

Chapter 4

Farmers' Perceptions and Adaptation Strategies in Response to Climate Change: A Case Study of Shallot Farmers in Indonesia

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Summary: Climate change is a global issue that threatens agriculture, especially in developing countries. Shallots are a seasonal crop that are particularly threatened by climate change. The negative impact of climate change is a decrease in production. Farmers can prevent or mitigate risks through adaptation strategies based on their understanding and knowledge. This study aims to determine the level of farmers' perceptions of the impacts of climate change, the factors that influence farmers' perceptions of the impacts of climate change, and farmers' adaptation strategies to address the impacts of climate change. This study used data from the 2014 Horticultural Household Survey (SHR) from the Central Statistics Agency (BPS), with a research focus on shallot farmers with a total of 9,147 respondents. The methods used were descriptive analysis and ordinal logistic regression. The results showed that 1) 40% of farmers are affected by climate change, 9% of them are highly affected, while 31% are partially affected. 2) Factors that significantly influence shallot farmers' perceptions of climate change impacts include education, gender, cropping system, and rainfall. 3) The most common adaptation strategy carried out by shallot farmers in dealing with the impacts of climate change is to become a member of a farmer group with a percentage of 23.75%. This research recommends that farmers should be encouraged to increase their participation in farmer groups.

1. Introduction

Climate change is characterized by changes in the average value and diversity of climatic factors, with a tendency for temperatures to increase over time or for more frequent climate anomalies than before (Gao et al. 2022). The direct impact of climate change on the agricultural sector can manifest as damage and shrinkage of cultivated land areas, lack of water availability, and destruction of genetic resources or biodiversity (Qazlbash et al. 2021). The negative impacts of climate change cannot be avoided, but prevention or mitigation can reduce the risk of a decrease in production through adaptation in the face of climate change impacts (Guo et al. 2021).

Adaptation is a form of adjustment to changes in the surrounding environmental conditions. This adaptation is very important to reduce the impact of climate change, to minimize the level of vulnerability of communities and ecosystems, build resilience to climate change, support smooth production, and minimize the risks that will occur (Mulwa et al. 2017). This adaptation is based on the knowledge and skills of farmers in analyzing the level of impact of climate change. Farmers' perceptions of the impact of climate change also vary, depending on how they perceive changes in climate conditions. Understanding farmers' perceptions of the impact of climate change is crucial for preparing them to implement adaptations or adjustments to their farming techniques. Farmers' adaptation of farming methods due to climate change can be achieved in several ways, such as improving drainage, agronomic control of vegetation and soil, using biological agents, participating in partnerships, and selecting varieties that have resistance to climate change.

Research related to farmers' adaptation to the impacts of climate change on agriculture has been widely conducted in the world such as in China, Mexico, Pakistan, Nepal, Kenya, Tanzania, Benin, Malawi,

Indonesia, and some other developing countries (Fadina and Bajolle 2018; Gao et al. 2022; Gebre et al. 2023; Khanal et al. 2018; Kogo et al. 2021; Orduño et al 2020; Qazlbash et al. 2021). Farmers' ability to perceive climate change impacts to vary from high to low depending on several factors, including their gender, age, education, family size, access to credit, and income from farming.

Farmers' strategies for dealing with climate change are carried out by adjusting planting time, crop rotation, semi-organic farming, spraying medicines, tillage according to recommendations, making drainage channels, and replacing or adding work. In Indonesia, similar studies have also been conducted in Batu and Malang, East Java, and in Central Java. These studies focus more on the impacts of climate change on the production of and income from food commodities for food security. There is still very limited research on the impact of climate change on shallot commodities, especially at the national level. Some of these studies still have regional limitations, so research was conducted on the perceptions and adaptation strategies of shallot farmers in Indonesia. The results of this study can be useful as a recommendation material for increasing farmers' resilience in the face of climate change.

2. Materials and Methods

(1) Research Method

This research employs a combination of quantitative and qualitative methods. Quantitative research methods in this study include explaining and interpreting the perceptions of shallot farmers on the impact of climate change with a Likert scale; measuring factors that influence the perceptions of shallot farmers in dealing with the impact of climate change on the decline in shallot production with ordinal logistic

regression; and analyzing the adaptation strategies of shallot farmers in dealing with the impact of climate change using descriptive analysis with quantitative data from the Central Statistics Agency (BPS) survey results in the form of the Horticultural Household Survey (SHR) in 2014. The qualitative research method in this study is used to explore in depth the results of secondary data analysis by conducting in-depth interviews with shallot farmers in Probolinggo Regency, which is one of the centers of climate change.

(2) Data and Method

This study used data from the 2014 Horticultural Household Survey (SHR) conducted by the Central Statistics Agency (BPS). The data used included 9,147 shallot farming households in Indonesia. Data was taken from horticultural business households and included, demographic information of the selected farmers, namely their gender, age, and education level, planting system by farmers, harvest area of shallot plants, the impact of pest attacks, the main control method if exposed to pest attacks, the impact of climate change or natural disasters, the percentage of farmers' perceptions of the impact of climate change on the decline in production, as well as farmers' membership in partnerships and farmer groups.

Farmers' perceptions of the impacts of climate change were analyzed using a scoring analysis method with a Likert scale and descriptive analysis to describe and elaborate on its interpretation. The scoring analysis was conducted in 4 stages, the first stage being the determination of the answer scale with value of 1, where farmers felt no impact of climate change; 2, where farmers felt low impact of climate change; and 3, where farmers felt high impact of climate change. The second stage is determining the answer score by multiplying the scale value with the respondent's answer for each category. The third stage is

determining the scale range of the score results that have been obtained. The fourth stage is obtaining the final score. Thus, the Likert scale value of farmers' perceptions of the impacts of climate change is obtained.

Factors affecting farmers' perceptions of climate change impacts were analyzed using ordinal logistic regression analysis. The dependent variable used in this study is the farmer's perception of the impact of climate change on the decline in shallot production analyzed on an ordinal scale with three levels of impact, namely Y1 = farmers feel unaffected with a percentage of 0%, Y2 = farmers feel low impact with a percentage of 1–50%, and Y3 = farmers feel high impact with a percentage of 51–100%. The independent variables in this study consist of several ratio-scale factors and dummies, namely age (X1), education (X2), harvest area (X3), cropping system (D1), partnership (D2), gender (D3), and rainfall (D4). A description of each variable is provided in Table 4.1.

Table 4.1. Summary of Variables and Statistical Definitions of Each Variable

No.	Variable	Description	Percentage
Dependent variable (Y)			
1	Farmers feel unaffected (Y1)	0% impact rate on production decline	5.495 farmers (60,07%).
2	Farmers perceive low impact (Y2)	1–50% impact rate on production decline	2.809 farmers (30,71%).
3	Farmers feel high impact (Y3)	Farmers feel high impact	843 petani (9,22%).
Independent variables (X)			
1	Age(X1)	Year	48
2	Education (X2)	Year	6
3	Area (X3)	m ²	2.171
4	Cropping pattern(D1)	Dummy variables (0 = monoculture, 1 = polyculture)	0: 8.039 farmers (87,89%), 1: 1.108 farmers (12,11%).
5	Contract farming (D2)	Dummy variables (0 = contract, 1 = not contract)	0: 9.059 farmers (99,04%), 1: 88 farmers (0,96%).
6	Gender (D3)	Dummy variables (0 = female, 1 = male)	0: 695 farmers (7,60%), 1: 8.452 farmers (92,40%).
7	Farmer group participation (D4)	Dummy variables (0 = participated, 1 = not participated)	0: 6.975 farmers (76,25%), 1: 1.172 farmers (23,75%).

Source: Author's survey

The adaptation strategy of shallot farmers is analyzed using descriptive analysis by describing the precautions or adaptations taken by farmers in the face of climate change that occurs, where the level of adaptation will be presented in the form of percentages and categorization of farmers affected and not affected by climate change. Indicators of shallot farmer adaptation strategies in the face of climate change include agronomic control (by fertilizing, tillage, irrigation arrangements, etc.), using intercropping or intercropping systems, making partnerships with companies or partner businesses, performing biological control, performing mechanical control, and becoming members of farmer groups (Fadina and Bajolle 2018; Mulwa et al. 2017).

3. Impacts of Climate Change by Shallot Farmers

The results of the analysis showed that out of 9,147 samples, 39.93% of farmers were affected by climate change in the form of drought, flooding, high rainfall, and other disasters. The greatest impact was high rainfall at 59.47%, drought was 24.56%, flooding was 11.58%, and other disasters were 4.38%. Farmers' perceptions of climate change impacts were also accumulated based on the criteria for the level of impact, such as not affected, low impact, and high impact based on the percentage level of impact.

(1) Influencing Factors on Farmers' Perceptions

Factors influencing farmers' perceptions of climate change impacts were analyzed using ordinal logistic regression analysis. The results of the ordinal logistic regression analysis are presented in Table 4.2.

Table 4.2. Results of Ordinal Logistic Regression Analysis

Variables	Coefficient	S.E.	Wald	df	Sig.	Exp(B)
Constant	2,470	0,574	18,490	1	0,000	
Age (X ₁)	-0,010	0,004	5,985	1	0,014 **	0,990
Education (X ₂)	-0,036	0,011	9,881	1	0,002 **	0,965
Gender (D ₄)	-0,219	0,157	1,963	1	0,161	0,803
Area (X ₃)	0,000	0,000	0,693	1	0,405	1,000
Cropping pattern (D ₁)	-0,443	0,145	9,386	1	0,002 **	0,642
Contract farming (D ₂)	-0,345	0,504	0,468	1	0,494	0,708
Rainfall (D ₃)	0,514	0,092	31,182	1	0,000 **	1,671

Note: ** denote significant at 5%

Source: Author's calculation

Of the seven independent variables analyzed using ordinal logistic regression analysis, four variables were found to significantly influence farmers' perceptions of climate change impacts, namely age, education, cropping system, and high rainfall intensity. The variable that positively influenced the impact of climate change was the high intensity of rainfall, while the variables that negatively influenced it were age, education, and cropping system.

The estimation results show that the variables of age and education of farmers have a significantly negative effect. The results show that if the age and education of farmers increase by 1 year, it will reduce the odds ratio of farmers having the perception of being affected by climate change. Many studies have discussed the role of age and education in farmers' perceptions of climate change impacts. A study in Padang Jaya Sub-district, North Bengkulu Regency, showed that older farmers will have a better understanding of climate change and strategies to deal with climate change impacts due to their greater experience.

The farmers' education variable has a significantly negative effect. Another study on the role of education related to the perception and

adaptation of farmers of rice commodities in Indonesia showed that the ability to adopt technology and information was higher for farmers with higher levels of education. Therefore, better educated farmers can understand the indicators of the impact of climate change on crop land and are able to implement appropriate adaptations in the face of the impact of climate change. The results of the ordinal logistic regression analysis are also adjusted to the SHR data, where farmers with three perceptions of the impact of climate change have the highest level of education at the level of elementary school graduates, so it is in line with the results of the study that a higher level of education can increase the knowledge and skills of farmers in dealing with the impacts of climate change.

The variable of harvest area in the study did not have a statistically significant effect, so it can be said that if there is an increase in harvest area, it will not affect the perception of farmers. This can be caused by the fact that the majority of farms have a small land area, with a harvest area of $<2,500 \text{ m}^2$ at 69.59%. Furthermore, the cropping system dummy variable is negative and statistically significant, with a significance value of 0.002. It can be said that if the intercropping system increases, it will reduce the odds ratio of farmers having the perception of being affected by climate change by -0.443. This is also in accordance with previous research, which found that uncertain climatic conditions lead farmers to intercrop shallot plants with other commodities, such as chili plants, to reduce the risk of production loss and a decrease in the income of shallot farmers due to the impact of climate change their land.

The estimation results also show that the gender dummy variable has no statistically significant effect. This is in line with the results of research in Amadanom Village, Dampit Subdistrict, Malang District, which indicate that gender as an internal factor of farmers has no significant effect on farm risk. This was because the majority of farmers

in the 2014 SHR data, were male, amounting to 92.40%. This causes the data to be biased and causes the gender variable to have no effect on farmers' perceptions of the impact of climate change on reducing shallot production in Indonesia.

Furthermore, the study also revealed that the variable of farmers' participation in partnerships had no effect on farmers' perceptions as the majority of farmers - 99.04%- have not joined a partnership. The low rate of partnership in the shallot commodity is because the shallot downstream industry is a small business industry player whose raw material needs are not large.

The ordinal logistic estimation shows that high rainfall intensity has a positive effect and is statistically significant. The dummy variable of high rainfall intensity shows that if the intensity of high rainfall increases, it will increase the odds ratio of farmers having the perception of being affected by climate change. A study shows that high rainfall from La-Nina events causes soil moisture to also tend to be higher, which can make it easier for mold to develop and attach to plants, especially on the bulbs of shallots. This can cause the bulbs in the soil to rot and potentially reduce shallot production.

(2) Adaptation Strategies in Facing the Impact of Climate Change

Adaptation strategies carried out by shallot farmers in the face of climate change consist of seven controls, including agronomic control, using intercropping or intercropping systems, making partnerships with companies or partner businesses, carrying out biological control, carrying out mechanical control, and becoming members of farmer groups. Table 4.3 presents the distribution of sample farmers based on adaptation strategies in Indonesia.

Table 4.3. Distribution of Sample Farmers Based on Adaptation Strategies Practiced in Indonesia

No.	Adaptation strategy	Frequency	Percentage (%)
1	Performing Agronomic Control	114	1,58
2	Applying an Intercropping Cropping System	1.108	12,11
3	Generating Partnerships with Partner Companies or Businesses	88	0,96
4	Performing Biological Control	16	0,22
5	Performing Mechanical Control	60	0,83
6	Become a Farmer Group Member	2.172	23,75

Source: Author's calculation

The results of the analysis show that the most common adaptation strategy carried out by shallot farmers is to become members of farmer groups at 23.75%, while the least common adaptation strategy is to carry out biological control at 0.22%. The description of each adaptation strategy carried out by shallot farmers in Indonesia in facing the impacts of climate change is as follows:

1) Agronomic control is carried out as one of the adaptation strategies for dealing with attacks by plant pest organisms (OPT) on shallots due to indications of climate change in the form of extreme differences between temperatures during the day and night. The temperature difference causes plants to experience frost or haze disease, where these symptoms allow soil-borne pathogens to infect plants, resulting in haze disease and plant death in the early phase. The 2014 SHR data shows that the percentage of farmers who apply agronomic adaptation strategies is 1.58%. Agronomic control by shallot farmers is the second most common pest control after chemical control. This shows that shallot farmers still fertilize to control pests, but most farmers still use chemical fertilizers compared to the use of organic fertilizers for shallot plantations. The results of a simple field survey of shallot farmers in Dringu Village, Dringu Subdistrict, Probolinggo

Regency show that, on average, shallot farmers in the village apply tillage once in shallot farming before the planting period.

2) Intercropping is another adaptation strategy used by shallot farmers to reduce the production risk due to the impact of climate change, where farmers generally intercrop shallot plants with chili plants. SHR 2014 data shows that the percentage of farmers who apply intercropping adaptation strategies is 12.11%. The reason intercropping systems are seldom applied by farmers is due to some shortcomings or weaknesses in their application, where a study revealed the application of intercropping systems allows competition between plants that are above and below the ground, so that the existence of different morphologies and physiologies between intercropped plants causes farmers to have more knowledge and experience related to the application of the cropping system.

3) Partnerships carried out by shallot farmers are usually in an informal form through general trading patterns or sales contracts between farmers and sellers without going through formal or written contracts. The advantages for shallot farmers in following the partnership are the availability of assistance in the form of business capital, assistance in cultivation training in providing superior seeds, and the certainty of shallot marketing at an agreed price, so that farmers do not have to worry about production risks in the form of climate change. The percentage of farmers who follow partnership activities based on 2014 SHR data is only 0.96%. Based on SHR 2014 data, shallot farmers have partnerships with State-Owned Enterprises (BUMN) as many as 9 people, Village-Owned Enterprises (BUMD) as many as 37 people, private companies as many as 33 people, and cooperatives as many as nine people, where the most partner businesses that cooperate with farmers are BUMD, and the least are BUMN and cooperatives. A few partnership agreements require farmers to cultivate shallots outside the

season or during the off-season. This is done to fulfill the supply needs of partners.

4) The percentage of farmers who apply biological control adaptation strategies is only 0.17%. Biological control in the form of the use of *Trichoderma* in each planting hole can reduce the risk of being attacked by diseases such as *Fusarium* wilt, which attacks the base of the layer bulbs, and the use of natural enemies of dragonflies, as well as biological agents Feromon exi, *Beauveria bassiana*, and SE-NPV can reduce the attack of onion caterpillar pests on shallots. A study shows that the lack of shallot farmers who apply adaptation strategies in the form of biological control can be caused by the additional higher costs of using biological agents compared to farming without using biological agents.

5) Mechanical control is also a form of control for shallot plants that employs fencing or barriers to prevent pest attacks, such as installing mulches, traps, and so on. The percentage of farmers who apply mechanical control is 0.83%, while farmers who use protective nets are only 0.53%. This shows that the overall number of farmers practicing mechanical control is still relatively low, although the number is still higher than that of biological control.

6) The most common adaptation strategy followed by farmers is participation in farmer groups. Farmer groups serve as a forum for providing information about prices, partnerships, and agricultural production facilities for farmers. Shallot farmers who are actively involved in farmer groups benefit from the availability of information related to farming activities with the help of agricultural field extension (PPL) in the application of information technology, so that they can jointly anticipate pest attacks and the impact of climate change that occurs. The percentage of farmers who apply adaptation strategies to become members of farmer groups amounted to 27.65%.

4. Conclusion and Policy Implications

Shallot farmers perceive that climate change reduces production. 39.93% of shallot farmers experienced climate change impacts from drought, flooding, and excessive rainfall. Farmers' perceptions are influenced by geographic and demographic factors including age, farmers' education, cropping system, and rainfall. The variable that positively influences the impact of climate change is rainfall, while the variable that negatively influences is intercropping.

The most common adaptation strategy among farmers for dealing with climate change impacts is joining farmer groups (23.75%), while the least common is biological pest control (0.22%). Farmers' limited use of biological agents stems from their preference for chemical controls, despite these being potentially harmful to the environment and worsening climate change effects. This preference is driven by farmers' goals of maintaining shallot production levels and controlling pests and diseases. This study recommends that Indonesian shallot farmers should enhance their knowledge and skills regarding climate change by learning how to implement more appropriate and environmentally friendly adaptation strategies. Additionally, farmer group participation should be further encouraged as a key adaptation strategy.

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Chapter 4. Farmers' Perceptions and Adaptation Strategies in Response to Climate Change: A Case Study of Shallot Farmers in Indonesia

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