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How does climate change adaptation strategy accelerate sustainable food security?

Etty Puji Lestari[1+]
Sucihatiningsih Dian Wisika Prajanti[2]
Etty Soesilowati[3]
Heffi Christya Rahayu[4]
Albert Gamot Malau[5]

[1]*Department of Economics, Universitas Terbuka, Tangerang Selatan, Indonesia.*
Email: ettypl@ecampus.ut.ac.id
[2]*Department of Economics, Universitas Negeri Semarang, Semarang, Indonesia.*
Email: dianwisika@mail.unnes.ac.id
[3]*Department of Economics, Universitas Negeri Malang, Malang, Indonesia.*
Email: ettysoesilowati.fe@um.ac.id
[4]*Department of Management, Universitas Pasir Pangaraian, Pekan Baru, Indonesia.*
Email: heffirahayu@upp.ac.id
[5]*Department of Agribusiness, Universitas Terbuka, Tangerang Selatan, Indonesia.*
Email: albert@ecampus.ut.ac.id

(+ Corresponding author)

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ABSTRACT

This study examines the key factors influencing farmers' decisions to adopt climate change adaptation strategies in agriculture, focusing on Kopeng Village in Semarang, Indonesia. Using a multinomial logit (MNL) model, the article analyzes various strategies in response to climate challenges. It shows that household characteristics, tenure characteristics, and institutional support are important for adaptation decisions. Variables such as age, education level, family size, farming experience, age at first marriage, and age at first childbirth are also significant; older and more educated individuals with larger families are more likely to adopt innovations such as organic fertilizers and fast-growing seeds. Landholding and land size also influence adoption behavior, and the distance from home to agricultural land may hinder the use of organic fertilizers due to transportation logistics. Notably, institutional support—including credit availability, extension services, and farmers' associations—is critical for the successful adoption of strategies. The government's role in promoting agriculture, particularly organic farming, is highly anticipated. Through farmer groups, the government can provide necessary technological assistance and digital marketing training to help farmers reach broader markets.

Contribution/Originality: The analysis consolidates the drivers of farmers' adaptation to climate change at the individual, land, and institutional levels; such a comprehensive approach has not been adopted by many other research teams.

1. INTRODUCTION

Climate change is now widely acknowledged as a global issue, and its impact on the agricultural sector is particularly evident in developing countries. Farmers in Indonesia are more vulnerable because the weather is more unpredictable, there are more extreme weather events, and crop production is less certain (Garcia, Osburn, & Jay-Russell, 2020; Shrestha et al., 2025). Consequently, it is imperative to adapt to the effects of climate change to ensure food security and increase producers' profitability. Although their effectiveness depends on various factors, including household, land use, and institutional factors, adaptation strategies aim to mitigate these effects (Gitz, Meybeck, Lipper, Young, & Braatz, 2016; Pawlak & Kołodziejczak, 2020). The ability and choice of farmers to implement adaptation strategies are significantly influenced by household characteristics, including age, education, size, and farming experience. Older and more experienced farmers are more likely to understand climate conditions and be ready to embrace new technologies, according to some studies (Mao, Chai, Shao, & Chang, 2024; Tyczewska, Twardowski, & Woźniak-Gientka, 2023). Obtaining formal education translates to acquiring better analytical skills, along with being more receptive to innovations, which is vital when addressing climate change (Hügel & Davies, 2024; Nusche, Rabella, & Lauterbach, 2024; Rahaman et al., 2021). The number of people living in a household is equally important, as larger households may have a greater ability to dedicate labor to farming, but they also have greater needs (Vågsholm, Arzoomand, & Boqvist, 2020; Xie, Zhang, Li, Xia, & Chen, 2024).

The adoption decisions made regarding land could be influenced by its physical features. The location of farmland relative to the home affects the expenses and time required for land management (Albahri et al., 2023; Lestari, Prajanti, Adzim, Mubarok, & Hakim, 2024). Farmers' ability to adopt more environmentally friendly farming methods, such as using organic fertilizers and better, faster-harvesting seeds, is influenced by their land ownership and size. According to research, farmers who have easy access to land are more likely to embrace innovations (Qureshi et al., 2022; Ulian et al., 2020). The adoption of adaptation strategies is significantly aided by institutional features such as the frequency of interactions with agricultural extension agents, the availability of technical training, and credit availability. While access to technical training improves farmers' abilities to implement more effective and ecologically friendly farming practices, regular interaction with extension agents offers current and useful information on adaptive farming techniques (Khurana & Kumar, 2020; Loboguerrero et al., 2019; Raza et al., 2019). Having access to credit allows farmers to invest in necessary technologies to increase productivity and adapt to climate change. Furthermore, participation in farmer associations or groups boosts social cohesion and provides valuable assistance for community resources, knowledge sharing, and support systems (Dang, Li, Nuberg, & Bruwer, 2019; Wang, Ma, Liu, & Yang, 2020).

The seasonal unpredictability of rainy and dry spells influences farmers' technology adoption and cropping patterns. These weather patterns affect agriculture on a broader scale than just rainfall alone (Abid, Scheffran, Schneider, & Elahi, 2019; Kwakye, Ekechukwu, & Ogundipe, 2023). For example, decreased rainfall frequency can encourage farmers to use more organic fertilizers to improve soil resilience and change planting times to optimize agricultural yields (Lestari, Prajanti, Wibawanto, & Adzim, 2022; Novita, Supriana, Sirozujilam, & Lubis, 2024). The importance of this research lies with farmers from developing nations who are more susceptible due to changes in climate conditions. Smallholder farmers face the brunt of the impacts, with diminishing agricultural productivity and food security, necessitating robust strategies for climate adaptation. At the same time, there is substantial variation among farmers concerning their level of adoption, such as education, family size, land ownership, supported institutions, or networks, which ultimately influences whether they implement the same or different CSA strategies. This research seeks to examine how household characteristics, land attributes, and institutional factors shape farmers' decisions regarding climate change adaptation strategy integration in farming practices. This represents a vital step towards mitigating adverse climatic effects on farming activities while enhancing agricultural resilience amidst changing climatic conditions.

2. LITERATURE REVIEW

2.1. Climate Change Theory

The agricultural sector is vulnerable to climate change because it relies heavily on weather and climate conditions. Climate change can lead to crop failure and negatively impact farmers' incomes (Ojo & Baiyegunhi, 2020; Putri & Cahyani, 2016). Climate change also impacts plant physiology, affecting plant growth and production, and can influence the quality of plants from agriculture and plantations. Currently, agriculture fundamental to food security and global economic development faces challenges due to climate change. Rising temperatures, erratic rainfall, and extreme weather events disrupt agricultural productivity and pose serious threats to food security and the livelihoods of rural communities worldwide. Climate change directly impacts agricultural productivity by accelerating soil erosion, increasing the prevalence of pests and diseases, reducing soil fertility, and heightening the risks of drought and flooding (Anderson, Bayer, & Edwards, 2020; Farah, Mohamed, Musse, & Nor, 2025). As a result, the food production system becomes weak, and crop yields and livestock productivity decline, which in turn leads to food insecurity at both local and global levels.

In South Asia and certain regions of Latin America, farmers are particularly vulnerable to the risks of climate-related disruptions, including prolonged droughts, erratic rainfall, and reduced soil fertility (Farah et al., 2025). It is the responsibility of all of us, including the audience, to adopt sustainable practices to mitigate these challenges. The effects of climate change already include disrupting global supply chains and food distribution networks, adding more financial stress on producers and consumers, and increasing food prices. Climate change threatens livelihoods, particularly for those dependent on agriculture and natural resources, the population groups most likely to lose jobs and face economic instability. In the face of these challenges, the sustainable management of soil and water resources is crucial for maintaining the earth's land productivity, as well as for maximizing irrigation efficiency and resilience to climatic variability. Soil conservation measures, such as cover cropping, crop rotation, conservation tillage, and better irrigation practices, have been proven beneficial for soil health, carbon sequestration, and water storage, offering hope for the future of agriculture.

2.2. Climate Smart Agriculture

Many previous researchers have conducted studies on Climate Smart Agriculture (CSA). CSA is recognized as a key adaptation strategy, integrating sustainable farming techniques, precision agriculture, and resilient crop varieties to increase productivity under changing climate conditions (Farah et al., 2025; Taylor, 2018; Wekesa, Ayuya, & Lagat, 2018). Numerous findings suggest that CSA adoption has led to a 10.5% increase in productivity, a 29.4% rise in profitability, and a 43% decrease in greenhouse gas emissions. However, barriers such as limited access to finance, inadequate infrastructure, and low farmer awareness especially in low-income regions continue to hamper widespread implementation. Many studies have focused on specific climate risks in particular regions, which have broader implications for global food security, policy frameworks, and socio-economic transformation. Technological and policy innovations play a critical role in mitigating the adverse impacts of climate change on agriculture. Advanced technologies, including satellite-based climate monitoring, early warning systems, and AI-based precision farming tools, offer real-time adaptation and risk management solutions. Additionally, policy interventions such as climate-resilient agricultural subsidies, carbon tax programs, and investments in climate adaptation research are essential for promoting long-term agricultural resilience and food security.

3. RESEARCH METHOD

3.1. Data and Sample

The population in this study consisted of farmers in Kopeng Village, Semarang Regency, with a sample size of 110 farmers. The farmers completed questionnaires and participated in in-depth interviews to gather the data needed for analysis. The village is located in Central Java, at the foot of Mount Merbabu, and has a climate suitable for growing various vegetables, including organic ones. Figure 1 illustrates the location of the research sampling. The distance from Kopeng to Semarang City is approximately 54 kilometers, with a travel time of around 1.5 to 2 hours by car. This region is not only an economic center but also an agricultural hub. Crops grown in private gardens include tomatoes, potatoes, lettuce, chili, and cabbage.

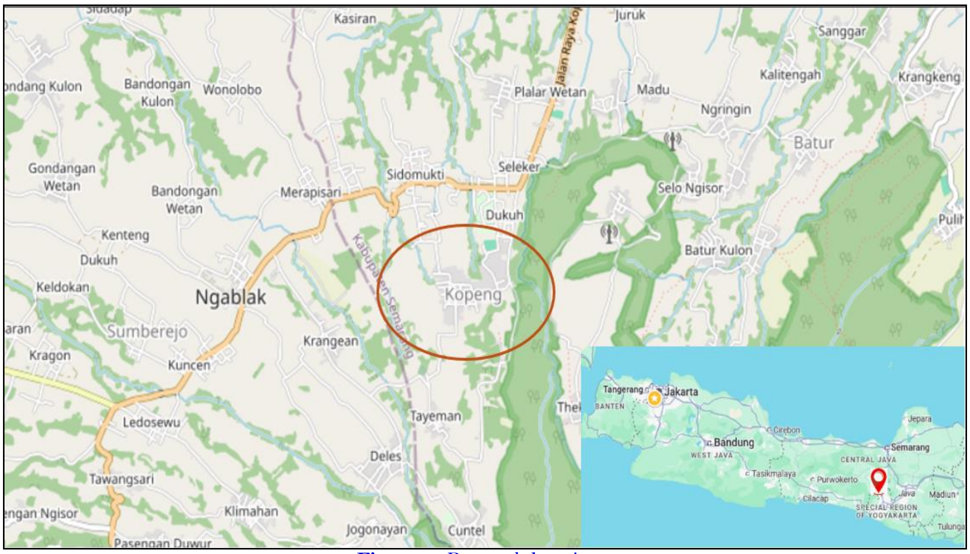

Figure 1. Research locations.

The majority of the population in Kopeng Village works as vegetable farmers or traders of vegetables or ornamental plants. One of the areas in Kopeng Village that is the center of economic and agricultural activities is Sleker, Getasan District, Semarang. Sleker is the center of various economic and agricultural activities for residents due to its strategic location in the heart of Kopeng Village. Kopeng is known for its agricultural value and is the center of cultivation for many agricultural crops, especially vegetables.

3.2. Research Model

A multinomial logit model analysis was conducted to identify factors influencing the choice of climate change adaptation strategies in agriculture. The dependent variable is the adaptation strategy, which includes applying organic fertilizer, planting seeds with shorter maturity periods, and shifting planting dates. Independent variables encompass household characteristics such as farmer age (years), education (years of formal schooling), household size (number of family members), and farming experience (years). Land characteristics include distance from home to agricultural land (kilometers), land ownership, and land size (hectares). Institutional factors involve the frequency of extension contacts, participation in farmer groups or associations, access to technical training and credit, engagement in off-farm work, and membership in farmer organizations. Seasonal variables are represented as dummy variables, such as short rainy season (1) and not (0), short dry season (1) and not (0), and decreased rainfall frequency (1) and not (0).

Multinomial logistic regression considers more than two categories of nominal-scale dependent variables. The multinomial logit analysis equation model in this study is as follows:

$$\text{ADAPTAST}_{ikm} = \omega_{0m} + \sum_{k=1}^{4} \omega_{km}\, \text{HOUSCHA}_{ikm} + \sum_{k=5}^{7} \omega_{km}\, \text{PLOTCHA}_{ikm} + \sum_{k=8}^{12} \omega_{km}\, \text{INSTICHA}_{ikm} + \sum_{k=13}^{15} \omega_{km}\, \text{SEASON}_{ikm} + \varepsilon_{im}$$

Where ADAPTAST_{ikm}: climate change adaptation strategy, HOUSCHA_{ikm}: characteristics of farming households, PLOTCHA_{ikm}: Land characteristics, INSTICHA_{ikm}: Institutional characteristics, SEASON_{ikm}: Season, $\omega_{0m}\ dan\ \omega_{km}$: The parameter vector is to be estimated using the maximum likelihood simulation approach and ε_{im}: Error term. Steps of data analysis in the multinomial logistic regression method comprise: estimating parameters, global test (G-test), partial test (Wald test), interpretation of the multinomial logistic regression model, model adequacy evaluation, and accuracy of classification evaluation.

4. RESULTS AND DISCUSSION

4.1. Likelihood Ratio and Logistic Multinomial Regression Test

The results of the goodness-of-fit test are found in Table 1. In the research interview and observational study with 110 farmers from the Kopeng region, Central Java, the results from likelihood ratio tests indicate that multinomial logistic regression models significantly predict the decision-making process regarding climate change adaptation strategy adoption among farmers (p-value < 0.05).

Table 1. Model suitability test results.

Statistical test	Chi-square value	df	Sig. (p-value)
Likelihood ratio test (Model fit)	132.64	15	0.00
Pearson chi-square	87.25	90	0.11
Deviance (Deviance test)	86.83	90	0.17

The Pearson Chi-Square and deviance tests show that the model is entirely appropriate to the data because the p-value > 0.05 indicates no problem with its suitability. In the next step, the researchers measure the classification accuracy to evaluate the classification model's performance. The results of the classification accuracy test in this study are shown in Table 2. The next step is logistic multinomial regression to examine household, land, institutional, and seasonal characteristics. The multinomial logistic regression model showed a classification accuracy rate of 80.8%, indicating that it could accurately predict the climate change adaptation strategies farmers chose based on household, land, and institutional characteristics.

Table 2. Classification accuracy test results.

Adaptation strategy	Correct prediction (%)	Wrong prediction (%)	Total (%)
Use of organic fertilizer	78.2	21.8	100
Use of fast-harvest duration seeds	83.5	16.5	100
Changes in planting time	80.9	19.1	100
Average classification	80.8	18.1	100

The result indicates that the decision to use organic fertilizer is highly influenced by the age of the farmer, suggesting that older farmers are more likely to employ this method. However, using fast-growing seeds and adjusting the planting time have no impact on age (see Table 2). The results of hypothesis testing in this study, using multinomial logistic regression, are presented in Table 3.

4.2. Relationship between Household Characteristics and Climate Change Adaptation Strategies

Education, household size, and farming experience have a positive and significant impact on the three adaptation strategies (see Table 3). This indicates that farmers with higher education, larger households, and more extensive experience are more likely to adopt the CSA strategy. Higher education, a larger family size, and extensive experience make farmers more prepared and capable of adopting climate-smart agricultural strategies for food security. Education is believed to improve farmers' ability to understand technical information, including knowledge about climate change. With more household members, there is a possibility of diversification of economic activities, which can increase resilience to the risks of adopting new technologies. Farmer education has a significant influence on the adoption of all adaptation strategies. More emphasis, however, should be placed on education and adaptation, particularly on the use of fast-growing seeds, since educated farmers have a greater ability to understand technical information and agricultural innovations and are more willing to take risks associated with new technologies (Jhu & Oldroyd, 2023; Mbow et al., 2020; Mwangi & Kariuki, 2015). Educated farmers can utilize information from the media, extension workers, or agricultural institutions and have an open attitude toward change and innovation in smarter farming practices (Lestari, Prajanti, Adzim, Primayesa, et al., 2024). Large households have the advantage of providing more labor. This is necessary for implementing CSA strategies, which sometimes require additional work, such as terracing or organic composting.

According to the findings of the study, the age of a farmer significantly influences their adoption of organic fertilizers. It was observed that older farmers are more willing to adopt this technology. This is likely due to their experience in farming, which provides them with knowledge about the advantages of organic fertilizers and resource management over time (Agovino, Casaccia, Ciommi, & Ferrara, 2019; Keil, D'Souza, & McDonald, 2020). Looking at younger ages does not seem to trigger the adoption of provided services such as using fast-growing seeds or changing planting dates. Such shifts are only likely as a result of dominant variables like education and access to information when it comes to decision-making about the use of fast-growing seeds and changes in planting times.

Based on personal observations, Kopeng households provide moral support during adoption as well as financial assistance during the transition towards CSA due to having large families. More experienced farmers are able to cope with climate change; its effects are anticipated and understood. Through experience, farmers become adept at blending traditional agricultural techniques with modern innovations, which bolsters confidence in utilizing strategies centered on climate-smart agriculture.

Considered within this context, family size impacts significantly, especially regarding the employment of fast-growing seeds and organic fertilizer usage. A larger household will most likely have more people available to help in adopting new agricultural technologies, thereby increasing the ability to adapt to climate change (De Amorim et al., 2019; Qaim, 2020). The choice of how best to adapt is informed by farming experience. Older farmers pay more attention to climate change impacts, thus warranting better practices for them to adapt, such as changing planting schedules or using organic fertilizers (Anderson et al., 2020; Asfaw, Simane, Bantider, & Hassen, 2019; Bedeke, Vanhove, Gezahegn, Natarajan, & Van Damme, 2019; del Pozo et al., 2019). They can access weather and soil conditions more accurately for optimal planting and to maximize agricultural yields (Malhi, Kaur, & Kaushik, 2021).

Table 3. The estimation results of the hypothesis testing.

Variables	Organic fertilizer (β)	Z-statistics	P-value	Fast harvest seeds (β)	Z-statistics	P-value	Change in planting time (β)	Z-statistics	P-value
Household characteristics									
Farmer age (Years)	0.026	2.151	0.043*	0.016	0.841	0.417	0.003	-1.589	0.121
Education (School years)	0.056	3.761	0.000**	0.076	5.921	0.011*	0.031	2.011	0.057
Household size (Number of members)	0.101	2.381	0.029*	0.131	3.011	0.004**	0.056	1.511	0.145
Farming experience (Years)	0.033	2.451	0.026*	0.019	1.011	0.329	0.041	3.011	0.004**
Land characteristics									
Distance from house to land (km)	-0.029	-2.659	0.009**	-0.004	-1.239	0.221	-0.014	-1.779	0.084
Land ownership (1 = Yes)	0.461	2.381	0.029*	0.391	2.121	0.046*	0.531	2.681	0.008**
Land size (ha)	0.191	3.611	0.000**	0.161	3.341	0.002**	0.121	2.761	0.007**
Institutional characteristics									
Frequency of extension contacts (Times/Year)	0.231	3.151	0.013*	0.191	3.011	0.014*	0.151	2.161	0.043*
Technical training access (1 = Yes)	0.571	2.681	0.019*	0.501	2.461	0.025*	0.621	2.781	0.017*
Credit access (1 = Yes)	0.341	2.551	0.022*	0.321	2.491	0.024*	0.461	3.221	0.012*
Off-farm work participation (1 = Yes)	-0.179	-2.229	0.036*	-0.099	-1.369	0.178	-0.209	-2.429	0.026*
Farmers association membership (1 = Yes)	0.261	2.641	0.02*	0.311	3.011	0.014*	0.221	2.481	0.025*
Season									
Short rainy season (1 = Yes)	0.411	2.231	0.037*	0.391	2.251	0.036*	0.531	2.751	0.017*
Short dry season (1 = Yes)	-0.279	-2.059	0.051	-0.239	-1.839	0.075	-0.319	-2.189	0.039*
Decrease in rain frequency (1 = Yes)	0.521	2.561	0.022*	0.451	2.271	0.035*	0.491	2.301	0.033*
Constants	-1819.989	-2.449	0.025*	-1609.989	-2.319	0.031*	-1949.989	-2.699	0.008**

Note: * significant at 5% level, ** significant at 1% level.

4.3. Relationship between Land Characteristics and Climate Change Adaptation Strategies

The distance from home to land has a significant negative effect on the use of organic fertilizer, indicating that farmers who are farther away from their land tend to avoid using organic fertilizer. Land ownership and land size positively affect the three adaptation strategies, indicating that farmers with more extensive land ownership and larger land are more likely to adopt climate-smart agriculture (CSA). Land ownership and land size have significant influences on the adoption of adaptation strategies, such that farmers with larger land holdings are more encouraged to invest in technologies that would improve long-term yields, such as organic fertilizers and changes in planting times (Aryal et al., 2020; Gebrehiwot & van der Veen, 2015; Marie, Yirga, Haile, & Tquabo, 2020). Also, how far the land is from home affects what farmers decide, especially regarding the use of organic fertilizers. Farmers whose land is farther away from home usually do not want to use organic fertilizers because it requires more work and logistics (Ojo & Baiyegunhi, 2020; Shiferaw, Kassie, Jaleta, & Yirga, 2014).

Farmers in Kopeng generally have sufficient land area to adopt CSA technologies or strategies at a lower cost per hectare, such as irrigation, periodic crop rotation, or the use of organic fertilizers. Large land areas allow farmers to experiment with new techniques on a portion of the land without disrupting the entire production. Training institutions or projects are often more interested in supporting farmers with large land areas because the impact is considered greater.

4.4. Relationship between Institutional Characteristics and Climate Change Adaptation Strategies

The number of extension contacts, participation in technical training, and access to credit significantly increased the likelihood of employing all three adaptation strategies. Being a member of a farmers' association and having access to credit both had notably positive effects on the adoption of all three strategies. However, off-farm employment negatively influenced the use of organic fertilizer and the timing of planting.

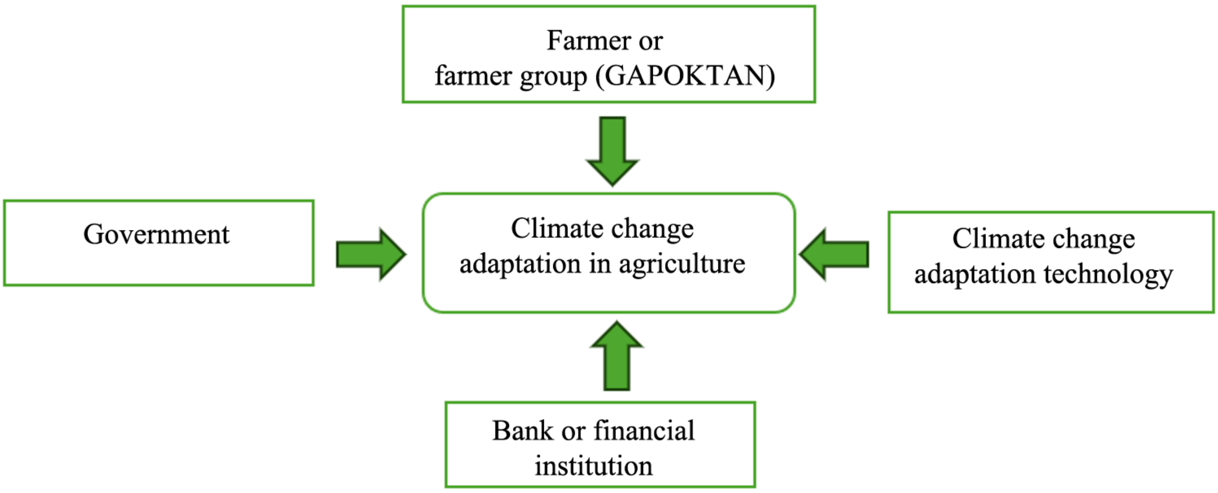

Figure 2. Climate change adaptation strategy.

Institutional characteristics, such as access to extension services, technical training, and credit, also significantly influence the decision to adopt adaptation strategies. Contact with agricultural extension workers or farmer groups (Gapoktan) plays a role in the likelihood of farmers adopting all three adaptation strategies. Through agricultural extension services, information is disseminated on new technologies, practices, and climate change adaptation methods (Aryal et al., 2020; Asfaw et al., 2019). Access to credit also influences the adoption of adaptation strategies, such as shifting planting dates. This is particularly important during the initial adoption stage, as it provides access to funds needed for various agricultural inputs (Chopra et al., 2022). In addition, membership in a farmer association increases the likelihood of adopting fast-growing seedlings, given that associations often provide faster and more facilitated access to information and technology. The government facilitates farmers' access to financing for farming loans (see Figure 2). In Indonesia, the Association of Farmer Groups also helps facilitate farmer credit so that farmers can obtain business capital for better management of their agricultural ventures (Lestari, Prajanti, Adzim, Primayesa, et al., 2024).

4.5. Relationship between Season and Climate Change Adaptation Strategies

In addition, shortened rainy seasons and dry spells, along with infrequent rains, have altered the adoption of strategies to adapt to changes in climate. Hence, from the findings of the study, it is evident that several elements are critical in motivating farmers to adopt climate change adaptation technologies such as CSA. These considerations include, but are not limited to, the farmer household's socio-economic profile, land attributes, access to institutional services, and weather variations.

The need to respond to seasonal changes is also very important for driving farmers' adaptation strategies. With an increase in short rainy seasons, there is greater use of organic fertilizers and shifts in planting schedules, as farmers must economize on both time and resources due to fluctuating rain patterns. Shorter dry spells, coupled with lower frequencies of rainfall, encourage greater utilization of early-maturing seeds, as crops can grow and produce more quickly before a longer dry period occurs (Amare & Simane, 2017; Khan et al., 2020). As this study suggests, a household's socio-economic status, land features, access to institutions, and prevailing weather conditions are critical determinants in adopting changes among farmers. This aligns with earlier research that underscored the role of information access, available resources, and technical skills training on climate change adaptation in agriculture (Makate, Makate, Mutenje, Mango, & Siziba, 2019). Given this information, enhancing farmer education coupled with improving credit services seems like an ideal approach toward empowering adaptive responses to climate change impacts among farmers.

5. CONCLUSION

5.1. Conclusion

This study indicates that factors related to household structure, land features, and institutional frameworks significantly influence farmers' decisions regarding climate change adaptation strategies. Emphasized are farmer age, education, household size, and years spent farming, which are pivotal in the use of adaptation techniques such as organic fertilizers and fast-maturing seeds. Older individuals with more education tend to be more receptive to new technologies like organic fertilizers and faster-maturing seeds. Additionally, land characteristics such as ownership and size greatly impact the adoption of changes in planting schedules and the use of fast-growing seed varieties.

Farmers with larger plots generally support adaptive technologies along with landownership since they can afford the risks and costs involved. In addition to this, the distance from home to farmland affects the use of organic fertilizers; farmers with fields further away tend to be less likely to adopt these practices due to logistical constraints. There are also institutional factors that are crucial for providing support toward the implementation of adaptation strategies. Membership in farmer associations, along with access to credit and routine interactions with extension workers, significantly boosts the chances of farmers implementing multiple adaptive measures. This underscores how enhancing institutional frameworks can bolster farmers' adaptability.

Adaptation decisions made by farmers are greatly influenced by seasonal factors such as the duration of rainy and dry spells and the frequency of rainfall. To cope with extreme weather conditions, many farmers resort to accelerated planting strategies. With these observations in mind, a few recommendations can be provided: first, farmer education must be prioritized to increase their ability to adopt relevant technologies. Their training requires considerable revamping designed to better equip them through formal and non-formal programs. Remote areas require more targeted efforts for extension services and technical training. There is potential for increased collaboration between governments, agricultural bodies, and organizations that focus on adaptation technologies to increase information accessibility and extension visit frequencies. Investment in adaptation technologies like organic fertilizers and improved seeds needs financing expansion, especially among small-scale farmers, for immediate support. The adoption of these technologies can be made easier through microloans with lower interest rates. In addition, the government ought to promote involvement in associations and groups, as their participation leads to better information and resource access. Through this initiative, farmer association formation can reinforce collaboration among farmers to combat climate change challenges.

5.2. Research Limitations

This study focuses on the behavior of farmers in the Kopeng area, which is a center for vegetable production, with organic vegetables as its primary product. These results may vary when this study is conducted in other locations with different behaviors. Other researchers can also combine it with various research methods.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Conceptualization, methodology, formal analysis, writing—original draft, Etty Puji Lestari (EPL); conceptualization, methodology, validation, writing—original draft, writing—review & editing, Sucihatiningsih Dian Wisika Prajanti (SDWP); conceptualization, formal analysis, writing—review & editing, Etty Soesilowati (ES); visualization, supervision, project administration, Heffi Christya Rahayu (HCR); visualization, supervision, Albert Gamot Malau (AGM). All authors have read and agreed to the published version of the manuscript.

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