Farmers' perceptions and adaptation strategies in facing climate change: a study of shallot farmers in Batu City, Indonesia

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Abstract. Climate change is currently a challenge faced by farmers. Climate change has an impact on farming such as lower yields, more frequent pest and disease attacks, and unpredictable planting seasons. Therefore, farmers' perceptions of climate change have a role in influencing their decisions about how to manage their land and crops. This study aims to investigate farmers' perceptions of and responses to climate change. East Java's Batu City served as the study's location. Thirty shallot farmers participated in this trial, chosen at random. The analysis employed was qualitative descriptive. According to the analysis's findings, 97% of farmers are aware of climate change and gather knowledge from various sources. Shallot farmers view climate change as a serious concern affecting crop harvests. Most Batu City's shallot farmers are aware of and concur that weather-related variables, including wind, humidity, rainfall, and air temperature, significantly impact their shallot yield. To adjust to climate change, 73.3% of farmers decided to substitute other crops, and another 26.6% decided to keep growing shallots. To mitigate the effects of climate change and lower farming hazards, efforts must be made to strengthen farmers' adaptive capacity.

1 Introduction

Climate change is one of the leading global issues threatening agriculture and food security [1]. The global average temperature increase triggers extreme climate events that affect various aspects of life [2]. Climate change, along with various other variables, causes environmental and ecosystem damage, which ultimately impacts economic, social, and human life activities [3, 4]. In this case, climate change can also indirectly impact food security [5].

Climate change has become one of the most significant challenges affecting agricultural activities in various regions [6]. Farmers, as the main actors in the agricultural industry, must

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adapt to dynamic climate changes. However, climate change also presents various types of uncertainty that can affect crop yields and farmer incomes [3].

In the agricultural sector, climate change significantly affects productivity and food security, which are very important for the welfare of agricultural communities. One of the commodities significantly affected is shallots, which are an important horticultural crop. However, high climate variability and changes in weather patterns have created significant challenges for farmers in managing shallot farming [7].

In several studies, farmers were found to be able to carry out effective adaptation strategies in facing the uncertainty of climate change. For example, farmers in some regions have adapted by changing their cropping patterns to deal with more frequent weather changes. Farmers have also used more modern technology, such as more effective irrigation systems, to deal with drought and high rainfall [8]. However, many farmers still face difficulties in adapting to climate change. These difficulties can be caused by various factors, such as lack of access to more modern technology, lack of education and training, and lack of support from the government.

Junrejo is the center of shallot production in Batu City, as explained by BPS Batu City in 2017. That year, Junrejo District produced 191 tons of shallots, Batu District 105 tons, and Bumiaji District 136 tons. Climate change can cause a decrease in production in the following years, caused by attacks by plant pests and diseases on shallots, such as caterpillars and fungal infections.

Shallot farmers in Junrejo face various problems due to climate change, such as decreased productivity, increased pest and disease attacks, and uncertainty in the planting season. Therefore, farmers' perception of climate change is a factor that influences their decisions when managing their land and crops. These perceptions include how farmers understand and assess the risks posed by climate change, as well as how they respond and adapt their agricultural practices to meet these challenges. While there is an extensive literature on farmers' perceptions of climate change [9] [10], comparative studies analyzing the perceptions of horticultural farmers are scarce. This research can help tailor adaptation strategies to specific local contexts and needs. The influence of information sources (e.g., media, extension services, peer networks) on farmers' perceptions and subsequent adaptation strategies is poorly documented. Investigating how different types of information influence farmers' understanding and responses to climate change can inform better communication strategies and education programs.

This research aims to analyze the perceptions of shallot farmers in Batu City regarding climate change and their adaptation strategies in facing climate uncertainty. Understanding farmers' perceptions of climate change is essential to anticipate its impacts [11]. By understanding farmers' perceptions and adaptation strategies, it is hoped that policy recommendations can be formulated to support agricultural resilience in the area. In addition, it is expected that the results of this research will provide insight for policymakers, researchers, and agricultural practitioners in formulating more effective and sustainable adaptation strategies.

2 Research Methods

The research was carried out in Batu City with a case study in Junrejo Village, and data collection was carried out from February to March 2024. The location was chosen considering that this village has quite a lot of shallot production and Batu City is famous for being a cold but hot area. The air temperature is getting higher, and the weather is becoming more uncertain. In collecting data, the number used was 30 respondents. This number was determined with the consideration that 30 respondents were a sufficient number to describe

statistical data. This also refers to [12], who stated that a suitable sample size in research is at least 30 samples. Sampling was carried out using the simple random sampling method.

The data were analyzed using a descriptive statistical analysis approach, and the data analysis method explained how shallot farmers perceive climate change. Farmers' perceptions are seen from farmers' knowledge of climate change, farmers' perceptions of temperature, rainfall, humidity, and wind speed on harvest, and mitigation efforts made by farmer's shallots.

3 Results and Discussion

3.1 Farmer Characteristics

Climate change has an impact on agriculture in various parts of the world, including in Indonesia [13]. Farmers have different knowledge and adaptive behavior regarding climate change depending on their environment, ecology, topography, or socioeconomic conditions [13]. In this research, respondents were selected using a simple random sampling method. Based on the results, it is known that the characteristics of the respondents are different. These differences in course characteristics also influence how farmers perceive climate change and their mitigation attitudes. The characteristics of the respondents can be seen in Table 1.

Table 1. Farmer Characteristics

Farmers Characteristics	**min**	**mean**	**max**	**std. deviation**
Age (years old)	27	48	68	10,981
Long Time Farming Shallots (years)	1	8	17	8,033
Land area m^2	300	1006,67	3000	814,918
Gender	Man 30 (100%)		Female 0	
Educations	Elementary school 13 (43,3%)	Junior High School 10 (33,4%)	Senior High School 7 (23,3%)	

Source: Processed data, 2024

Table 1 shows that the average age of the shallot farmer respondents in the research location is 48 years. Older farmers often have experience and in-depth knowledge of traditional farming practices and ways to cope with various weather conditions. These farmers may have insight into local ways of dealing with changing weather and adapting to extreme conditions. However, this traditional knowledge may not always be enough to face the challenges of modern climate change. Older farmers may face difficulty adopting new technologies or more climate-friendly farming methods.

Farming experience shows that the average farmer has eight years of experience in shallot farming. This farming experience shows that farmers already have sufficient knowledge about shallot farming, including climate change, and have experienced enough experience of climate change in shallot farming. Experienced farmers may be more skilled in applying proven successful farming techniques, but they may also need to adapt these methods to deal with changing climate conditions. For example, they may have strategies to manage irregular rainfall patterns.

The average area of shallot farmers is 1006.67 m^2. Limited land can limit the capacity for sufficient food production. In the context of climate change, this can exacerbate food security issues because extreme weather conditions or changes in rainfall patterns can affect agricultural output.

In terms of gender, all of the shallot farmers are male. In many cultures, men are often associated with a more dominant role in economic and technological aspects and decision-making. This can affect how they view and respond to climate change issues, especially if they see it as more related to sectors they do not consider a priority.

The level of farmer education shows that the majority of farmers have elementary school education. Farmers with higher education tend to be more able to make rational and informed data-based decisions, including in the context of climate change. They may be better able to analyze weather data, climate trends, and technical recommendations to plan and implement effective adaptation strategies.

3.2 Farmers' Knowledge and Experience of Climate Change

Understanding climate change refers to the extent to which farmers can explain climate change and related phenomena. Farmers' knowledge about climate change is an essential aspect of efforts to adapt and mitigate climate change. Farmers with a good level of knowledge about climate change will try to adapt to minimize its impact on the farming business they run [14]. Farmers' experiences in dealing with the impacts of climate change provide an understanding of the various challenges and obstacles they face [13]. They directly experience how climate change affects crop productivity, water availability, pest and disease attacks, and the overall condition of the agricultural environment [15, 16]. This experience provides an essential basis for formulating adaptation strategies for local situations and agricultural needs. Farmers' knowledge of climate change is measured with several questions related to climate change and farmers' ability to explain climate change.

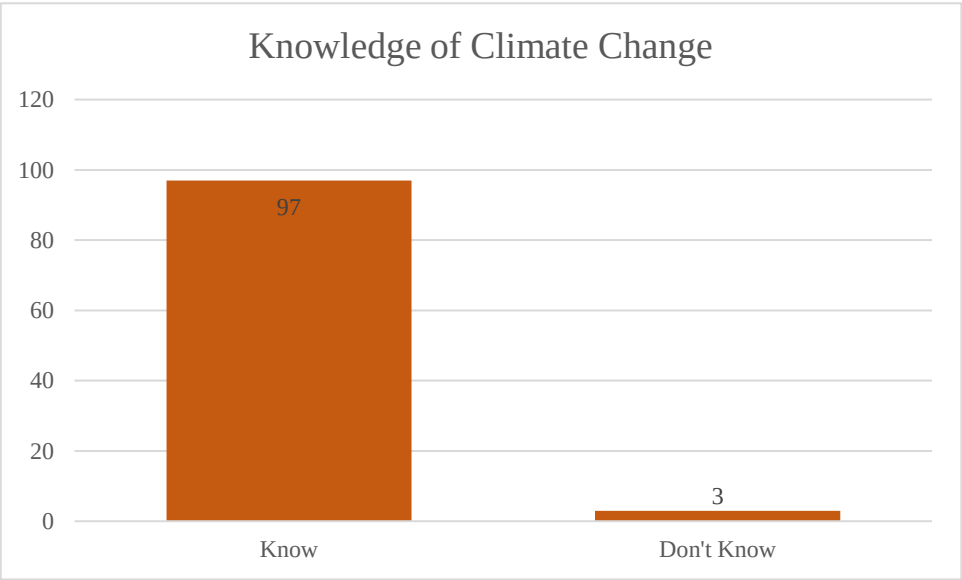

Figure 1. Distribution of farmers based on climate change knowledge

The research results show that most shallot farmers are aware of climate change, and 97 percent of farmers understand climate change. Farmers who know about climate change

obtain information through media such as TV, radio, newspapers, direct experience, the internet, and farmer group organizations. Meanwhile, 3 percent of farmers unaware of climate change have limited means of accessing the internet and have never joined farmer group organizations.

Even though they have limited access to the internet and have never participated in farmer group organizations, farmers still have an understanding of climate change; they feel the unusual climate difference from previous years and are aware of the impact it has. Educational factors also play a role in farmers' knowledge about climate change, but the existence of media such as social media, the internet, and television also influences their understanding of this phenomenon. Even though they do not fully understand the term climate change, farmers are still aware of the impact that climate change has on their farming.

The results of this study support the findings of previous research [17], which also stated that the majority of respondents (98%) knew about the phenomenon of climate change; they got information about climate change from village officials, agricultural extension workers, field officers, and training.

3.3 Farmers' Perceptions of Climate Change

Climate change refers to long-term and significant changes in temperature, rainfall, wind, or snow patterns 18[]. Climate change studied in this research includes four aspects, namely: (a) Air temperature can affect shallot harvest, (b) Rainfall can affect shallot harvest, (c) Air humidity can affect shallot harvest, and (d) Wind can affect shallot harvest. In this research, perceptions of climate change are focused on how it affects shallot harvest at the research location. According to [10], human perception of a person, object, or event and their reactions to these things are based on their past experiences (and learning) relating to similar people, objects, or events. Shallot farmers' perceptions of climate change can be seen in Figure 2.

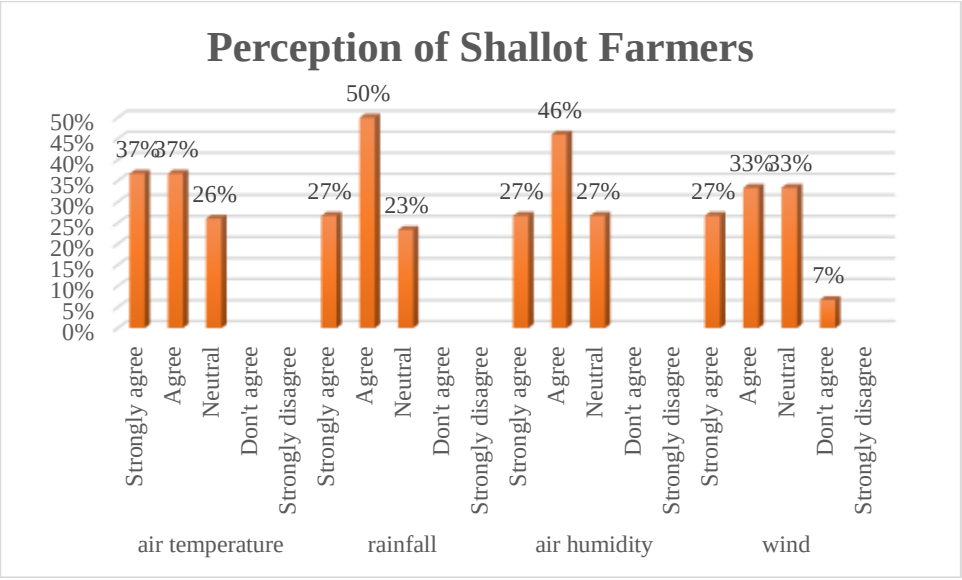

Figure 2. Farmers' perceptions of climate change

Based on the analysis results in Table 2, the perceptions of shallot farmers regarding changes show that 37 percent of farmers strongly agree that air temperature affects shallot harvests in the Batu City area. Meanwhile, 37 percent of people also agreed that air temperature affected the shallot harvest, and the remaining eight people, or 26 percent, answered neutrally. Air temperature is a threat to farmers who are farming shallots. The optimal air temperature for shallot growth is between 20-25°C. Temperatures that are too high or too low can cause problems with plant growth and quality [20]. Extreme temperatures can cause plants to become stressed and susceptible to pest attacks. Shallot plants have an optimal temperature range for their growth; temperatures too high or too low can damage or hinder their production. The majority of farmers, 74 percent, agreed that air temperature affects shallot harvest, indicating there is significant awareness of the influence of air temperature on shallot plant growth.

Sufficient rainfall can meet plant water needs, but rainfall that is too high can cause flooding and disrupt growth [21]. Rainfall that is too low can cause drought and growth disorders. As many as 50 percent of people said they agreed that rainfall could affect shallot harvest, 27 percent said they strongly agreed, and 23 percent answered neutral. This means that 77 percent of farmers admit that rainfall has an impact on shallot yields.

Air humidity also affects shallot harvest yields; as many as 46 percent agreed with this statement, 27 percent of farmers answered strongly agree, and farmers answered neutral is of 27 percent. This means that 73 percent of farmers agreed with the effect of air humidity on shallot yields. Optimal air humidity for shallot growth is between 60-80%. Humidity that is too high can cause growth problems, while humidity that is too low can cause dryness [20, 21].

Furthermore, wind can affect shallot harvest. Wind that is too strong can cause growth problems and damage plants, while wind that is too weak can cause plants to become stressed and vulnerable to pest attacks [21]. A total of 27 percent of farmers agreed with this statement, 33 percent answered strongly agreed, 33 with neutral answers, and 7 percent who answered disagree. This shows that farmers' perceptions of the influence of wind are more varied, with the majority, 60 percent, still recognizing the influence of wind on shallot yields.

Thus, overall, most shallot farmers in Batu City are aware of and agree that climate factors such as air temperature, rainfall, air humidity, and wind influence their shallot harvest. In synthesis, air temperature, rainfall, humidity, and wind affect shallot farming because they influence the environmental conditions necessary for plant growth. Optimal environmental conditions will allow plants to grow well and produce better production.

The findings of this research resemble those of the study [14], which found that climate change affects vegetable farmers in the Dhading district of Nepal. The effects include reduced rainfall intensity, duration, and frequency, higher annual temperatures, prolonged droughts, diminished soil fertility, and the onset of diseases and pests. Consequently, vegetable farming productivity and profits declined, leading to a negative impact on farmer well-being.

The Ministry of Agriculture (2022) states that climate change has the potential to cause changes in planting patterns, cause crop yields to decrease, and increase the potential for attacks by plant pests (OPT) and the potential for plants to be damaged. It is [18] explained that apart from having a direct impact on plants, climate change also harms the soil system. Fluctuations in atmospheric carbon dioxide concentrations, rates, patterns, and amounts of precipitation, as well as increases in temperature, alter soil-plant systems by affecting decomposition rates and soil organic carbon levels. Changes that occur in the soil certainly have an impact on plants and how they are produced. With climate change, production can decrease, and income can decrease [3].

3.4 Farmers' Adaptation Strategy to Climate Change

In dealing with climate change, various mitigation efforts can be carried out. Climate change mitigation can be carried out by governments, institutions, communities, or farmers themselves [16]. Mitigation efforts by the government can be carried out through related departments such as the Meteorology, climatology, and Geophysics Agency, the Environment Ministry, or the Agriculture Ministry. Climate change adaptation strategies can also be carried out from the farm level. Farmers who understand climate change will act reactively and anticipate its impacts. Adaptation to climate change can be planned or carried out spontaneously. Spontaneous actions are taken without awareness in predicting climate change but based on experience and existing conditions.

According to The World Bank, adaptation to climate change is a process that involves various interrelated aspects. This process requires combining elements such as raising awareness, setting priorities, preparing action plans, building capacity, and mobilizing available resources. Based on the information obtained in this research, the adaptation strategy carried out by shallot farmers in Junrejo, Batu City, is planting other commodities, such as vegetables, or continuing to farm shallots by replacing new varieties. These adaptation efforts are needed to withstand the adverse impacts of climate change and seek profitable opportunities from these conditions. The table below shows respondents' choices regarding adaptation strategies to face climate change.

Table 2. Farmers' Adaptation Strategies to Climate Change

Substituting Other Commodities (vegetables)	Changing to New Varieties (still farming shallots)
22 respondents 73.3%	8 respondents 26.6%

Source: Processed data, 2024

Based on the research results, 22 respondents, or 73.3 percent of farmers, chose to replace other commodities, namely vegetables, and 8 respondents, or 26.6 percent of farmers, chose to continue farming shallots by replacing new varieties. It can be concluded that this shows a tendency among farmers to adapt different agricultural strategies in response to climate change.

Most farmers choose to change commodities because some vegetable varieties have shorter growth cycles, allowing them to adjust their planting times to change weather patterns. In addition, different vegetable crops have different water, nutrient, and tolerance requirements for environmental conditions, thereby increasing the likelihood of farming success in the face of climate variations.

This research is also similar to research conducted [17], namely, farmers respond to climate change by changing the planting of vegetable commodities that can adapt to particular climates. Adaptation of vegetable farmers to climate change means that farmers respond through adapting activities in selecting plant types, planting times, how to cultivate the land, and applying fertilizer. Furthermore, in efforts to mitigate climate change, farmers can adopt several adaptation efforts such as crop diversification, using varieties that are resistant to climate change, improving water management, improving plant nutrition management, using greenhouses, setting planting times, and weather forecasting [15].With various efforts and support from all parties. It is hoped that farmers can minimize the impact of climate change on crop production. With stable food availability, prices will be stable, and food security can be achieved.

4 Conclusion

Based on the results, the study can conclude that as many as 97% of farmers realize the impact of climate change. Farmer shallots see a change in climate as a problem that has a serious impact on harvest. Most farmers in shallots Batu City are aware and agree that variable-related weather, including wind, humidity, bulk rain, and temperature air, significantly impact the results of harvest shallots. To adjust to change the climate, as many as 73.3% of farmers decide to replace plants with others, and 26.6% of others decide to plant shallots.

5 Suggestion

Suggestions are given to farmers to minimize the impact of climate change, namely by strengthening farmers' adaptive capacity, strengthening farmer institutions, and using superior varieties that are resistant to climate change. In addition, information related to weather changes needs to be disseminated massively to farmers so they can anticipate loss risks and determine the proper planting patterns.

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