Assessing Coffee Farmers' Awareness of Climate Change Through the Climate Change Awareness Index Approach in Tutur, Pasuruan, Indonesia

Mirza Andrian Syah[1*], Ifwarisan Defri[2], Worawan Panpipat[2], Manat Chaijan[2]

1 Agribusiness Department, Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Raya Rungkut Madya Street No.1, Surabaya, Indonesia
2 School of Agricultural Technology and Food Industry, Walailak University, Nakhon Si Thammarat 80160, Thailand

*corresponding author: mirza.a.agribis@upnjatim.ac.id

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Abstract

Climate change poses significant challenges to coffee production, particularly in regions highly dependent on stable agroclimatic conditions. This study assesses the awareness of coffee farmers in Tutur, Pasuruan, Indonesia, regarding climate change using the Climate Change Awareness Index (CCAI). A quantitative survey was conducted among 100 coffee farmers to measure their knowledge, perceptions, and adaptive actions toward climate change. The findings reveal that farmers recognize climate change primarily through shifts in rainfall patterns, rising temperatures, and increased pest infestations, leading to reduced coffee productivity. Farmers engaged in farmer groups exhibit higher awareness levels due to enhanced access to information and knowledge exchange. The CCAI analysis indicates a high awareness level among respondents, with perception as the dominant dimension. However, adaptation efforts remain limited, necessitating further interventions such as improved agricultural extension programs and policy support. This study provides empirical evidence on the level of climate change awareness among coffee farmers in Tutur and underscores the critical role of farmer groups in enhancing adaptive capacity. It offers valuable insights for policymakers and stakeholders aiming to build climate-resilient coffee production systems.

Keywords: Climate Change Awareness, Coffee Farmers, Adaptation Strategies, Sustainable Agriculture, Indonesia

Introduction

Indonesia remains one of the world's largest coffee producers, ranking fourth after Brazil, Vietnam, and Colombia. According to data from the Ministry of Agriculture Republic of Indonesia (2023), Indonesia's coffee production in 2023 reached 774,600 tons, with a plantation area of approximately 1.24 million hectares. Despite increased production, the average productivity remains around 700 kg of coffee beans per hectare per year. Coffee's contribution to the national economy remains significant, particularly as a foreign exchange earner through exports. However, climate change threatens the sustainability of coffee production in various regions, including Tutur Subdistrict, Pasuruan Regency. Climate change has significantly impacted the agricultural sector, particularly crops that heavily rely on stable agroclimatic conditions, such as coffee. Natural risks associated with climate change include rising air temperatures, shifting rainfall patterns, and the increasing frequency of extreme weather events. These factors can disrupt the coffee growth cycle, leading to reduced productivity and lower bean quality. Climate change also exacerbates production risks, including the increased prevalence of pests and diseases due to changing temperatures and humidity levels. Research by Altieri et al. (2015) indicates that extreme weather events trigger higher pest and disease populations, negatively affecting coffee productivity.

Climate change poses a global challenge that affects the agricultural sector. Weather anomalies such as shifting rainfall patterns, rising temperatures, and extreme weather events significantly impact coffee productivity (IPCC, 2021). Coffee farmers in various regions struggle to adapt to changing environmental conditions, including those in Tutur, Pasuruan, Indonesia, known as a key coffee production center with an altitude conducive to coffee cultivation (Ministry of Agriculture Republic of Indonesia, 2023). The impact of climate change on coffee production has been confirmed through various studies in Indonesia. In Jember Regency, East Java, for example, an extended drought due to El Niño in 2023 drastically reduced coffee plantation productivity. A farmer reported a harvest decline of more than 50% due to dried coffee flowers

and widespread leaf shedding as trees withered. This production decline highlights the crucial role of climate variability in affecting agricultural yields, including in Tutur, which shares similar agroclimatic characteristics.

Farmers' awareness of climate change is a key factor in maintaining production levels and harvest quality. Studies indicate that farmers' awareness of climate change contributes to the adoption of sustainable agricultural practices, such as agroforestry and soil conservation (Altieri et al., 2015). Lack of awareness can hinder optimal adaptation responses, potentially reducing coffee farmers' productivity and well-being (Lipper et al., 2014). The Climate Change Awareness Index (CCAI) approach is used to assess farmers' awareness levels regarding climate change. This analysis evaluates farmers' understanding, attitudes, and actions in response to climate change impacts. This approach aims to provide empirical insights into the extent to which coffee farmers in Tutur recognize and respond to climate change in their agricultural practices.

When discussing awareness, it is not solely dependent on farmers' direct experiences with the impacts of climate change but can also be examined through three dimensions: knowledge, perception, and adoption. The knowledge dimension reflects the extent to which farmers understand the basic concepts of climate change, its causes, and its impacts on agriculture. Previous studies indicate that farmers with higher levels of knowledge tend to be better prepared to adopt mitigation and adaptation strategies in response to climate change (Lipper et al., 2014). Additionally, farmers' perceptions of climate change influence their decisions in adjusting their farming practices. Perceptions, shaped by personal experiences and information obtained from various sources, contribute to how farmers assess the risks of climate change to their production and economic well-being (Nelson et al., 2009).

Beyond knowledge and perception, the adoption of adaptation practices serves as an indicator of farmers' readiness to cope with climate change. The adoption of adaptation strategies, such as crop diversification, agroforestry, and water management, depends on farmers' understanding and perception of the benefits of these strategies. A study by WeldeMichael & Teferi (2019) found that farmers with higher climate change awareness are more likely to adopt sustainable agricultural practices to mitigate the negative effects of climate change on their yields. Thus, measuring farmers' awareness through these three dimensions is essential in designing effective strategies to enhance the agricultural sector's resilience to climate change through mitigation efforts.

Tutur's diverse agroecological characteristics allow for variations in farmers' climate change awareness levels. Socioeconomic factors, education levels, information access, and farming experience are primary determinants shaping farmers' perceptions of climate change (Lipper et al., 2014). A deeper understanding of these factors can aid in designing more targeted policy interventions. Research on coffee farmers' awareness of climate change in Indonesia remains limited. Previous studies have predominantly focused on climate change impacts on coffee production without specifically measuring farmers' understanding levels (Gokavi & Kishor, 2020). This study seeks to address this literature gap by adopting a quantitative, index-based approach to systematically assess farmers' awareness.

This research directly contributes to achieving Sustainable Development Goal (SDG) 13: Climate Action, as improved understanding of farmers' awareness can drive the adoption of more adaptive and environmentally friendly farming practices. Additionally, this study enhances comprehension of farmers' awareness of climate change, serving as a foundational step in developing adaptation and mitigation strategies while identifying how coffee farmers in Tutur perceive and respond to climate change impacts on their production. Greater climate change awareness can encourage farmers to adopt more sustainable agricultural practices, such as shade trees to mitigate temperature increases, agroforestry systems, water conservation, and crop diversification to enhance resilience against climate variability. Furthermore, increased awareness can promote farmer participation in climate change mitigation programs, such as reducing greenhouse gas emissions through more efficient and environmentally friendly farming practices.

Materials and Methods

This study employs a quantitative approach using a survey method to assess coffee farmers' awareness of climate change. Data collection was conducted in Tutur, Pasuruan, Indonesia (Figure 1) from August to October 2024. The research sample was determined using a purposive sampling technique, selecting coffee farmers who have been farming for at least five years, totaling 100 respondents (Table 1). The research instrument consisted of a questionnaire comprising closed and open-ended questions related to farmers' understanding, awareness, attitudes, and actions regarding climate change. The validity and reliability of the questionnaire were tested through a limited trial before being used in the main study. The research stages and data analysis process are illustrated in Figure 2 below:

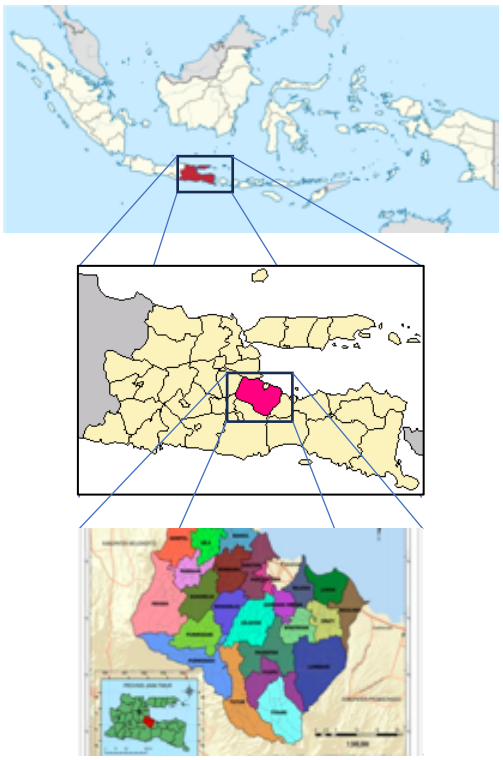

Figure 1. Research Location

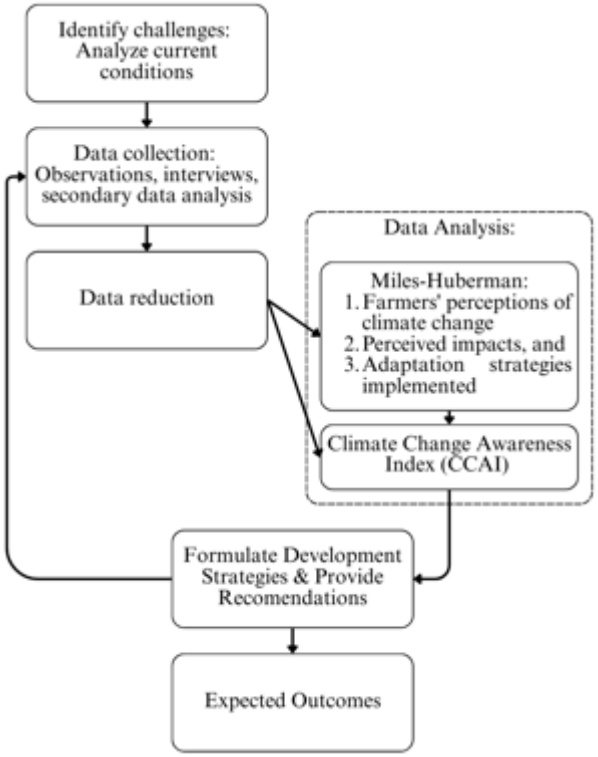

Figure 2. Research Flow

Based on Figure 2, this study begins by identifying the challenges faced by farmers in responding to climate change through an analysis of current conditions. Data were collected through observations, interviews, and secondary data analysis to understand farmers' perceptions, the impacts they experience, and the adaptation strategies they have implemented. The collected data were then reduced and analyzed using Miles and Huberman's approach, which includes three key aspects: farmers' perceptions of climate change, the impacts they experience, and their adaptation strategies. The results of this analysis were used to develop the CCAI as an indicator of farmers' awareness levels regarding climate change. Based on the awareness index obtained, the study formulated development strategies and recommendations to enhance farmers' preparedness in facing climate change. These recommendations aim to strengthen adaptive capacity through appropriate interventions. Ultimately, this study is expected to produce outcomes that support farmers in adopting mitigation and adaptation strategies more effectively.

Table 1. Respondent Characteristics

No.	Description	Number of Respondents
1.	Gender	
	- Male	90
	- Female	10
2.	Age (Years)	
	20 – 29	2
	30 – 39	15
	40 – 49	54
	50 – 59	27
	60 – 69	2
3.	Years of Coffee Farming	
	5	3
	>5 – 12	56
	13 – 20	28
	> 20	13

Data analysis was conducted using the Miles-Huberman model and the Climate Change Awareness Index (CCAI). The Miles-Huberman model was employed to explain how coffee farmers in Tutur Subdistrict, Pasuruan, Indonesia, become aware of climate change. This model consists of three main stages: data reduction, data presentation, and conclusion drawing and verification, based on primary data obtained through interviews and observations with coffee farmers in the study area. The Climate Change Awareness Index (CCAI) was used to assess farmers' awareness of climate change based on three indicators: knowledge of climate change (K), perception of climate change impacts (P), and adaptation actions to climate change (A). The measurement scale follows a Likert scale: 1 = not aware at all to 5 = highly aware for each indicator. The weight and index score were determined using the following formulas:

$$K = \frac{\sum K_i}{n}, P = \frac{\sum P_i}{n}, A = \frac{\sum A_i}{n} \quad \text{.....(1)}$$

The Climate Change Awareness Index was then calculated using the following equation:

$$CCAI = (\omega_K \times K) + (\omega_P \times P) + (\omega_A \times A) \quad \text{.....(2)}$$

The interpretation of the analysis results is as follows:

Table 2. Climate Change Awareness Index Interpretation

CCAI Index	Awareness Level
0.00 - 1.99	Low
2.00 - 3.49	Medium
3.50 - 5.00	High

Result and Discussion

Climate change has significantly impacted coffee farming activities, affecting production, quality, and the sustainability of agricultural systems, which indirectly influences farmers' economic stability. The economic impact of climate change on coffee farming is unavoidable, as it is closely related to agricultural sustainability. Declining coffee productivity and quality result in decreased income for farmers, particularly those whose primary earnings depend on coffee harvests. Low-quality coffee beans fetch lower prices in the market, making it difficult for farmers to cover production costs. Morton (2007) found that climate change not only affects harvest yields but also exacerbates economic uncertainty for small-scale farmers with limited access to capital and markets. To further explore the impact of climate change, this study illustrates how farmers perceive climate change events.

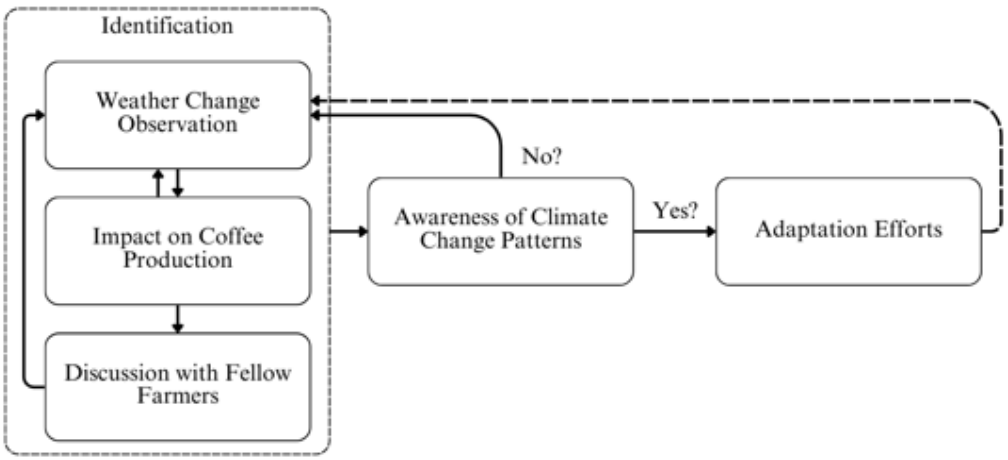

Figure 3. The Process of Coffee Farmers' Awareness of Climate Change

Identification

Findings presented in Figure 3 indicate that coffee farmers in Tutur Subdistrict, Pasuruan, gradually recognize climate change through firsthand experiences in their fields. Key indicators observed include irregular rainfall patterns, rising temperatures, and increased occurrences of strong winds and extreme

rainfall. Awareness of these changes has developed alongside declining coffee productivity and increased pest and disease infestations, previously uncommon in the area. Interviews with farmers revealed that climate change has led to a 20% decrease in coffee yields over recent years. Pests such as *Hypothenemus hampei* (coffee berry borer) (Figure 4) and diseases like coffee leaf rust (*Hemileia vastatrix*) (Figure 5) have become more prevalent due to higher temperatures and humidity. These findings align with studies by WeldeMichael & Teferi (2019) and Ramadhillah & Masjud (2024), which also established a correlation between rising temperatures and increased disease prevalence in coffee-producing regions. In Tutur, farmers experiencing the most significant yield reductions were those practicing monoculture farming without shade trees, which exacerbated heat stress on coffee plants and accelerated pest proliferation.

Figure 4. *Hypothenemus hampei* Ferr. attack on coffee plants
Source: Hendrival et al. (2024)

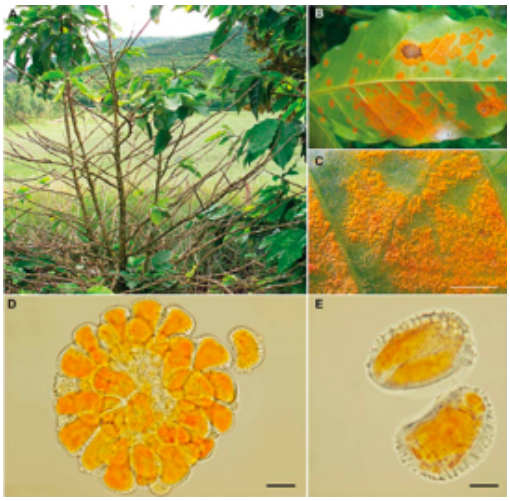

Figure 5. Coffee Rust, *Hemileia vastatrix* on coffee plants
Source: Carvalho et al. (2011)

Farmer groups play a crucial role in raising awareness about climate change. Discussions among farmers within these groups serve as a primary means of understanding weather pattern changes and seeking solutions. Farmers actively participating in such groups tend to have better knowledge of climate change due to improved access to information and agricultural extension programs. These groups often function as key platforms for government agencies, academics, and non-governmental organizations to provide education on climate change patterns, its agricultural impacts, and applicable mitigation and adaptation strategies. This finding is consistent with research by Nelson et al. (2009), which highlights the crucial role of farmers' social networks in disseminating information and adaptation strategies for climate change. Membership in farmer groups also facilitates knowledge exchange and collective learning, allowing farmers to adopt best practices in coffee farming.

Awareness of Climate Change Patterns

An individual's awareness of a phenomenon, including climate change, develops through a complex process involving direct experiences, social interactions, and access to information and education. This process progresses through several stages, from exposure to an event, individual perception, experience-based interpretation, and eventually, the formation of knowledge and adaptive responses. The resulting awareness influences individuals' attitudes and actions in adjusting to changes. Farmers who recognize that climate change affects productivity are more likely to implement mitigation or adaptation measures.

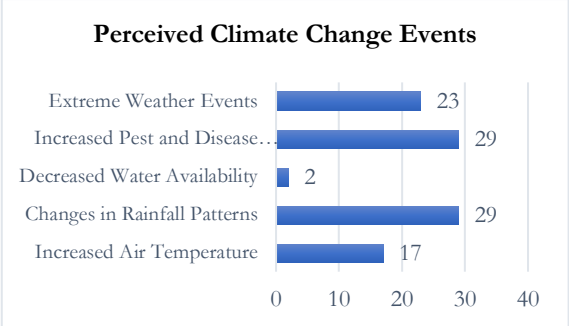

Figure 6. Perceived Climate Change Events

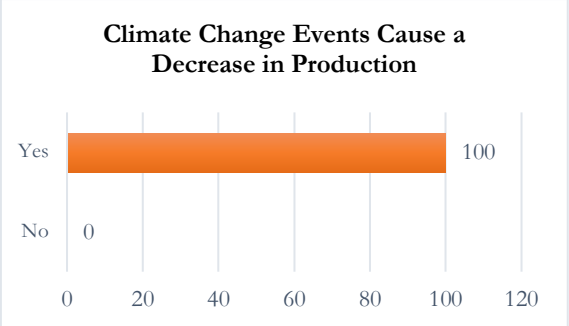

Figure 7. Climate Change Events Cause a Decrease in Production

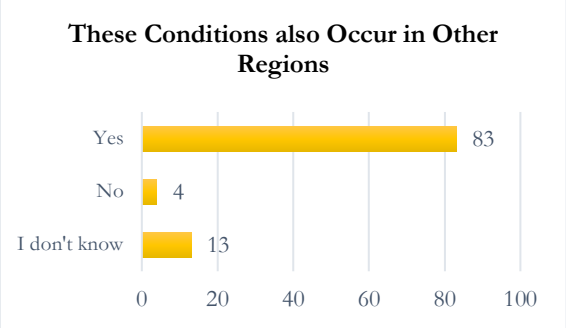

Figure 8. These Conditions also Occur in Other Regions

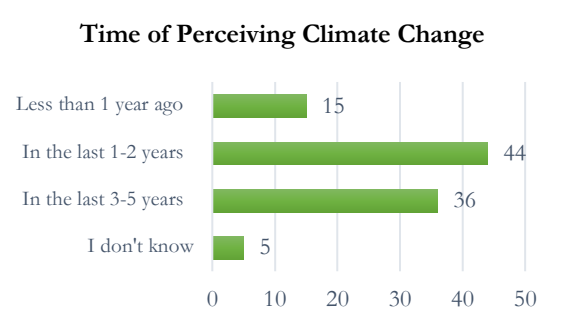

Figure 9. Time of Perceiving Climate Change

Climate change awareness results from the interplay of direct experience, individual perception, and access to information. This study finds that coffee farmers in Tutur exhibit varying levels of awareness in identifying and responding to climate change (Figures 6 and 9). Awareness develops over time, influenced by multiple factors shaping farmers' perceptions of changing climate events. The findings confirm that climate change has negatively impacted coffee farming, particularly through reduced yields (Figure 7). Respondents in this study associate extreme climate events with decreased agricultural productivity, indicating that climate change awareness strongly correlates with direct experiences of its adverse effects.

Figure 6 reveals that the most frequently perceived climate change events by farmers include altered rainfall patterns and increased pest and disease infestations. Unpredictable rainfall has emerged as one of the primary challenges for coffee farmers. Earlier or delayed rainy seasons disrupt the coffee growth cycle, potentially affecting flowering and fruit-setting processes. Imbalances in rainfall, whether prolonged droughts or excessive rainfall, can hinder flowering and cause premature flower drop. Additionally, water shortages lead to plant stress, inhibiting root and leaf growth and ultimately reducing productivity. Moreover, erratic rainfall can disrupt harvest and post-harvest processes, as rainfall during the drying phase increases the risk of unwanted fermentation, reducing final product quality (Rahmawati et al., 2025; Rizki et al., 2020). Consequently, changes in rainfall patterns affect coffee bean quality, as irregular wet and dry periods result in inconsistent bean sizes, diminishing coffee flavor and reducing its market value, ultimately lowering farmers' income.

Conversely, increased humidity due to excessive rainfall can trigger a rise in pest and disease infestations. Changes in temperature and rainfall patterns create favorable conditions for agricultural pests. Rising temperatures accelerate the life cycle of pests such as Hypothenemus hampei (coffee berry borer), causing population surges that intensify coffee plant damage (Angka & Dewi, 2021). Furthermore, high humidity due to erratic rainfall enhances fungal pathogen growth, such as Hemileia vastatrix, the causative agent of coffee leaf rust, which inhibits photosynthesis and significantly reduces coffee fruit production (Prasetyo et al., 2017). The combination of increased pest and disease attacks contributes to declining yields and coffee bean quality, ultimately threatening the sustainability of coffee farming. Farmers are compelled to allocate additional resources for pest and disease management, whether through pesticide use or by adopting more adaptive cultivation techniques, such as integrating shade trees and implementing more resilient planting systems.

Extreme weather events, including heavy rainfall, strong winds, and storms, have become more frequent, causing direct physical damage to crops and agricultural infrastructure. Intense short-duration rainfall increases landslide risks, particularly in hilly areas such as Tutur Subdistrict, leading to the loss of arable land. Farmers also reported damage from strong winds, which caused shade trees to topple, damaging coffee plants. The loss of shade trees further disrupts coffee plant productivity, as these trees play a crucial role in maintaining the microclimate conditions necessary for coffee growth. These findings align with research by Bunn et al. (2015), which highlights the increasing frequency of extreme weather events experienced by coffee farmers, resulting in greater land and crop damage compared to previous decades.

Global temperature rises also impact coffee productivity and bean quality. Higher-than-average temperatures accelerate fruit maturation but often result in smaller beans and diminished quality. Additionally, excessive sunlight exposure can scorch coffee blossoms, preventing them from developing into fruit. Climate-induced temperature changes can also shift optimal coffee-growing regions. Areas previously suitable for coffee cultivation may become too hot, while higher-altitude areas, previously less optimal, may become more favorable for production. This study supports findings by Bunn et al. (2015), indicating that rising temperatures, coupled with changing rainfall patterns, contribute to fluctuating yields,

disrupting synchronization between flowering and fruiting cycles. Such variability affects production stability, potentially impacting both local and global coffee supply chains.

Moreover, the study reveals that farmers perceive climate change as a broader phenomenon extending beyond their immediate surroundings (Figure 8). This finding confirms that climate change awareness has a spatial dimension—farmers recognize climate change events and their impacts not only within their locality but also on a larger scale. Climate change awareness is influenced not only by direct experience but also by information about similar occurrences in other regions. When farmers realize that climate change effects are widespread, they are more likely to acknowledge its global significance and take proactive measures. For example, coffee farmers in Tutur, who experience reduced productivity due to increased pest infestations, may better understand climate change urgency when they learn that farmers in neighboring areas like Tosari and Puspo face similar issues. Such information is disseminated through farmer group discussions, agricultural extension programs, and media outlets.

The measurement of farmers' awareness of climate change events was analyzed using the Climate Change Awareness Index (CCAI), which comprises three dimensions, each with specific indicators. Awareness is a key factor in determining the preparedness of coffee farmers in Tutur to adopt effective adaptation strategies to maintain coffee yield productivity. According to Lipper et al. (2014), low awareness of climate change can lead to delays in the adoption of adaptation technologies, increasing the risk to harvest yields and agricultural sustainability. The analysis results are presented in Table 3.

Table 3. Climate Change Awareness Index Calculation

Dimension	Average Score	Weight (ω)	$\omega \times$ Average Score
1. Knowledge	3.780	$^1/_3$	1.26
1.1. Basic knowledge			
1.2. Information source			
1.3. Causal factors			
1.4. Impacts of climate change			
2. Perception	3.796	$^1/_3$	1.26533333
2.1. Concern about crop failure			
2.2. Perception of weather pattern changers over the last 5-10 years			
2.3. Impact of temperature & rainfall changes on coffee production			
2.4. Increasing occurrence of pests and plant diseases			
2.5. Impact of climate change on economic well-being			
3. Adaptaion	3.220	$^1/_3$	1.07333333
3.1. Agricultural enterprise diversification			
3.2. Participation in sustainable agriculture training			
3.3. Participation in sustainable agriculture training			
3.4. Implementation of agroforestry			
CCAI Score			**3.59866667**

The analysis in Table 3 indicates that the Climate Change Awareness Index score is 3.59866667, meaning that coffee farmers in Tutur Subdistrict, Pasuruan, Indonesia, have a high level of awareness regarding climate change events. A high awareness score suggests that farmers have a good understanding of climate change and its impact on coffee farming activities. This condition reflects their ability to recognize changes in weather patterns, assess associated risks, and demonstrate readiness to implement mitigation efforts to avoid greater threats. These findings align with previous studies showing that farmers in agrarian

regions with high environmental risk exposure tend to have higher climate change awareness levels (Ratakonda et al., 2024; Smit et al., 2000).

The CCAI analysis reveals that perception is the highest-scoring dimension. Several indicators support the high perception level among farmers. First, concerns about crop failure are a key component of farmers' perception evaluation. Farmers recognize that unpredictable weather patterns increase the risk of crop losses, directly affecting agricultural sustainability. Second, their perception of weather pattern changes suggests that farmers have observed significant shifts in rainfall patterns, irregular growing seasons, and higher-than-usual temperatures. Third, temperature and rainfall changes substantially impact coffee production, where increased temperatures and unstable rainfall can hinder growth and bean quality. These findings reinforce previous research by Ratakonda et al. (2024), Prasetyo et al. (2017), Nelson et al. (2009), and WeldeMichael & Teferi (2019), indicating that farmers who have experienced climate change impacts over long periods tend to develop higher awareness of its risks. As climate change effects persist, farmers increasingly recognize the need for mitigation and adaptation strategies, which, in turn, enhance their awareness levels.

The high awareness level in the knowledge dimension indicates that farmers understand climate change concepts. This knowledge includes factors such as the causes of climate change, its impacts on agricultural activities, and how various elements contribute to climate change occurrences. Farmers with high knowledge awareness generally perceive climate change as a long-term trend rather than a temporary phenomenon, recognizing its potential implications for agricultural sustainability. According to Belay et al. (2022), a strong understanding of climate change correlates with adequate access to information, whether through media, agricultural extension services, or firsthand experiences with shifting weather patterns and agricultural production. Farmers' direct experiences with shifting rainfall seasons and rising average temperatures play a crucial role in strengthening their climate change comprehension.

Although its value is relatively lower compared to other dimensions, adaptation remains a contributing factor in shaping coffee farmers' awareness of climate change. Adaptation reflects the extent to which farmers can recognize, respond to, and adjust their agricultural practices to changing climatic conditions. Field observations indicate that most farmers rely on direct experience and inherited knowledge in managing their farms. However, some farmers have gradually adopted adaptation strategies such as shade management and agroforestry implementation. Despite being lower than the knowledge and perception dimensions, farmers' increasing tendency to adopt adaptation strategies demonstrates their recognition of the importance of adjusting agricultural practices to climate change dynamics.

Adaptation Efforts

Adaptation to climate change is crucial in maintaining the sustainability of coffee production amid increasingly unpredictable environmental challenges. Awareness of climate change plays a significant role in encouraging farmers to take more proactive adaptation measures. Various studies have shown that higher awareness levels correlate with the adoption of more sustainable and risk-mitigating agricultural practices ((Belay et al., 2022; Nelson et al., 2009; WeldeMichael & Teferi, 2019). To understand the relationship between farmers' climate change awareness and the adaptation strategies they implement, this study analyzes the distribution of farmers based on their awareness levels regarding different adaptation efforts. Table 4 presents the correlation between farmers' awareness levels and their chosen adaptation strategies in response to climate change.

Table 4. Crosstab of Farmers' Awareness Levels and Climate Change Adaptation Efforts

Adaptation Effort	**Farmers' Awareness Levels**		
	Low	**Medium**	**High**
Crop Diversification	0	10	13
Shade Management	0	9	27
Agroforestry Implementation	0	3	11
Integrated Pest Management	0	4	9
Water Management	0	1	4
No Adaptation	0	7	2

Based on the analysis in Table 4, no farmers in the study area exhibited low awareness of climate change. Meanwhile, farmers with medium and high awareness levels demonstrated various adaptation strategies, with a tendency for higher awareness levels to be associated with more active adaptation

measures. Shade management was the most commonly adopted adaptation strategy among farmers with high awareness (27 farmers), followed by crop diversification (13 farmers) and agroforestry implementation (11 farmers). These findings align with Nelson et al. (2009), who stated that farmers with high climate change awareness are more likely to adopt ecologically-based adaptation practices to enhance their agricultural resilience.

On the other hand, farmers with medium awareness levels also exhibited adaptation tendencies, albeit in lower numbers compared to those with high awareness. The difference in the number of farmers adopting adaptation strategies between the medium and high awareness groups indicates that awareness influences farmers' decisions to be more proactive in managing climate change risks. This finding suggests that higher awareness levels enable farmers to better understand the importance of sustainable management techniques in addressing climate change, as supported by the study of WeldeMichael & Teferi (2019), which found that farmers' awareness of climate change contributes to increased adoption of sustainable farming methods.

Interestingly, some farmers with medium awareness (7 individuals) did not adopt any adaptation measures, and two farmers with high awareness also refrained from implementing adaptation strategies. This result indicates that while awareness is a crucial factor in driving adaptation actions, other potential constraints may influence farmers' decisions. As noted by Sajise et al. (2017), economic factors and access to resources can also pose significant barriers to the implementation of climate change adaptation strategies.

Development Strategies

Climate change mitigation strategies heavily depend on farmers' awareness levels in understanding and responding to climate dynamics affecting coffee production. Farmers with higher awareness levels tend to be more proactive in implementing adaptation strategies compared to those with moderate awareness. Therefore, classifying farmers based on their awareness of climate change can serve as a foundation for formulating more effective mitigation strategies.

Table 5. Proposed Strategies for Farmers' Climate Change Mitigation Efforts

Cluster	Characterictics	Number of Farmers	Recommended Strategies
High Awareness	Recognizes climate change causes, obtains information from reliable sources, highly concerned about crop failure, understands the impact of climate change on production and economic well-being, adopts farm diversification, participates in training, and implements agroforestry.	66	1. Enroll in agricultural insurance 2. Encourage diversification of coffee varietas that are more resilient to temperature and rainfall changes 3. Organiza climate change aweness campaigns
Moderate Awareness	Possesses only basic knowledge, relies on personal experience, is less aware of long-term impacts, and tends to be passive in adaptation strategies.	34	1. Enroll in agricultural insurance 2. Develop shade management by planting drought-resistant shade trees to improve soil fertility 3. Promote simple agroforestry practices with intercropping systems

Coffee farmers with high awareness levels will be more proactive in adopting mitigation strategies to reduce production risks. One recommended strategy is enrolling in agricultural insurance, which can provide financial protection against losses caused by extreme climate conditions. Agricultural insurance has been proven to enhance farmers' resilience to climate uncertainties and encourage investment in more sustainable farming practices (Ceballos et al., 2019). Additionally, diversifying coffee varieties that are more resilient to temperature and rainfall changes is an adaptive step aimed at maintaining productivity. Previous studies have shown that adopting climate-adaptive coffee varieties can enhance yield resilience and mitigate the negative impacts of rising global temperatures (Bunn et al., 2015). Furthermore, organizing climate change

awareness campaigns serves as a strategic effort to enhance collective adaptation capacity among farmers. Such campaigns not only strengthen understanding of climate risks but also promote the broader adoption of adaptation practices within farmer groups (Wood et al., 2014).

For coffee farmers with moderate climate change awareness, several approaches can enhance their resilience and sustainability. One strategy is enrolling in agricultural insurance, which offers financial protection in cases of natural disasters or extreme weather events caused by climate change. Agricultural insurance can be an effective risk mitigation tool, helping farmers cope with the increasing uncertainties of climate variability. Additionally, developing shade management by planting drought-resistant shade trees can enhance coffee plants' resilience to excessive heat and improve soil fertility. Shade trees not only protect coffee plants from heat stress but also enhance biodiversity and maintain soil moisture. Furthermore, implementing simple agroforestry systems with intercropping can support increased yields and enrich agricultural ecosystems. Intercropping plants help improve soil quality, enhance water retention, and provide additional income sources for farmers. These strategies can be applied to mitigate climate change impacts, enhance food security, and sustain coffee production in the future (Bliska et al., 2013; Chavan et al., 2014).

Conclusion

This study emphasizes that coffee farmers in Tutur District, Pasuruan, are becoming increasingly aware of climate change through firsthand experiences on their land, particularly from changes in rainfall patterns, rising temperatures, and increased pest and disease attacks. This awareness is higher among farmers actively involved in farmer groups, which serve as platforms for discussion and information exchange regarding adaptation strategies. The Climate Change Awareness Index (CCAI) analysis indicates that farmers' awareness levels are relatively high, with perception being the dominant dimension. Some farmers have begun to implement adaptation strategies, such as shade management and agroforestry, although these efforts are still limited. Therefore, efforts to enhance adaptation capacity through education, training, and policies that support sustainable farming practices are necessary.

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