimum annual rainfall of 1817.34 mm in 2003. The percentage variation from mean in annual rainfall was 17.80 per cent while the inter year variation in large cardamom production was 16.83 per cent. The average annual minimum and maximum temperature was 16.94°C and 26.83°C during 2003-2019 (Table 4).

Table 4: Descriptive statistics of the variables used in regression model

Particular	Average	Maximum	Minimum	CV (%)
Production ('000MT)	3.83	5.03	2.88	16.83
Annual rainfall (mm)	2636.47	3310.08	1817.34	17.80
Minimum temperature (°C)	16.94	17.45	16.32	—
Maximum temperature (°C)	26.83	27.37	25.81	—

[Original].

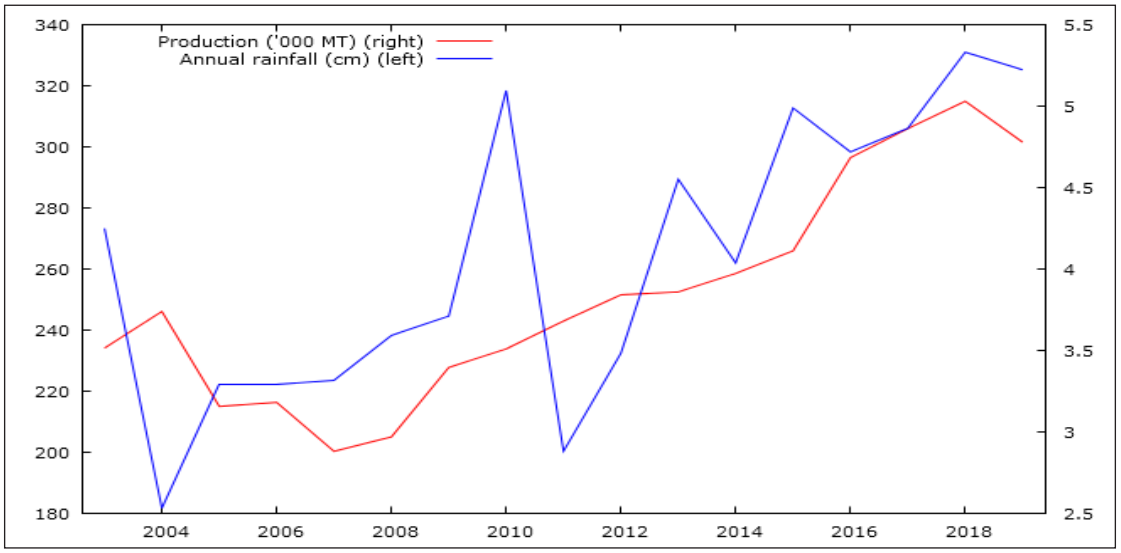


Fig. 3: Plotting annual rainfall and production of large cardamom in Sikkim

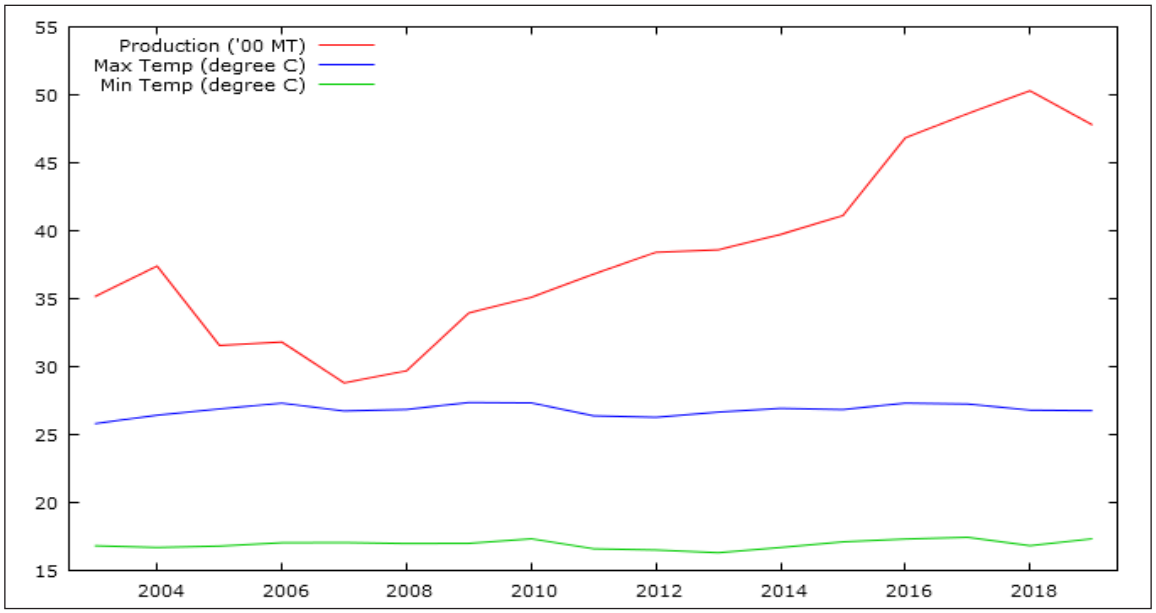


Fig. 4: Plotting minimum and maximum temperature and yield of large cardamom in Sikkim

Table 5: Estimated correlation co-efficient and regression coefficients dependent variable: Production of large cardamom

Variables	Regression Coefficient	SE	p-value	Correlation coefficient (r)
Constant	5.296	9.201	0.575	
Annual rainfall	0.001***	0.000	0.007***	0.688***
Max T	-20.02	36.19	0.772	0.109
Min T	-0.064	0.574	0.912	0.269
R-square	0.48			

Note: **** represents p< 0.01.*

[Original].

Fig. 3 exhibits that with increase in rainfall amount the production of large cardamom has increased in the state. The estimated correlation indicates strong positive linear relationship ($\beta = 0.688$; $p<0.01$) between production of large cardamom and annual rainfall in the state. Similarly, the results of OLS model also reveal that the annual rainfall has positive and significant ($\beta = 0.001$; $p<0.01$) influence on production of large cardamom. Jamtsho *et al.* (2020) reported that amount of rainfall had positive effect on yield of cardamom in the first few years, however as the years passed by, increase in rainfall negatively affect yield of cardamom in Bhutan. Chapagain (2011) also observed that rainfall during critical season was one of the factors influencing yield of the crop. The regression coefficients for maximum and minimum annual temperature turned out to be negative but they are statistically insignificant which can be observed in Fig. 4 also. It implies that with the increase in annual maximum and minimum temperatures production of large cardamom will decrease. Climate-induced diseases such as *Chirkey, Furkey,* fungal disease *Colletotrichum* blight *etc.* which cause drastic loss in production and area under cardamom (Sharma *et al.* 2016). Partap *et al*. (2014) have also identified factors such as erratic, unseasonal, and scanty rainfall, loss of soil moisture and fertility, long dry spells and rising temperature emergence of diseases and pests, altered seasons for flowering and fruiting which caused reduction in production and ultimately decline in area under cardamom.

CONCLUSION

The study revealed the production of large cardamom has increased due to increase in yield and area during 2013-20. Though the growth for yield is encouraging the area under crop has reached to stagnancy and projected to decline by 2030 while the production and yield is estimated to increase in future. Hence, policy measures are necessary for arresting the decline in area and bringing new areas under this crop to have its dominance over other large cardamom growing areas. The study also revealed the significant positive influence of annual rainfall on production of large cardamom but the State receives good amount of rainfall in some years, while low rainfall in some years. Hence, sprinkler irrigation facilities should be created for all the large cardamom growers to cope up with the possible production loss in less rainfall years.

ACKNOWLEDGEMENTS

This article is derived from the ICSSR, New Delhi funded project on "*Spice based rural economy and livelihood under climate change in Himalayan region of India: Economics of adaptation measures*". The authors acknowledge the funding agency.

REFERENCES

Ajmera, P., Chauhan, A. S., Sharma, L. and Singh, M. 2018. Cardamom crop production and harvesting: A review. *Int. J. Food Sci. Nutr.,* **3**(2): 174–178.

Changnon, S.A. and Winstanley, D. 2000. Long-term variations in seasonal weather conditions important to corn production in Illinois. *Clim. Change,* **47**: 353–372.

Chapagain, D. 2011. Report on assessment of climate change impact on large cardamom and proposed adaptation measures in eastern hill of Nepal. Submitted to NAPA Project Team National Adaptation Programme of Action (NAPA) Project Office Ministry of Environment Singha Durbar, Kathmandu Nepal.

Cuddy, J.D.A. and Della Valle, P.A. 1978.Measuring the instability in time series data. *Oxford Bull. Econ. Statist.*, **40**: 79- 85.

GoI 2021a. Item wise export of spice from India. Spice Boards of India, Government of India.

GoI 2021b. Major Spice / State wise area and production of spice. Spice Boards of India, Government of India.

GoS 2018. Statistical Journal 2018. Department of Economics, Statistics, Monitoring, and Evaluation. Government of Sikkim, Gangtok.

Jamtsho, T., Gyeltshen, T. and Chettri, N. 2020. The effect of rainfall on cardamom production in Bhutan, Middle European Scientific Bulletin, ISSN 26949970.

Murugan, M., Backiyarani, S., Josephrajkumar, A., Hiremath, M.B. and Shetty, P.K. 2007. Yield of small cardamom (*Elettaria cardamomum* M) variety PV1 as influenced by levels of nutrients and neem cake under rain fed condition in southern Western Ghats, India. *Caspian J. Environ. Sci.,* **5**(2): 19–25.

Murugan, M., Shetty, P.K., Mukund, V. and Panigrahy, B. 2009. Soil and surface air warming in Cardamom ecosystem in Southern Western Ghats, Kerala, India. *Int. J. Agri. Rural Dev.,* **11**(2): 52-64.

Parry, M.L., Rosenzweig, C., Iglesias, A., Livermore, M. and Fischer, G. 2004. Effects of climate change on global food production under SRES emission and socio-economic scenarios. *Global Environ. Chang.,* **14**: 53–67.

Partap, U., Sharma, G., Gurung, M.B., Nakul, C. and Eklabya, S. 2014. Working Paper 2014/2 on Large Cardamom farming in changing climatic and socioeconomic

conditions in the Sikkim Himalayas. International Centre for Integrated Mountain Development, Kathmandu, Nepal, June 2014.

Sharma, E., Sharma, R., Singh, K.K. and Sharma, G. 2000. A boon for mountain populations: Large cardamom farming in the Sikkim Himalaya. *Mt. Res. and Dev.,* **20**(2): 108–111.

Sharma, G., Partap, U., Dahal, D.R., Sharma, D.P. and Sharma, E. 2016. Declining Large-Cardamom production systems in the Sikkim Himalayas. *Mt. Res. and Dev.,* **36**(3): 286-298.

Sharma, R., Xu, X. and Sharma, G. 2007. Traditional agroforestry in the eastern Himalayan region: Land management system supporting ecosystem services. *Trop. Ecol.,* **48**(2): 189–200.

Sihmar, R. 2014. Growth and instability in agricultural production in Haryana: A district level analysis. *Int. J. of Sci. and Res. Pub.,* **4**(7): 1-12.

Tao, F., Xiong, W., Xu, Y. and Lin, Y. 2000. Simulation of peanut potential yield under future climate scenario in China. *Chin. Environ. Sci.,* **20**: 392–395.

Thompson, L.M. 1975. Weather variability, climatic change, and grain production. *Sci.,* **188**: 535–541.

Thompson, L.M. 1986. Climate change, weather variability, and corn production. *Agron. J.,* **78**: 649–653.