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Impact of Climate Change on the Production of Cardamom in one of the Chiwog under Samtse Dzongkhag, Bhutan

Chheku Wangchuk[1], Kinley Dem[2], Karma Nidup[3], Tshelthrim Pelden[4], Dorji Wangdi[5], Karma Dorji[6]

[1]Yebilaptsa Central School, Ministry of Education and Skills Development, Bhutan

Email: wchheku777@gmail.com

[2]Zhemgang Central School, Ministry of Education and Skills Development, Bhutan

Email: kinleydem1@education.gov.bt

[3]Wanakha Central School, Ministry of Education and Skills Development, Bhutan

Email: karmanidup@education.gov.by

[4]Nganglam Middle Secondary School, Ministry of Education and Skills Development, Bhutan

Email: tshelthrimpelden@education.gov.bt

[5]Radhi Middle Secondary School, Ministry of Education and Skills Development, Bhutan

Email: dorjiwangdi2016@education.gov.bt

[6]Sherubgatshel Middle Secondary School, Ministry of Education and Skills Development, Bhutan

Email: karmadorji55@education.gov.bt

Abstract

Cardamom plantation is one of the most lucrative commercial farming, especially in southern parts of Bhutan. Cardamom is their main source of income generation. However, the production of cardamom has declined over the past years and farmers claimed that climate change is the main reason. Climate change is a global phenomenon that has far-reaching implications for agriculture, particularly in regions characterized by their sensitivity to climatic variability and Bhutan is no exception. Nevertheless, it is unclear how climate change has affected cardamom production. Therefore, it has become necessary to study how climate change hampers the production of cardamom. The aim of this study is to explore the impact of climate change on the production of cardamom (Elettaria cardamomum) in one of the Chiwogs, under Samtse Dzongkhag. Farmers of this Chiwog mainly depend on cardamom for their livelihood and it is the backbone of their livelihood. To understand the impact of climate change on cardamom growers, the study has adopted a mixed method as a research approach. The study reveals that local farmers are already experiencing the consequences of climate change like erratic temperatures and rainfall declining the yield of cardamom. The increasing number of pests and disease outbreaks in cultivated land are creating challenges for the farmers depending on cardamom for living. Adaptive measures, such as altering planting and harvesting schedules and introducing new cardamom varieties resilient to changing conditions, are essential for mitigating these impacts. Furthermore, community-based efforts, enhanced access to climate information, and support from relevant agencies are necessary to

ensure the long-term sustainability of cardamom production in the region. The study highlights the urgent need for proactive climate adaptation strategies and underscores the importance of a comprehensive understanding of climate change impacts on agricultural systems, especially in vulnerable regions. The findings provide valuable insights for policymakers, researchers, and local communities to foster resilience and sustainable cardamom production in the face of a changing climate.

Keywords: climate change, cardamom production, climate adaptation, pest and diseases, socio-economic impacts.

Introduction

Large cardamom growers have recently encountered several difficulties maintaining production, especially because of pests and diseases, the effects of climate change, and fluctuating market prices. Climate change is the main factor that leads to a decline in cardamom production in Bhutan. Cardamom farming is becoming a less reliable source of income for mountain communities due to climate change and its effects (Gurung, 2017). The study by Ghalley (2018) concluded that the crop is being destroyed by blight, and farmers are suffering because of poor production. Farmers have been observing blight infestations on their plants for more than three years. Farmers assert that their crop has been affected by four different diseases. After the roots rot, the leaves aresaid to dry. A disease that is known as "Furkey" locally has also become a common reason for reduced yield. Farmers agree that pests and diseases are spreading at a faster rate due to changes in climatic patterns. Farmer who grows cardamom in large scale said that the harvest is so low they do not have enough to sell (Ghalley, 2018). According to Rijal and Rabyal (2020) in 2016 cardamom production was 2736 tons and drop to 2245 tons in 2017. A study by Jamtsho et al. (2020) in Pemagatsel Dzongkhag also reveals that water is essential to both the overall quality and the yieldof cardamom, too much water reduces both the yield and the production. Excessive moisture in the soil mass has the tendency to rot the plant's roots and lower stem, weakening it over time and making it more susceptible to fungus pests and diseases, which reduces the output.The commercial lifespan of large cardamom was lowered by seven to eight years because of climate change (Vijayan et al., 2014). Similarly in Nepal, the production of large cardamom has declined because of climate change (Rijal, 2013).

This is an indication that there is an issue with cardamom plantations and production dueto climate change. During interviews with local leaders and field visits, the researcher found a similar situation. To better understand the issues, the researcher believes that proper study is required. In the absence of evidence-based research or scholarly works, no proper planning can be made to address this in the future. Thus, it has become necessary for educatorsto do in-depth research pertaining to the decline of cardamom production due to climate change.

It is hoped that the knowledge that emerged from this study would fill this knowledge gapand point out some possible strategies for improving cardamom plantations and production for better economic income.

Literature Review

Cardamom has become a substantial high-value cash crop and a significant source of income for people in the southern region since it was introduced to Bhutan in the early 1970s. Similarly, one of the most promising livelihood options for farmers in Samtse Dzongkhag has been cardamom farming. Due to the

changing climatic condition, cardamom growers have faced numerous difficulties recently. The impact may be observed in the decrease in productivity, production stability, and earnings of the farming community.

History of cardamom in Bhutan

Cardamom is a spice produced from the seeds of various ginger plants. Cardamom pods are triangular in cross-section and spindle-shaped. Although the cardamom pods contain a varietyof seeds, the complete pod can be utilized whole or powdered. Small and black in hue, the seeds vary in size and colour depending on the species (Alfaro, 2022). Black cardamoms and green cardamoms are the two main types of cardamoms. Green cardamom (*Elettaria cardamomom*) is known as true cardamom. The Amomum subulatum, or black cardamom, contains bigger, dark brown pods. It has a smokey component that makes it more suitable for savory foods, but southernIndia often uses it in sweet dishes. Since it has been used as a medicinal and a food component forso long, cardamom has health advantages, according to studies. A 2009 study indicated that cardamom's strong antioxidant content helps lower blood pressure, and a 2007 study found that cardamom has diuretic qualities, which means it encourages urination. A recent study discovered that cardamom is efficient at disrupting microorganisms that might cause gum disease or infections. It has also been used for millennia as a breath refresher (Alfaro, 2022).

The locally grown cardamom called the large cardamom, was first introduced in Bhutan in the early 1970s from Sikkim and has since become an important high-value cash crop and a major source of livelihood for many people in the southern region. Sibsoo in Samtse dzongkhag and Kalikhola in Sarpang dzongkhag are said to have been the entry points forits cultivation. The initial planters were farmers from the above-mentioned regions (Mehta et al, 2015). Cardamom, along with cordyceps, is one of the greatest valued crops in Bhutan. The farmer’s fetch price is between Nu 1,000 and Nu 2,000 per kg (Mehta et al., 2015). In Bhutan, 17,000 farmers are engaged in large cardamom farming earning approximately USD 500 – 1200 per farmer. Bhutan’s topography suits the growth of large cardamom as the strength of large cardamom is its capacity to thrive in harsh environments, including gullies and steep slopes whereother crops cannot (Pradhan, 2020). However, the production of cardamom has been drastically reduced and farmers blame it for climate change.

Farmers’ perception of climate change on cardamom production

According to NASA (2014) climate change refers to a shift in the planet's climate. This could be a deviation from the average temperature of Earth. Alterations to where rain and snow typically fall on Earth could also be the cause. Long-term changes in temperature and weather patterns are referred to as climate change.These changes could be caused by natural processes, such as oscillations in the solar cycle. But since the 1800s, human activities—primarily the combustion of fossil fuels like coal, oil, and gas—have been the primary cause of climate change. Fossil fuel combustion produces greenhouse gas emissions that serve as a blanket around the planet, trapping heat from the sun and increasing temperatures (UN, 2021). Climate change has an impact on our work, housing, safety, and abilityto grow food. Some residents of small island states and other developing nations are already more susceptible to the effects of the climate. Long-lasting droughts are putting people at risk of starvation, while conditions like sea level rise and saltwater intrusion have progressed to the point that entire communities have been forced to evacuate. The quantity of "climate refugees" is anticipated to increase in the future.

Bhutan's agriculture industry is particularly vulnerable to the effects of climate change because of its geographic characteristics. Climate threats such as heavy rainfall, flash floods, wind, hail, and droughts, as well as pest and disease outbreaks, are occurring more frequently across thenation. Therefore, crop damage, a fall in yield, and a reduction in production can have a significantnegative impact on the nation's food security (Parker et al., 2017). Bhutan has a climate that is arguably more varied than any other country of comparable size. Different exposures to sunlight and moisture-laden winds lead to complicated local fluctuations, and the climate changes with elevation, providing stunning meteorological contrasts (Karan & Norbu, 2022). Pests and diseasesare on the rise because of climate change. Diseases and pests are still a challenge for farming communities. According to the GNH Survey (2015), 9.94% of respondents said they had left their property fallow over the previous year especially due to wildlife hazards. In 2017, wild animals and pests destroyed 1,284 MT of paddy, 5,151 MT of maize, 78 MT of buckwheat, 221 MT of vegetables, and 1,407 MT of potatoes. Each household spent an average of 48 days and 67 nightsprotecting crops from wild animals (MoAF, 2017).

Climate change and cardamom production

An important spice crop in India, Nepal, and Bhutan is cardamom. According to Bhutan's2017 statistical report, the cardamom crop was grown on 13,880 acres, produced 22,45 tons of product, and yielded 162 kg per acre (Rijal & Rabyal, 2020).

One of the highest cardamom production dzongkhags in the nation is Samtse. The Dzongkhag recorded 1,162 metric tons (MT) of cardamom in 2016, a decrease from 1,008MT the previous year. Cardamom is grown in practically every area of the dzongkhag in Samtse. Farmers grow cardamom on a little or large scale (Ghalley, 2018). Close to 250,000 kgs or Nu 129 M worthof cardamom have been exported till October from Samtse (BBS, 2020). Even though farmers increased the cardamom production area from 2013 to 2017 (6904 and 13880 acres respectively) the production declined (168 kgs/ acre and 162 kgs/acre). The cardamom growers reason climatechange for declining production each year (Rijal & Rabyal, 2020).

Challenges imposed by climate change on cardamom production

Climate change has caused cardamom farmers to face several challenges: productivity,production stability, and incomes of marginal farmers have all been affected (Dema, 2021). In addition, climate change accelerated the onset of rhizome rot disease, with an increase of leaf-eating caterpillars and aphids destroying cardamom and reducing productivity, according to farmers. The early onset of summer and monsoon, warmer weather, earlier flowering, less snow in the mountains and rapid melting of snow, and the drying up of water sources are all effects of climate change that are having a significant negative impact on farming systems that depend on cardamom (Partap & Partap, 2009; Chaudhary & Bawa, 2011; Chaudhary et al., 2011; Bawa & Ingty, 2012; & Sharma & Rai 2012).

Experts believe that the intensity, development, and geographic distribution of diseases aswell as the population size, survival rate, and distribution of pests can all be impacted by climate change. According to an expert, there are two ways that climate change has boosted the activity ofinsect pests. First, as temperatures rise, insects can digest food more quickly, which speeds up thedestruction of crops. Second, ectothermic (cold-blooded) insects in temperate locations may become more active and hence better able to breed because of rising temperatures (Dema, 2021).The recent records of rising temperatures and rising elevations have been favorable for the development of aphids, which in turn contributed to the widespread occurrence of viral

illnesses like Chirkey and Foorkey on cardamom plantations. Mold occurrence is also influenced by the presence of aphids (fungal infection). By secreting honeydew onto the leaf, an aphid might encourage the development of mold. Large cardamom leaves were covered in several types of black molds or fungi. In extreme circumstances, the black growth might even block sunlight and hinder photosynthesis.

Adaptation to reduce the impact of climate change on cardamom production

According to Sharma et al. (2016) in Sikkim, many cardamom producers have created adaptable strategies using conventional wisdom to mitigate the effects of climate change and restore cardamom production. The creation and introduction of enhanced or disease-resistantcultivars, replanting on new farmland, introducing cardamom into backyard gardens to replace food crops, using manure to maintain soil fertility, irrigating during dry seasons, and managing diseases and pests by uprooting, drying, and burning infected plants are the main adaptive measures. According to Sikkim-based studies, cardamom requires two irrigations each week for three to four hours during the dry season (Rijal & Rabyal, 2020). Nevertheless, this is not so convenientin in our country due to the topography of the landscape and the scarcity of water resources in the dry season. However, farmers agree that they either remove and replace or cut the infected plants and burn them. These are the only solutions farmers implement and need to continue until a concrete solution is drawn by concerned stakeholders.

Research Approach

Research approaches are the strategies and procedures for the research that provide the steps from wide assumption to detailed methods of data collection, organization, analysis, and interpretation (Creswell & Pablo-Clark, 2018). For this research, a mixed method approach is used since it offers better ways of addressing research problems than qualitative and quantitative in isolation. Using this approach, one method can overcome the limitations of another method. Since quantitative or qualitative data alone will not sufficiently answer the research questions, theresearcher has adopted a mixed-method approach.

According to George (2021), the mixed method is further divided into convergent parallel, explanatory sequential, and exploratory sequential. The researcher adopted a convergent parallel mixed method for this study. Collecting data that is both quantitative and qualitative is gathered simultaneously and examined independently. When both analyses are finished, compare the results to make a final judgment. The characteristics of a convergent parallel design are that the researcher converges or merges quantitative and qualitative data to provide a comprehensive analysis of the research problem. A convergent parallel design entails that the researcher concurrently conducts the quantitative and qualitative elements in the same phase of the research process, weighs the methods equally, analyzes the two components independently, and interprets the results together (Creswell & Clark, 2011). Thus, using this design employed the strengths of both qualitative and quantitativeapproaches.

Sampling strategy

The sampling strategy is the plan set forth to ensure that the sample used in research represents the population from which the sample is drawn (Landreneau, 2011). Sampling is important because it is impossible to study a whole population due to time, expense, andaccessibility (Cohen & Meléndez, 2005).

Therefore, the sampling method, allows researchers to gather information about a population based on results from a set of the population, without havingto study every single population.

Creswell and Clark (2018) note that in general, there are two types of sampling probability sampling and non-probability sampling. For this study, non-probability sampling was used to collect quantitative data. From a different nonprobability strategy for collecting quantitative data, a snowball sampling technique was adopted by the researcher according to the situation. It is a type of sampling method in which research participants were asked to assist researchers in identifying other potential subjects.

Purposive sampling was employed in the research on the impact of climate change on cardamom production to deliberately select participants who could provide valuable insights and experiences related to the focus of the study. Careful consideration was given to choosing individuals with expertise in cardamom cultivation or whose livelihood depends on cardamom production and found out that 15 household . This intentional approach to sampling allowed the researchers to focus on individuals who could offer rich perspectives on the relationship between climate dynamics and cardamom cultivation, ultimately contributing to a more comprehensive analysis of the subject.

Sample size

The sample size is the group of participants in a study selected from the target population which the researcher generalizes to the target population (Cresswell, 2014). The size of the sampleshould not be very large or too small and it should be optimum. Kothari (2004) stated that the optimum sample size fulfils the requirements of efficiency, representativeness, reliability, and flexibility.

For the study, 15 households were chosen as a sample size for quantitative and 4 for qualitative approaches. These households were selected based on their direct involvement in cardamom cultivation, ensuring that the participants could provide firsthand insights into the effects of climate change on this specific agricultural practice. Moreover, the selection of 15 households for the study was particularly significant as these households were dependent on cardamom cultivation, and their production had been noticeably affected. By intentional sample size, the research aimed to capture a diverse range of experiences and perspectives within the targeted community, thereby enhancing the depth and relevance of the findings. This focused approach to sampling allowed for a detailed examination of the study's intent.

Quantitative data collection tools

According to Cresswell (2014), an instrument is a tool for measuring, observing, or documenting quantitative data that contains specific questions and response possibilities that are developed in advance of the study. The process involves asking people for information througha questionnaire, which can be either online or offline. In this study, an offline survey questionnairewas used. Researchers guided the participants to complete the forms since they were illiterate. Quantitative data on cardamom production was collected using a survey questionnaire. For the collection of data, a 6-point Likert scale was used where (1=Strongly Disagree, 2=Disagree, 3=Somewhat Disagree, 4=Somewhat Agree, 5=Agree and 6= Strongly Agree). The data, were collected through questionnaires. The questions were validated by the supervisors to make it more credible. The questionnaires were developed based on the objectives of the study.

Qualitative data collection tools

The quantitative data was collected through a one-on-one semi-structured interview with the farmers of X Chiwog. An interview is typically a one-on-one conversation between a researcher and a participant involving a transfer to the interviewer (Creswell, 2012). A total of 9 semi-structured questions were designed and used to collect the qualitative data from 4 participants.

Reliability and validity

The reliability and validity of the research instrument are important aspects of data authentication (Creswell, 2014). Therefore, it is important to guarantee the authenticity and reliability of the interview and survey questions. Validity is a way to assess the quality of a research study and describes the degree to which the results measure what they are intended to measure (Adamu & Mohamad, 2019). For the survey questionnaire, the validity of the study was assured after consultation with supervisors. Reliability in research describes how reproducible or replicablea study is (Efthymiou et al., 2019). There are several tools for measuring reliability which includethe split-half method, test-retest method, internal consistency, and reliability coefficient. The current study adopted internal consistency and the reliability questionnaires were based on Cronbach's alpha. The pilot test of questionnaires revealed .87 Cronbach's alpha.

Data Analysis

The data analysis is the process involves analyzing the survey questionnaire and interview transcriptions. The raw data gathered in the research process were analyzed and interpreted. Dataanalysis according to Cohen et al. (2007) involves "organizing, accounting for, and explaining the data, which means making sense of the data in terms of the participants' definitionsof the situation, noting patterns, themes, categories, and regularities."

Quantitative Data

The quantitative data collected using questionnaires were analyzed using Statistical Package for the Social Science -22 (SPSS-22). Before analysis, the data were cleaned for statisticalanalysis. The selected software (SPSS-22) tool is used for quantitative data analysis. The software was utilized to assist the researcher in managing many documents of this research, which combined numerical and categorical information. The quantitative data to find the impact of climate change on cardamom production were analyzed using the Descriptive Statistics in SPSS 22 for (Mean and Standard Deviation).

Qualitative Data

The data collected from interviews were analyzed thematically. According to Braun and Clarke (2006), thematic analysis is a method for systematically identifying, organizing, and offering insights into patterns of meaning across a dataset. Similarly, Nowell et al. (2017) state that thematic analysis is useful in examining the perspectives of different research participants, highlighting similarities and differences, and generating unanticipated insights. The accessibility and flexibility of this method make it preferable.

Thematic analysis was done following the steps of Braun and Clarke thematic analysis steps.

Result and Discussion

The data presented here are generated from both the quantitative and qualitative gathered through survey questionnaires and interviews. Data gathered through survey questionnaires and interviews were analyzed and triangulated to validate the findings. Survey questionnaires are administered to 30 farmers to gather the farmers' perceptions of the impact of climate change on cardamom production. In addition, a face-to-face interview was conducted to get the answers to the research questions.

The discussion is divided into three themes: 1. Farmers' perception of the impact of climatechange on cardamom production; 2. the impacts of climate change on the production of cardamomproduction. and, 3. The interventions to reduce the impact of climate change on cardamom production by the people and local government.

Farmers perception of the impact of climate change on cardamom production

Bhutan's agriculture sector is particularly vulnerable to the effects of climate change due to its geographic characteristics. Climate threats such as heavy rainfall, flash floods, wind, hail, and droughts can reduce crop yields and production. Thus, the Bhutanese farming communities arevulnerable to climate threats. Therefore, it is crucial to understand the farmers' views on climate change and its impact.

Table 1

Statements	N	Mean	Std. Deviation	Level of Acceptance	%
Q1_1. An increase in summer temperature over the past few years decreases the growth of cardamom.	30	5.20	.68	Highly Positive	86.7
Q1_2. I feel scorching heat is the major cause of the declining cardamom production.	30	5	.76	Positive	83.3
Q1_3. Less soil moisture during winter could be the major cause of drying cardamom sapling plantations.	30	5.07	.70	Positive	84.5
Q1_4. I have noticed changes in temperature and weather patterns which impacts cardamom production.	30	4.87	.64	Positive	81.2
Q1_5. The low productivity of the cardamom over the past few years is mainly due to the rise in temperature.	30	4.67	.72	Positive	77.8
Q1_6. The increase in the frequency of rainfall and windstorms during the flowering season affected the production of cardamom yield.	30	4.87	.52	Positive	81.2
Q1_7. Erratic rainfall due to climate change is also affecting the flowering and fruition of cardamom.	30	4.80	.68	Positive	80
Q1_8. The climate change makes cardamom plants more vulnerable to pests and diseases.	30	5.27	.46	Highly Positive	87.8
Q1_9. The low productivity of the cardamom over the past few years is mainly due to the rise in temperature.	30	4.93	.80	Positive	82.2
Q1_10. I feel that climate change has the potential to have a long term impact on cardamom production.	30	5.20	.56	Highly Positive	86.7

Farmer's perception of the impact of climate change on cardamom production

Note: *1.00 – 1.82=Highly Negative, 1.83 – 2.65=Negative, 2.66 – 3.48= Slightly Negative, 3.49 – 4.31= Slightly Positive, 4.32 – 5.14= Positive, 5.15 – 6.00 Highly Positive. Adapted from Pimentel (2019)*

The farmers' perceptions of the impact of climate change on cardamom production in Table 1 reveal stimulating patterns, particularly when considering the statement with the minimum mean score. Statement Q1 item 5, asserting that "The low productivity of cardamom over the past few years is mainly due to the rise in temperature," obtained a mean score of 4.67 (SD = 0.72). This indicates a relatively lower level of agreement among farmers regarding the direct correlation between rising temperatures and diminished cardamom productivity. Despite being categorized as "Positive" with an acceptance level of 77.8%, the standard deviation of 0.72 suggests a notable degree of variability in farmers' perceptions of this specific aspect of climate change impact. This finding aligns with existing literature that underscores the complexity of farmers' attitudes toward climate change and its implications for crop production. Factors such as individual experiences, local climate variations, and differing levels of awareness can contribute to the observed divergence in opinions among farmers regarding the influence of temperature on cardamom cultivation (Smith et al., 2019; Brown & Kaya, 2020). Studies in Bhutan have documented the increasing incidence of pests and diseases in crops, including cardamom, attributed to changing climatic conditions (Dorji et al., 2019). The heightened vulnerability of crops to pests and diseases aligns with the unique challenges faced by Bhutanese farmers, emphasizing the importance of targeted interventions to address these specific concerns. Research in Bhutan has highlighted the variability in farmers' perceptions of climate change impacts on agriculture, emphasizing the need for context-specific adaptation strategies (Rinzin et al., 2018).

On the other end of the spectrum, the statement with the maximum mean score is Q1 item 8, stating that "Climate change makes cardamom plants more vulnerable to pests and diseases," with a mean of 5.27 (SD = 0.46). This statement is classified as "Highly Positive," with an acceptance level of 87.8%, indicating a strong consensus among farmers regarding the association between climate change and increased susceptibility of cardamom plants to pests and diseases. The minimal standard deviation of 0.46 suggests a high level of agreement and coherence in farmers' perspectives on this particular aspect of climate change impact. This aligns with prior research emphasizing the intricate linkages between climate change and changes in pest and disease patterns, which can significantly affect agricultural systems (Rosenzweig et al., 2014; Thornton et al., 2017).

In support of quantitative data analysis, the analysis of qualitative data revealed a similar finding that climate change leads to a decline in cardamom production. For instance, all the participants agreed that climate change is the major factor affecting the decline in cardamom production. They also stated that cardamom production declined due to the dying of cardamom plants resulting from high temperatures and excessive rainfall during off season (R1, R2, R3 and R4). Further, the majority of the participants expressed that climate change has caused their cardamom plants to die due to the disproportioned amount of sun and rain. The participants explained that excessive rainfall during the off-season leads to rotting of the roots. It is because of the excessive water in the soil. This finding is supported by the findings of Vijayan etal. (2014). Excessive moisture in the soil mass has the tendency to rot the plants' roots and weaken it over time making them more susceptible to fungus pests and diseases, which reduces the output (Vijayan et al., (2014). On the other hand, scorching sun or heat during winter also leadsto dying up of the soil moisture and causes the plants to die. In addition, some argued that the spreadof "Furkey" fungal disease is one factor that causes the decline in cardamom plants to die. This finding is aligned with the findings of Ghalley (2018) who stated that pests and diseases are spreading at a faster rate due to changes in climatic patterns. The drying of cardamom plants was evidenced during the field visits of data collection.

In conclusion, the findings not only reveal the variation in farmers' perceptions of specific aspects of climate change impact on cardamom production but also highlight the importance of considering diverse factors that contribute to these perspectives. These findings underscore the need for targeted interventions and communication strategies that address the nuanced and context-specific nature of farmers' perceptions,

ultimately aiding in the development of sustainable and effective climate change adaptation strategies in agriculture.

Table 2

The impact of climate change on the production of cardamom production

Statements	N	Mean	Std. Deviation	Level of Acceptance	%
Q2_1. The climate change has deteriorated the quality of cardamom.	30	5.20	.68	Highly Positive	86.7
Q2_2. Variations in temperature and precipitation levels have influenced the quality of cardamom.	30	5.47	.52	Highly Positive	91.1
Q2_3. The decrease in cardamom production is due to pests and diseases caused by climate change.	30	5.33	.62	Highly Positive	88.8
Q2_4. High temperatures affect flower bud induction and fruit development.	30	5.20	.56	Highly Positive	86.7
Q2_5. Erratic rainfall affects the growth of cardamom plants.	30	4.93	.46	Positive	82.2
Q2_6. Climate change has led to increase in the frequency of pest and diseases attack to cardamom plant.	30	5.00	.53	Positive	83.3
Q2_7. The impact of climate change discourages the farmer to focus on cardamom cultivation.	30	4.60	.74	Positive	76.7
Q2_8. The changes in climate has led to shifts in the flowering, fruiting and ripening patterns of cardamom.	30	4.93	.46	Positive	82.2
Q2_9. The quantity of cardamom has been impacted by climate change, leading to changes in market price and income.	30	5.07	.46	Positive	84.5
Q2_10. The climate change has led to an increase in production cost, affecting overall cardamom income.	30	4.87	.52	Positive	81.2

Note: *1.00 – 1.82=Highly Negative, 1.83 – 2.65=Negative, 2.66 – 3.48= Slightly Negative, 3.49 – 4.31= Slightly Positive, 4.32 – 5.14= Positive, 5.15 – 6.00 Highly Positive. Adapted from Pimentel (2019)*

The study found that the climate change has impacted the cardamom production in many ways. The quantitative data from table 2 reflects the farmers' perceptions of the impacts of climate change on cardamom production and provides a comprehensive understanding of the multifaceted challenges faced by farmers in

the context of changing climatic conditions. Notably, the statement with the minimum mean score is Q2 item 7, suggesting that "The impact of climate change discourages the farmer to focus on cardamom cultivation," which obtained a mean score of 4.60 (SD = 0.74). While categorized as "Positive" with an acceptance level of 76.7%, the relatively lower mean, and higher standard deviation indicate a certain level of divergence in farmers' perspectives on whether climate change impacts act as a discouraging factor for cardamom cultivation. This finding emphasizes the need for further investigation into the specific factors contributing to farmers' perceptions and the potential implications for the sustainability of cardamom cultivation. In the context of international literature, studies such as those conducted by Vermeulen et al. (2012) emphasize the importance of understanding farmers' perceptions and attitudes towards climate change impacts to formulate effective adaptation strategies.

Conversely, the statement with the maximum mean score is Q2, item 5 indicating that "Variations in temperature and precipitation levels have influenced the quality of cardamom," with a mean score of 5.47 (SD = 0.52). Categorized as "Highly Positive" with an acceptance level of 91.1%, this statement highlights a robust consensus among farmers regarding the significant influence of temperature and precipitation variations on cardamom quality. The minimal standard deviation suggests a high level of agreement and coherence in farmers' perceptions of this specific aspect of climate change impact. This aligns with global literature, such as the work of Khanal et al. (2019), which underscores the susceptibility of spice crops, including cardamom, to variations in temperature and precipitation, impacting their quality and market value.

The result from the qualitative analysis revealed that climate change is one-factor affecting cardamom production on a larger scale. The majority of the farmers said that climate change has lead to the deaths of cardamom plants, and increased the rate of the spread of the fungal diseases known as “Furkey” in their local language. This resulted in the decline of cardamom yields and production. All the participants agreed and stated that climate change has adversely impacted the cardamom production. According to Rijal and Rabyal (2020) state that due to the decline in cardamom production, their income level has been drastically dropped. The majority of the farmers also expressed that climate change has not only impacted the production of cardamom but also affected their income level.“The yield, quality, income, and the test of the cardamom were better in the previous year. This year our income level has drastically gone down” (Respondent 1).However, farmers expressed that the expenses incurred, time and labour requirements were relatively higher in 2021 compared to 2022. This is because most of the time farmers remain ideal since cardamom production has declined and they do not grow it in large quantities. One of the farmer participants said that due to fungal infections, a disproportionate amount of rain and water, low yield of cardamom demotivates them to work harder. Therefore, many of them either gave up or reduce the production of cardamom in their locality. One of the participants said;

“Climate change has affected us in so many ways. Due to the disproportionate amount of sun and rain, the cardamom growing has become challenging for me. I tried growing cardamom in differentplaces having different weather temperatures, however, the cardamom plants die either due to a disproportionate amount of sun and rain or a wild boar attack. For example, last year I sold 40kg but this year it would be only 10 kg which is too little for me to meet my daily expenses. Thus climate change has severely affected us this year”

The literature supports the finding that climate change has caused cardamom farmers to face several challenges such as productivity, production stability, lower income, dying up of cardamom due to pests and diseases, disproportioned amount of water and rain and excessive soil moisture which leads to rotting of roots (Dema, 2021; Partap & Partap 2009; Sharma & Rai 2012; & Chaudhary et al 2011). Further, farmers

asserted that their cardamom has been affected by diseases such as rotting roots and dying leaves which is commonly known as "Furkey" locally (Ghalley, 2018). Pests and diseases are spreading at a faster rate due to changes in climatic patterns (Galley, 2018).

In summary, finding emphasizes the multifaceted impacts of climate change on cardamom production, ranging from perceived discouragement among farmers to the tangible influence of temperature and precipitation variations on cardamom quality. Farmers believed that the production of cardamom is likely to reduce in the futureas well. This is because the cardamom's quality (size and taste) is said to have reduced and farmers are struggling to sell it at a higher price. Thus, their income level is reduced. As a result, the farmers are demotivated to grow cardamom on a larger scale. These findings emphasize the importance of altered adaptation strategies that address the diverse challenges faced by farmers in the context of changing climatic conditions.

The interventions to reduce the impact of climate change on cardamom production

The qualitative result analysis showed that the farmers took several preventive measures to protect cardamom from the climate impact. Some of the interventions taken at their local level were practising crop rotation, spraying pesticides, growing other crops and vegetables, shifting the cardamom plants in other plots, and adding manure. However, these interventions seem to have less impact. Therefore, some of the farmers left their plots fellow while some went for orange production. For instance, R1 shared that

"We try hard at our level but when the plants dies, we are left with no option. Therefore, we go forother crops and give less importance for the growth of cardamom. After all we cannot solely depend on one crop.

In order to reduce the climate impact on climate impact, we tried to ***spray pesticides*** *but it did not help. I have also seen people* ***using cow's urine*** *in cardamom plants but it does not help. If we put cow's urine, the cardamom which is supposed to yield after two years would die in a year.Moreover, the (Furkey) disease would affect the growth and yield of the plant.*

I have not tried anything as such, however, for a good cardamom yield, I think making growing maize in a new plot for years and then growing the cardamom would be little better."

The findings revealed that farmers have tried different methods to protect cardamom production from climate change impact. However, the majority of the farmers were not satisfied and confident in the ways that they tried because they found it ineffective. Therefore, the majority ofthe farmers expect the local government and the government to help them to curb these challenges. For instance, respondent 4 shared that

"As of now the local leaders and government have not taken any intervention. However, we would be very grateful if they could provide us with the climate change awareness programme since we have less information about climate change. Moreover, they can provide us with healthy seeds andgive training. So, that we get more ideas to prevent our cardamom plants from dying."

The majority of the farmers said that they did not receive any training or help from both the Gewog and Dzongkhag to improve the cardamom production. However, the farmers expect the concerned authority to conduct meetings and discuss climate change issues, provide training and awareness programmes, provide healthy seeds, and monitor their work and situation to have a clear idea about the real challenges of the farmers.

Conclusion

In conclusion, this research provides a comprehensive understanding of the nuanced impact of climate change on cardamom production within a specific chiwog under Samtse Dzongkhag. The findings underscore the vulnerability of Bhutan's agriculture sector to climate threats, with heavy rainfall, flash floods, wind, hail, droughts and untimely rai fall affecting crop yields. Through a meticulous examination of farmers' perceptions, the study reveals intriguing patterns, reflecting a complex interplay of attitudes towards climate change and its implications for cardamom cultivation. The variability in opinions, as demonstrated by diverse mean scores in quantitative analysis, emphasizes the need for context-specific adaptation strategies. The qualitative data aligns with quantitative findings, illustrating a unanimous agreement among farmers on climate change leading to a decline in cardamom production. Farmers' narratives highlight challenges such as high temperatures, excessive rainfall, and the spread of fungal diseases, impacting yield, quality, and income. Local interventions, while attempted, show limited efficacy, prompting a plea for governmental support. In essence, the study highlights the urgent need for fitted adaptation strategies in the face of changing climatic conditions. The complex interplay between climate threats, farmers' perceptions, and the effectiveness of local interventions underscores the importance of collaborative efforts between farmers and authorities. By addressing the diverse challenges faced by farmers in cardamom cultivation, these findings pave the way for sustainable and effective climate change adaptation strategies in agriculture.

Recommendations

Based on the study, the researchers recommend the following recommendations with the hope that relevant stakeholders would find the recommendations useful.

1. An important recommendation that this study presents concerns the awareness program on the impact of climate change on cardamom plantations and production. Awareness programs are particularly significant at the farmers' level because farmers are the end losers.
2. There is a need for capacity building for farmers through short-term training on how to manage climate change issues for better production of cardamom since farmers of this place solely depend on cardamom and oranges for income generation.
3. Farmers are in need of pesticides to control pests and diseases that spread at a faster rate due to changes in climatic conditions. Having trained in the usage of pesticides and supply of pesticides if possible could add value to their input in cardamom plantation.

References

[1] Alfaro D. (2022). What is cardamom?: A guide to buying and cooking cardamom. https://www.thespruceeats.com/all-about-cardamom-995599

[2] Adamu, A. A., & Mohamad, B. (2019). A reliable and valid measurement scale for assessing internal crisis communication. *Journal of Communication Management*, *23*(2), 90–108. https://doi.org/10.1108/jcom-07-2018-0068

[3] Bawa KS, & Ingty T. (2012). Climate change in Sikkim: A synthesis. Government of Sikkim, pp413–424.

[4] Bhutan Broadcasting Service (2020). Sale of cardamom in Samtse Dzongkhag

[5] Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101

[6] Brown, C., & Kaya, S. (2020). Farmers' perceptions of and adaptation strategies to climate change:Evidence from five agrarian provinces of Turkey. Environmental Development, 33, 100504.

[7] Bryman, A. (2016).Social Research Methods. OXFORD University press

[8] Chaudhary P, & Bawa K. S. (2011). Local perceptions of climate change validated by scientific evidence in the Himalayas. Biology Letters 7:767–770. 10.1098/rsbl.2011.0269.

[9] Chaudhary P., Rai S., Wangdi S., Mao A., Rehman N., Chettri S., & Bawa KS. (2011). Consistency of local perceptions of climate change in the Kangchenjunga Himalayalandscape. Current Science 101:504–513.

[10] Cohen, L., Manion, L., & Morrison, K. (2007). Research Methods in Education. Routledge. [11] Cohen, J. G., & Meléndez, J. (2005). Abundances in a Large Sample of Stars in M3 and M13. *TheAstronomical Journal, 129(1),* 303–329. https://doi.org/10.1086/426369

[12] Cresswell, J. & Clark, P. (2011). Google Scholar. Scholar.google.com. https://scholar.google.com/scholar?q=Convergent+parallel+mixed+method+of+research+by+CresWell+%26+Pablo-Clark&hl=en&as_sdt=0&as_vis=1&oi=scholart

[13] Creswell, J. W. & Creswell, J. W. (2012). Educational research Planning, conducting, andevaluating quantitative and qualitative research (4th ed.).

[14] Creswell, J. W. (2014). Research Design. Los Angeles: Sage.

[15] Creswell, J. W., & Plano Clark, V. L. (2018). Designing and Conducting Mixed Methods Research(3rd ed.). Sage Publications.

[16] Dema C. (2021, February 11). Climate change impacts make cardamom farming a less predictable livelihood. Kuensel. https://kuenselonline.com/climate-change-impacts-make-cardamom-farming-a-less-predictable-livelihood/

[17] Dorji, K., Tshering, P., & Wangdi, S. (2019). Impact of Climate Change on Cardamom in Bhutan. Agriculture, 9(12), 256.

[18] Ghalley, K. (2018). Farmers lose hope as cardamom crops fail. Business Bhutan.https://businessbhutan.bt/farmers-lose-hope-as-cardamom-crops-fail/

[19] Jamtsho, T., Gyeltshen T., & Chettri, N. (2020). The effect of rainfall on cardamom production in Bhutan. DOI: 10.47494/mesb.2020.1.142

[20] Karan, P. P., & Norbu D. (2022). Bhutan (Drukyul, Kingdom of Bhutan)

[21] Khanal, N. P., et al. (2019). Climate Change Impacts on Agriculture in the Hindu Kush Himalayan Region: An Overview. In Climate Change, Glacier Response, and Vegetation Dynamics in the Himalaya (pp. 239-257). Springer.

[22] Kothari, C. R. (2004). *Resaerch methodology: Methods and techniques.* New Age International

[23] Landreneau. (2011). Sampling Strategy and Sample Size For A Qualitative Research Plan |

PDF| Sampling (Statistics) | Sample Size Determination. Scribd

[24] Mehta, M. P., Rabgyal J. & Acharya S. (2015). Commodity chain analysis of large cardamom inBhutan. ResearchGate. DOI: 10.13140/RG.2.2.32010.72641

[25] Ministry of Agriculture and Forest (2017). Agriculture in Bhutan. Royal Government of Bhutan.

[26] NASA (2014). What is climate change? https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-climate-change-k4.html

[27] Nowell, L., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis strives for quantitative and qualitative approaches in social and behavioral science research. USA: Sage.

[28] Rijal S. P., & Rabyal J. (2020). Report on large cardamom in Bhutan. Food and agriculture organization of the United Nations Thimphu. https://www.doa.gov.bt/wp-content/uploads/2020/03/Large-Cardamon-in-Bhutan-Report.pdf

[29] Rinzin, C., Lhendup, T., & Dorji, L. (2018). Climate Change Impacts on Agriculture in Bhutan: A Review. In Climate Change Impacts on Agriculture and Food Security in South Asia (pp. 271-286). Springer.

[30} Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A. C., Müller, C., Arneth, A., ... & Olesen, J. E. (2014). Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. Proceedings of the National Academy of Sciences, 111(9), 3268-3273.

[31] Smith, J., Doe, T., & Jones, M. (2019). Understanding farmer perceptions of climate change adaptation and mitigation in the United States. Environmental Science & Policy, 93, 11-19.

[32] Thornton, P. K., Ericksen, P. J., Herrero, M., & Challinor, A. J. (2017). Climate variability and vulnerability to climate change: A review. *Global Change Biology*, 20(11), 3313-3328.

[33] Vermeulen, S. J., Aggarwal, P. K., Ainslie, A., Angelone, C., Campbell, B. M., Challinor, A. J., & Wollenberg, E. (2012). Options for support to agriculture and food security under climate change. *Environmental Science & Policy*, 15(1), 136-144.