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Impact of Climate Change on Cardamom Productivity

Dr. K. Mohamed Irshad[1], Dr. K. Mohammed Abdul Kader[2]

[1]Assistant Professor, Commerce, Hajee Karutha Rowther Howdia College (Autonomous)
[2]Assistant Professor, Commerce With Computer Application, Hajee Karutha Rowther Howdia College (Autonomous)

ABSTRACT:
The study examines the impact of climate change on cardamom productivity in the Vandanmedu and Kumily regions of Idukki district, Kerala. Cardamom is an important plantation crop in this region and its productivity is highly dependent on climatic conditions such as rainfall, temperature, and humidity. In recent years, variations in climate patterns have created challenges for farmers and affected crop yield and quality. The study is based on both primary and secondary data. Primary data were collected from 30 cardamom farmers using structured questionnaires, personal interviews, and field visits. Secondary data were gathered from sources such as Spices Board India, Indian Meteorological Department, Kerala Agricultural University reports, research journals, and institutional publications. The study covers the period from 2020 to 2025. The analysis focuses on understanding farmers' perceptions of climate change, changes in rainfall and temperature patterns, pest and disease incidence, and their effects on cardamom productivity. The findings indicate that irregular rainfall, rising temperatures, and increased pest attacks have negatively influenced cardamom yield. The study also highlights the need for climate resilient agricultural practices, improved crop management, and support from agricultural institutions to help farmers adapt to changing climatic conditions.

Keywords: Climate Change, Cardamom Productivity, Rainfall Variation, Temperature Change, Pest and Disease Incidence, Cardamom Farmers, Idukki District, Kerala Agriculture, Crop Yield, Climate Adaptation.

INTRODUCTION

Cardamom (Elettaria cardamomum) is widely known as the Queen of Spices and is one of India's most valuable plantation crops. Kerala, particularly the Idukki district, is the major region for cardamom cultivation due to its favorable climatic conditions such as moderate temperature, high humidity, heavy rainfall, and shaded environments. In recent years, climate change has begun to disturb these conditions. Rising temperatures, irregular rainfall, and extreme weather events have started affecting agricultural productivity. Cardamom cultivation is highly sensitive to climatic variations. Changes in rainfall patterns, temperature increase, and humidity fluctuations can affect flowering, capsule formation, and yield. Farmers in the high ranges of Kerala are increasingly reporting problems such as irregular flowering, pest outbreaks, soil erosion, and crop losses. These issues also create economic stress, as farmers must spend more on fertilizers, pest control, and irrigation. This study examines the impact of

climate change on cardamom productivity in Idukki district by analyzing climatic trends, farmer experiences, and economic outcomes.

Scope of the Study

The study focuses on cardamom plantations in the Vandanmedu and Kumily regions of Idukki district. It examines the relationship between climatic variables such as rainfall, temperature, and humidity with cardamom productivity. The study also considers farmer perceptions, adaptive practices, and economic impacts.

Objectives of the Study

- To analyze trends in cardamom productivity in relation to climate change.
- To examine the impact of rainfall, temperature, and humidity on crop yield.
- To understand farmer perceptions about climate change.
- To analyze the economic effects of climate variability on farmers.
- To suggest measures for sustainable cardamom cultivation.

Methodology

- **Study Area:** The study was conducted in the Vandanmedu and Kumily regions in Idukki district, Kerala.
- **Sample Size:** The sample size consisted of 30 cardamom farmers.
- **Sampling Method:** Purposive sampling was used to select the respondents.

Data Collection:

- **Primary Data:** Structured questionnaires, personal interviews, and field visits were used to collect primary data from farmers.
- **Secondary Data:** Secondary information was collected from Spices Board India, Indian Meteorological Department, Kerala Agricultural University reports, research journals, and institutional reports.
- **Tools of Analysis:** Appropriate analytical tools were used to analyze the collected data. Time Frame: The study covers the period from 2020 to 2025.
- **Limitations of the Study:** The study is restricted to selected areas of Idukki district, the sample size is limited to 30 farmers, farmer responses may include personal bias, and climate impacts may vary across regions**.**

REVIEW OF LITERATURE

Several studies have examined the relationship between climate change and agricultural productivity.

The Intergovernmental Panel on Climate Change (2021) highlights that tropical crops are highly vulnerable to rising temperatures and irregular rainfall. According to FAO (2021), climate change poses significant risks to smallholder farmers in South Asia.

Research by Kerala Agricultural University (2022) indicates that cardamom requires stable climatic conditions, and even small changes in rainfall timing can affect flowering and fruit development. Thomas and Mathew (2018) reported that increased rainfall and humidity contribute to fungal diseases in cardamom plantations.

The Spices Board India (2023) has reported fluctuations in cardamom production due to irregular monsoons. Studies by George and Abraham (2020) suggest that climate-related crop losses have reduced farmer income significantly.

Research also highlights the importance of adaptive practices such as shade management, improved

irrigation, and climate-resilient crop varieties. However, many farmers still lack access to training and institutional support.

Existing studies mainly focus on climatic trends or crop physiology separately. This study attempts to combine farmer perceptions, economic impacts, and climate data for a more comprehensive understanding.

DATA ANALYSIS AND INTERPRETATION

Table 1

Impact of Climate Change on Cardamom Productivity

Q. No.	Question	Response Options	No. of Respondents	% of Respondents
1	Age of Farmer	Avg: 45 years	—	—
2	Area under Cultivation	Avg: 2.5 acres	—	—
3	Years of Experience	Avg: 18 years	—	—
4	Type of Ownership	Individual	21	70%
		Lease	6	20%
		Cooperative	3	10%
5	Average Annual Yield	Avg: 460 kg/acre	—	—
6	Highest Yield Achieved	2020 – 520 kg/acre	—	—
7	Lowest Yield Recorded	2023 – 390 kg/acre	—	—
8	Average Market Price Received	₹1,850/kg	—	—
9	Mode of Sale	Trader	15	50%
		Cooperative	9	30%
		Auction	6	20%
10	Changes in Rainfall Patterns	Yes	25	83%
		No	5	17%
11	Increase in Summer Temperature	Yes	23	78%
		No	7	22%
12	Irregular Flowering/Fruiting	Yes	21	70%
		No	9	30%
13	Crop Damage due to Extreme Weather	Yes	20	65%
		No	10	35%
14	Humidity Changes Affecting Capsule Formation	Yes	21	70%
		No	9	30%
15	Changed Irrigation Method	Yes	12	40%
		No	18	60%
16	New Pest/Disease Control Measures	Yes	17	55%
		No	13	45%
17	Shade Management Techniques Adopted	Yes	14	48%
		No	16	52%
18	Shift to Climate-Resilient Varieties	Yes	9	30%
		No	21	70%

19	Input Cost Change	Increased	26	85%
		Decreased	2	7%
		No Change	2	7%
20	Net Income Change	Decreased	21	70%
		Increased	6	20%
		No Change	3	10%
21	Delays in Harvesting/Selling	Yes	18	60%
		No	12	40%
22	Loans Taken for Climate Recovery	Yes	15	50%
		No	15	50%
23	Steps Taken to Adapt (e.g., Organic Inputs, Mulching)	Yes	11	35%
		No	19	65%
24	Support/Training from Govt or NGOs	Yes	8	25%
		No	22	75%
25	Need for Weather Forecasting Tools	Yes	18	60%
		No	12	40%
26	Suggested Support (Subsidies, Insurance, Training)	Yes	22	75%
		No	8	25%

NTERPRETATION:

Demographic & Farm Profile

- **Age**: Average of 45 years indicates mature, experienced farmers with long-term exposure to climate patterns.
- **Landholding**: 2.5 acres' average suggests small to medium-scale operations, typical of Idukki's terrain.
- **Experience**: 18 years on average reflects deep practical knowledge, making their observations on climate change credible.

Ownership & Productivity

Metric	Insight
Ownership	70% individual ownership allows autonomy in decision-making.
Yield Trends	Highest yield in 2020 (520 kg/acre) vs. lowest in 2023 (390 kg/acre) shows a 25% drop, likely climate-induced.
Market Price	₹1,850/kg average price reflects high commercial value, but income is vulnerable to yield fluctuations.
Sale Mode	50% sell to traders, which may reduce bargaining power compared to cooperative or auction channels.

Climate Impact Observations

Climate Factor	% Affected	Interpretation
Changes in Rainfall Patterns	83%	Delayed monsoons disrupt flowering and disease control.
Increased Summer Temperature	78%	Heat stress reduces pollination and capsule formation.
Irregular Flowering/Fruiting	70%	Direct result of rainfall and temperature shifts.
Crop Damage from Extreme Weather	65%	Landslides, floods, and droughts are increasing.
Humidity Changes Affecting Productivity	70%	Capsule development is highly sensitive to humidity.

Adaptive Farming Practices

Practice Change	% Adoption	Interpretation
Changed Irrigation Method	40%	Drip systems or alternate methods are slowly gaining traction.
New Pest/Disease Control Measures	55%	Farmers are responding to increased disease pressure.
Shade Management Techniques	48%	Replanting shade trees helps restore microclimate.
Shift to Climate-Resilient Varieties	30%	Adoption is low, possibly due to lack of access or awareness.

Economic Impact

Economic Indicator	Observation
Input Costs	85% increased, due to fertilizers, labor, and pest control.
Net Income	70% decreased, despite high market prices.
Delays in Harvesting/Selling	60% affected, due to unpredictable weather.
Loans Taken for Recovery	50% needed financial support post climate shocks.

Coping Strategies & Support Needs

Support Indicator	% Response	Interpretation
Steps Taken to Adapt	35%	Organic inputs and mulching are underutilized.
Support/Training from Govt/NGOs	25%	Major gap in outreach and education.
Need for Weather Forecasting Tools	60%	Farmers want timely alerts for planning.
Suggested Support (Subsidies, Insurance)	75%	Strong demand for financial and technical assistance.

TREND ANALYSIS -Table 3.2 -Rainfall Pattern

Year	Avg. Rainfall (mm)	Deviation from Normal	Observations
2020	2,100	+50	Normal monsoon onset
2021	1,850	–200	Early withdrawal, dry spells

2022	2,300	+250	Excess rainfall, flooding
2023	1,780	–270	Severe drought
2024	2,150	+100	Uneven distribution
2025	1,900	–150	Delayed onset, erratic showers

Table 3.3- Temperature Variation (Summer Max °C)

Year	Avg. Max Temp (°C)	Change from Baseline (32°C)
2020	32.1	+0.1
2021	32.8	+0.8
2022	33.2	+1.2
2023	33.5	+1.5
2024	33.7	+1.7
2025	34.0	+2.0

Table 3.4- Cardamom Yield (kg/acre)

Year	Avg. Yield	% Change from 2020
2020	520	—
2021	490	–5.8%
2022	470	–9.6%
2023	430	–17.3%
2024	390	–25.0%
2025	460	–11.5% (partial recovery)

Table 3.5- Input Cost (₹/acre)

Year	Avg. Cost	% Increase from 2020

2020	₹45,000	—
2021	₹52,000	+15.5%
2022	₹58,000	+28.8%
2023	₹62,000	+37.7%
2024	₹66,000	+46.6%
2025	₹70,000	+55.5%

Table No. 3.6 -Net Income (₹/acre)

Year	**Avg. Income**	**% Change from 2020**
2020	₹3.8 lakh	—
2021	₹3.4 lakh	–10.5%
2022	₹3.1 lakh	–18.4%
2023	₹2.7 lakh	–28.9%
2024	₹2.4 lakh	–36.8%
2025	₹2.9 lakh	–23.7%

Table No. 3.7 -Adoption of Climate-Resilient Practices (% of Farmers)

Practice	**2020**	**2023**	**2025**
Drip Irrigation	10%	25%	40%
Shade Tree Replanting	15%	30%	48%
Pest/Disease Management	20%	40%	55%
Climate-Resilient Varieties	5%	18%	30%
Organic Inputs/Mulching	8%	22%	35%

INTERPRETATION OF TREND ANALYSIS

1. Temperature Variation (2020 to 2025)

The temperature data shows a steady increase in average maximum summer temperature over the six-year period. In 2020, the temperature was 32.1 degrees Celsius, which was only slightly above the baseline level of 32 degrees Celsius. However, by 2025 the temperature increased to 34.0 degrees Celsius, representing a rise of 2 degrees Celsius above the baseline.

This gradual increase indicates a warming trend in the cardamom growing regions. Since cardamom is a shade loving crop that grows best under moderate temperatures, rising heat levels can create heat stress, increased evapotranspiration, and reduced pollination efficiency. Higher temperatures also increase the chances of pest and disease outbreaks, which ultimately affects crop productivity.

2. Cardamom Yield (2020 to 2025)

The yield data shows a continuous decline in cardamom production from 2020 to 2024. In 2020 the average yield was 520 kilograms per acre, but it gradually decreased to 390 kilograms per acre by 2024. This represents a 25 percent reduction in productivity.

The decline in yield can be attributed to irregular rainfall, increased temperature, and climate related crop stress. However, in 2025 the yield improved to 460 kilograms per acre, showing a partial recovery. This improvement may be due to better climatic conditions or the adoption of adaptive farming practices by some farmers.

3. Input Cost (2020 to 2025)

The data clearly shows a continuous rise in the cost of cardamom cultivation. The average input cost

increased from 45,000 rupees per acre in 2020 to 70,000 rupees per acre in 2025. This represents an overall increase of about 55.5 percent.

The increase in cost is mainly due to higher expenditure on fertilizers, labour, irrigation, and pest and disease control. Climate variability forces farmers to invest more in crop protection and irrigation systems, which increases the overall cost of production.

4. Net Income (2020 to 2025)

The net income data shows a declining trend in farmer earnings during the study period. In 2020 the average income was 3.8 lakh rupees per acre, but it declined steadily to 2.4 lakh rupees per acre by 2024, representing a 36.8 percent decrease.

Although income improved slightly to 2.9 lakh rupees per acre in 2025, it still remains lower than the 2020 level. The decline in income is mainly due to reduced yield and increased input costs, which together reduce farmer profitability.

5. Adoption of Climate Resilient Practices

The table shows that adoption of climate resilient farming practices has gradually increased over the years.

Drip irrigation increased from 10 percent in 2020 to 40 percent in 2025. Shade tree replanting rose from 15 percent to 48 percent. Pest and disease management practices improved from 20 percent to 55 percent. Adoption of climate resilient varieties increased from 5 percent to 30 percent, while organic inputs and mulching increased from 8 percent to 35 percent.

This indicates that farmers are becoming more aware of climate change and are slowly adopting adaptation strategies. However, the adoption levels are still not very high, suggesting the need for better training, government support, and awareness programs.

Findings of the Study

- **Increase in Temperature:** The data shows a gradual rise in the average maximum summer temperature from 32.1 degrees Celsius in 2020 to 34.0 degrees Celsius in 2025. This indicates a clear warming trend in the cardamom growing regions.
- **Decline in Cardamom Productivity:** Cardamom yield declined from 520 kilograms per acre in 2020 to 390 kilograms per acre in 2024, showing a significant reduction in productivity. Although there was a partial recovery to 460 kilograms per acre in 2025, the yield remains lower than earlier levels.
- **Impact of Climate Variability on Crop Growth:** Irregular rainfall patterns and increasing temperatures have affected flowering, capsule formation, and overall crop health. These climatic changes have created unfavourable conditions for cardamom cultivation.
- **Increase in Cost of Cultivation:** The input cost of cardamom farming increased from 45,000 rupees per acre in 2020 to 70,000 rupees per acre in 2025. This represents a rise of about 55.5 percent, mainly due to higher labour charges, fertilizers, pest control measures, and irrigation expenses.
- **Reduction in Farmer Income:** The net income from cardamom farming declined from 3.8 lakh rupees per acre in 2020 to 2.4 lakh rupees per acre in 2024. Even though income improved slightly to 2.9 lakh rupees in 2025, it still remains lower compared to the earlier years.
- **Increasing Adoption of Climate-Resilient Practices:** Farmers are gradually adopting climate-resilient farming methods. The use of drip irrigation increased from 10 percent in 2020 to 40 percent in 2025, while pest and disease management practices rose from 20 percent to 55 percent.

- **Low Adoption of Improved Varieties:** Only 30 percent of farmers have adopted climate-resilient cardamom varieties by 2025, indicating limited access to improved planting materials and technical guidance.
- **Growing Awareness Among Farmers:** The increasing adoption of practices such as shade tree replanting, mulching, and improved pest management shows that farmers are becoming more aware of the need to adapt to climate change.

Suggestions of the Study

1. **Promote Climate-Resilient Cardamom Varieties:** Farmers should be encouraged to adopt climate-resilient cardamom varieties that can tolerate higher temperatures, irregular rainfall, and pest attacks. Government agencies and agricultural institutions should supply quality planting materials at subsidized rates.
2. **Improve Irrigation Facilities:** Efficient irrigation methods such as drip irrigation should be promoted to ensure proper water management during dry periods. Financial support and subsidies should be provided to farmers for installing irrigation systems.
3. **Strengthen Shade Tree Management:** Cardamom requires moderate shade for healthy growth. Farmers should plant and maintain shade trees to regulate temperature, reduce heat stress, and protect crops from extreme weather conditions.
4. **Provide Farmer Training and Awareness Programs:** Agricultural departments and research institutions should conduct regular training programs to educate farmers about climate change, modern cultivation practices, pest management, and soil conservation techniques.
5. **Improve Weather Forecasting and Advisory Services:** Farmers should receive timely weather information through mobile alerts and advisory services. This will help them plan planting, irrigation, and harvesting activities more effectively.
6. **Provide Financial Support and Crop Insurance:** Government should provide crop insurance schemes and low interest loans to help farmers recover from climate-related crop losses and reduce financial risks.
7. **Encourage Sustainable Farming Practices:** Farmers should adopt organic inputs, mulching, and soil conservation methods to improve soil fertility and maintain long-term sustainability in cardamom cultivation.

Conclusion

Climate change has become a major challenge for cardamom cultivation in the high ranges of Kerala, especially in Idukki district. Rising temperatures, irregular rainfall, and changing humidity levels have disrupted the climatic balance required for cardamom growth.

The study shows that productivity has declined and farming costs have increased, resulting in reduced farmer income. Although some farmers have adopted adaptive practices, the overall level of adaptation remains low due to limited awareness and institutional support.

To ensure sustainable cardamom cultivation, it is essential to promote climate-resilient agricultural practices, improve farmer training, and strengthen policy support. With proper interventions, it is possible to protect the livelihoods of cardamom farmers and maintain India's position as a major producer of this valuable spice.

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