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The Impact of Climate Change Adaptation Strategies on Food Security: A Global Perspective

İklim Değişikliğine Uyum Stratejilerinin Gıda Güvencesi Üzerindeki Etkisi: Küresel Bir Bakış Açısı

Nur AFİANİ[1], Mehmet BOZOĞLU[2]

[1]Ondokuz Mayıs University, Faculty of Agriculture, Department of Agricultural Economics, Samsun · **afianinur@gmail.com** · ORCİD > 0009-0008-7517-1425

[2]Ondokuz Mayıs University, Faculty of Agriculture, Department of Agricultural Economics, Samsun · **bozoglumehmet@gmail.com** · ORCİD > 0000-0001-8333-1865

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Sorumlu Yazar/Corresponding Author: Nur AFİANİ

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THE IMPACT OF CLIMATE CHANGE ADAPTATION STRATEGIES ON FOOD SECURITY: A GLOBAL PERSPECTIVE

ABSTRACT

Climate change poses a serious threat to the agricultural sector due to its nature of being dependent on natural conditions. As a result, food productivity decreases by threatening global food security. This study aims to analyze the impact of climate change adaptation adopted by farmers on food security by providing impressions and perspectives from related studies. According previous studies, the variables of gender, education, family size, land size, livestock ownership, agricultural extension, access to credit, and climate information are factors that have a positive influence on farmers' decisions to adopt climate change strategies. Meanwhile, the age variable has a negative influence on farmers' decisions to adopt it. In addition, the results also show that the adaptation of climate change strategies has a significant impact on food security. Farmers can improve food insecurity by adapting to climate change. This study provides important insights for future research to develop climate-resilient approaches in the complex global food system.

Keywords: Climate Change, Adaptation Strategies, Food Security, Effective Factors.

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İKLİM DEĞİŞİKLİĞİNE UYUM STRATEJİLERİNİN GIDA GÜVENCESİ ÜZERİNDEKİ ETKİSİ: KÜRESEL BİR BAKIŞ

ÖZ

İklim değişikliği, doğal koşullara bağımlı yapısı nedeniyle tarım sektörü için ciddi bir tehdit oluşturmaktadır. Sonuç olarak, küresel gıda güvenliğini tehdit ederek gıda verimliliğini azaltmaktadır. Bu çalışma, çiftçiler tarafından benimsenen iklim değişikliğine uyumun gıda güvenliği üzerindeki etkisini, ilgili çalışmalardan izlenim ve bakış açıları sunarak analiz etmeyi amaçlamaktadır. Mevcut araştırmalar; cinsiyet, eğitim, aile büyüklüğü, arazi büyüklüğü, hayvan sahipliği, tarımsal yayım, krediye erişim ve iklim bilgisi değişkenlerinin çiftçilerin iklim değişikliği stratejilerini benimseme kararları/davranışlarını olumlu yönde etkilediğini göstermektedir. Buna karşın, yaş değişkeninin çiftçilerin iklim değişikliğe uyum kararları üzerinde olumsuz bir etkiye sahip olduğu anlaşılmaktadır. Bununla birlikte, iklim değişikliği stratejilerinin adaptasyonunun gıda güvenliği üzerinde önemli bir etkisi olduğunu tespit edilmiştir. Çiftçiler, iklim değişikliğine uyum sağlaya-

rak gıda güvenliğini iyileştirebilirler. Bu çalışma, karmaşık küresel gıda sisteminde iklime dirençli yaklaşımlar geliştirmeye yönelik gelecekteki araştırmalar için önemli bilgiler sağlamaktadır.

Anahtar Kelimeler: İklim Değişikliği, Uyum Stratejileri, Gıda Güvenliği, Etkili Faktörler.

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1. INTRODUCTION

The issue of climate change has become one of the biggest global challenges facing humanity today. This is caused by a variety of factors, including human actions such as burning fossil fuels, deforestation and industrial activities, as well as natural events such as volcanic eruptions and solar radiation (Owino et al., 2022). Some of the important aspects to understand include global temperature changes, changing rainfall patterns, increased frequency and intensity of natural disasters, and other extreme changes. Based on WMO (2023), the global average temperatures have increased significantly over the past few decades and it is likely to surge to record levels in the next five years. Since 1750, the concentrations of greenhouse gases such as carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) have increased by 150%, 40%, and 20%. The significance of these changes in the coming decades, particularly towards the end of the century, will depend on the success of greenhouse gas emission reduction policies and the responsiveness of the climate system (IPCC, 2007).

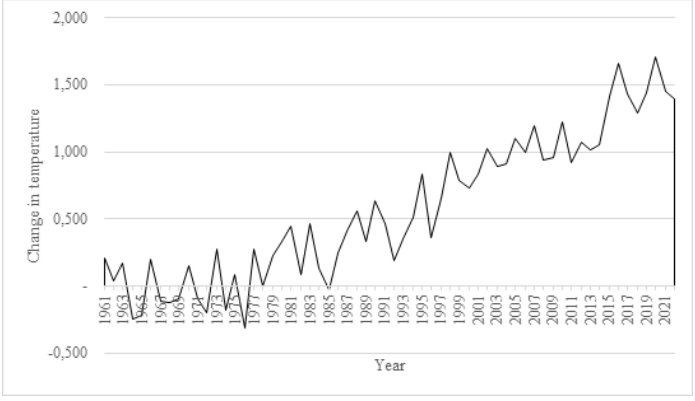

Figure 1. Changes in world temperature in 1961-2022

Source: FAO Temperature Change (2023)

Most of the impact is felt in developing countries, where food systems face greater vulnerability to the impacts of climate change due to limited resources, inadequate infrastructure and high poverty levels (Krishnamurthy et al., 2012; Owino et al., 2022). The severity of the effects of extreme events on agriculture is already considerable (FAO, 2015). The phenomenon of climate change has had a marked impact on global food production systems, with notable consequences seen in Australia, Europe and South Africa. In contrast, the impacts of climate change on food production in Asia and North and Central America show more mixed results (Ray et al., 2019). Several countries are making efforts to mitigate the adverse impacts of climate change. One example is UN Climate Change Conference (COP) 21 held in Paris on December 12, 2015, which resulted in Paris Agreement, a collaborative agreement aimed at reducing carbon emissions (Matemilola et al., 2020).

Meanwhile, the sustainability of production and access to sufficient, safe and nutritious food is a major challenge in maintaining the welfare of the world's growing population. Among the various sectors, agriculture is the most affected by climate change due to its highly dependent nature on climate and natural resources (Massagony et al., 2023). There are three main factors relating to global climate change which impacts the agriculture sector, namely: (i) change in rain pattern; (ii) increase in occurrences of extreme climate (flood and drought); and (iii) increase in air temperature (Akmalia, 2022). Nonetheless, each nation and crop are affected differently by climate change in terms of agricultural productivity (Adams et al., 1998).

Climate change has had significant impacts on agricultural ecosystems and food production, including reduced crop productivity, changes in seasonal patterns, and environmental damage. This has triggered uncertainty in food supply, resulted in food price fluctuations, and increased the risk of hunger and malnutrition in some regions. The impact of climate change not only affects the food production, but also influences the farmers' income, food accessibility, food supply, and food security (Anríquez and Toledo, 2019; Firdaus et al., 2019; Murniati and Mutolib, 2020)

Understanding farmers' perspectives on climate change is crucial for anticipating and mitigating climate change risk through mitigation and adaptation strategies such as modifying agricultural growing techniques (Speranza, 2010; Suranny et al., 2022). Therefore, it is important to implement an adaptation strategy in order to effectively address these challenges on agricultural output sustainability and the food security of farming households. In addition, a deep understanding of how climate change affects food security. A comprehensive explore the current studies can provide valuable insights into the various adaptation efforts that have been undertaken, potential vulnerabilities that need to be addressed, as well as opportunities to improve food security in the future.

This study aims to explore the current studies of the strategies employed by farmers in several countries to cope with the challenges posed by climate change, as well as the effects on food security. Specifically, this study analyses previous similar studies and summarizes them, looking at patterns and current trends in the studies that have been conducted. This study also seeks a deeper understanding of the solutions that have been proposed in the face of climate change.

This study is expected to offer valuable insights into the efficacy of adaption strategies and their possible implications on food production and food security. The data and insights derived from this study can provide valuable assistance to policy makers, international organizations, and other stakeholders in formulating sustainable strategies for addressing climate change and ensuring sufficient food supply for the global population. Furthermore, this research has the potential to assist farmers in making informed decisions regarding appropriate strategies for mitigating the impacts of climate change. Consequently, it is anticipated that the maintenance of agricultural productivity can be achieved.

2. MATERIAL AND METHOD

Figure 2 illustrates the relationship between climate variability and change, exposure to climate hazards, adaptation techniques, and food security status of farm households. Climate change can lead to exposure to hazards such as floods, droughts, soil erosion, and land degradation. These exposures can significantly impact the agricultural sector, causing loss of crop productivity, livestock mortality, crop failure, decreased water salinity, and price instability. As a result of these impacts, there are food shortages in the community. High prices also prevent farmers from accessing sufficient food. Therefore, various adaptation strategy options are needed to reduce the negative impacts on agricultural production. These adaptation strategies include crop diversification, drought-tolerant crop varieties, water conservation, early maturing crops, and diversifying livelihoods (Ali and Erenstein, 2017; Amare and Simane, 2018; Diallo et al., 2020; Gebre et al., 2023; Mariara and Mulwa, 2019). Farming households often use a variety of adaptation strategies to protect themselves from these threats. Based on some studies, these are the strategies that many farmers use to minimize the impact of climate change.

The decision of farmer households to implement various adaptation measures influenced by various factors such as household characteristics, asset holdings, social capital, access to extension services, access to climate information, and others. This study hypothesizes that farmers who implement various adaptation methods will reduce the vulnerability of farm households to the impacts of climate change. This may also affect their agricultural productivity. Thus, by implementing various adaptation measures, farmers can produce their own food and earn

higher income from the agricultural sector. This increase in productivity allows farmers to buy enough food, thus making access to food easier and improving their food security status.

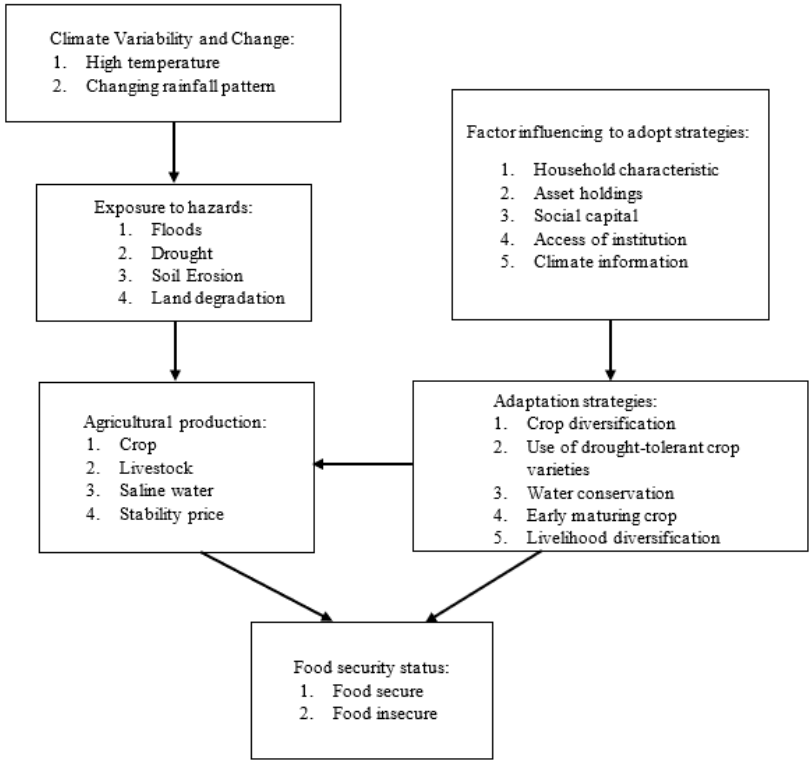

Figure 2. Conceptual framework of the study

The studies on climate change adaptation build on a critical perspective of previous research to better understand how climate change can build an ecosystem of adaptation strategies among farmers and how it affects food security in some countries. To understand how climate change and food security are interlinked, this study brought together the current studies on climate change adaptation and food security.

The data used in this study is secondary data from journals published on Google Scholar, Science Direct, and Web of Science. This research was conducted by analyzing some articles from selected studies that discussed adaptation climate change on food production and food safety. The first stage of this research is to conduct a search using the keywords "Climate Change and Food Security" and

collecting articles related to it. Second, sorting out the focus of the discussion in the article, by only selecting articles that focus on the discussion of climate change adaptation on food security. Third step is classifying articles related to the author, article title and year of publication. The results of this analysis provide information and literacy of climate change adaptation on food security.

Table 1. The summary of the title, study area, model and publisher of critically reviewed researches

Authors and Year	Title of Article	Study Area	Method	Publisher
Di Falco et al. (2011)	Does Adaptation to Climate Change Provide Food Security? A Micro-Perspective from Ethiopia	Ethiopia	Endogenous switching regression model	American Journal of Agriculture Economics
Ali & Erenstein (2017)	Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan	Pakistan	Probit Regression Model	Climate Risk Management
Amare & Simane (2018)	Does adaptation to climate change and variability provide household food security? Evidence from Muger sub-basin of the upper Blue-Nile, Ethiopia	Ethiopia	Propensity Score Matching approach and Household food balance model	Ecological Processes
Mariara & Mulwa (2019)	Adaptation to climate change and climate variability and its implications for household food security in Kenya	Kenya	Endogenous switching regression model	Food Security
Murniati et al. (2019)	Climate Change Adaptation Strategy for Sustainability and Food Security of Cassava Farming Households in Lampung, Indonesia	Indonesia	Ordinal Logit Model	Journal of Agricultural Extension
Diallo et al. (2020)	Climate change adaptation strategies, productivity and sustainable food security in southern Mali	Mali	Propensity Score Matching approach	Climate Change
Dirani et al. (2021)	Exploring climate change adaptation practices and household food security in the Middle Eastern context: a case of small family farms in Central Bekaa, Lebanon	Lebanon	Household Food Insecurity Access Scale (HFIAS) scores	Food Security

Savari & Zhoolideh (2021)	The role of climate change adaptation of small-scale farmers on the household's food security level in the west of Iran	Iran	Discriminant analysis	Development in Practice
Rahman et al. (2022)	Does adaptation to climate change promote household food security? Insights from Indonesian fishermen.	Indonesia	Two-stage residual inclusion (2SRI), and two-step predictor substitution (2SPS) approaches	International Journal of Sustainable Development and World Ecology
Ogundeji (2022)	Adaptation to Climate Change and Impact on Smallholder Farmers' Food Security in South Africa	South Africa	Propensity Score Matching approach and Household Food Insecurity Access Scale (HFIAS)	Agriculture
Gebre et al. (2023)	Farmers' use of climate change adaptation strategies and their impacts on food security in Kenya	Kenya	Multivariate probit model and Propensity Score Matching approach	Climate Risk Management

3. RESULT AND DISCUSSION

3.1. The Relationship Between Climate Change and Food Security

The relationship between food security and climate change is a complex one. It is because food security is not only about food and its production, but also involves trade, nutrition, and the efforts of communities and countries to maintain access to food over time, especially in the face of multiple pressures (Ziervogel and Ericksen, 2010). At the global scale, climatic shocks that affect regions of significant importance for food supplies can have indirect consequences by influencing: (i) the flow of supplies and causing spikes in food prices, leading to heightened market volatility; and (ii) the disruption of trade patterns due to impacts on bilateral contracts and/or import/export behavior. The role of trade is anticipated to be significant in adapting to changes in food production patterns caused by climate change (Gitz and Meybeck, 2016). Climate change is also expected to cause a reduction in crop yields of up to 25% in some regions, especially in developing countries. This situation could result in increased food insecurity, malnutrition and poverty, especially among vulnerable populations (FAO, 2015).

In order to face this challenge, a key priority is to respond to adaptation to climate change in the context of food security. Diverse actions must be taken to prevent an increase in food insecurity. Building resilience at all levels, from farm households and agricultural systems to larger levels, would involve deploying a wide range of instruments in order to provide food security and decent nutrition in climate change (Gitz and Meybeck, 2016).

3.2. Agricultural Adaptation Strategies to Climate Change

Climate change adaptation refers to a system's ability to respond to the impact of unpredicted climate, weather, and seasons (climate change). As a result, farmers must urgently adapt to the effects of climate change to maintain farming productivity (Murniati et al., 2019). Based on previous studies that has been conducted, there are several main variables that are the focus of this research in influencing adaptation to climate change. These variables include demographic factors, socioeconomics, livestock, land size, access to extension, access to credit, access to information and climate. Factors influencing farmers to adapt climate change strategies are shown in Table 2.

3.2.1. Age

In the study conducted by Mariara and Mulwa (2019), using the maize yield equivalent (MYE) measure, which expresses the equivalent weight agricultural production or grains to farming households in Kenya showed that the age of the household head was a positive significant factor in climate change adaptation. Meanwhile, research conducted by Ogundeji (2022), showed that the age of farmers was statistically significant but had a negative correlation with climate change adaptation in the study area. This implies that the older farmers are, the less interested they may be in investing in climate change adaptation due to farmers have more family responsibilities. Ali and Erenstein (2017), also stated that the age of the household head is negatively associated with the adoption of climate change adaptation practices, which suggests that younger farmers are more likely to adopt compared to older farmers, as they are more innovative and interested in trying new technologies and methods to improve agriculture. The negative relationship between the farmers' age and climate change adaptation strategies has been similarly found in other study (Gebre et al., 2023). While research conducted by Rahman et al. (2022), on fishermen in Indonesia using the 2SRI approach to address endogeneity issues in modelling the impact of climate change adaptation on household food security by regressing the treatment variable (adaptation to climate change) as a function of the fisher profile (control variable) shows that age does not show a significant effect on climate change adaptation. The same results that age is not a significant factor in climate change adaptation can also be seen in several studies (Amare and Simane, 2018; Di Falco et al., 2011).

Table 2. Factors influencing farmers in adapting to climate change strategies

Variables	Rahman et al (2022)	Ali & Erenstein (2017)	Di falco et al (2011)	Gebre et al (2023)	Mariara & Mulwa (2019)	Amare & Simane (2018)	Ogundeji (2022)
Age	0.030	-0.01***	0.007	-0.014**	0.271**	0.774	0.042**
Gender		0.01	0.149	0.040**	-0.138	0.000*	0.065**
Family size	0.175	0.02***	0.052**	0.003***	0.157**	0.004*	
Education	0.077*	0.03***	0.092	0.029**	0.005	0.263	0.565
Farm experience	0.026			0.009	0.0872**		0.451
Land size		0.03***		0.006**		0.003*	
Livestock Owned		0.01***	0.009	0.082		0.033*	0.056*
Income		0.03***		0.606***	0.057		
Social group	0.638	0.04***		0.300			
Agricultural Extension	0.501***	0.01***	0.457***	0.069***	0.275***	0.000*	0.321
Access of Credit	0.443**	0.02***	0.246***		0.054	0.196	0.753
Climate information	0.444**		0.465***	0.014***		0.051*	0.000***
Climate factor	0.241***		0.001		0.997**		

3.2.2. Gender

Gebre et al. (2023), show that the gender of the farmer is positively associated with the use of drought-tolerant crop varieties and crop diversification as the type of climate change adaptation. This result is also similar with previous study conducted by Amare and Simane (2018), using probit model estimation which shows that male-headed households have a better chance of taking adaptation actions compared to female households, mainly due to cultural and social barriers that limit women's access to land and information on climate change. Meanwhile in a study conducted by Ogundeji (2022), it was shown that the gender variable exhibited a negative and statistically significant relationship with the adoption of climate change adaptation. This suggests that female farmers are more inclined to use climate change adaptation measures compared to their male counterparts. The inclination of women to exhibit risk-averse behavior can be identified as a contributing factor to their heightened interest in implementing solutions aimed at mitigating the dangers connected with climate change. In several other studies, the relationship between gender and climate change adaptation shows insignificant results, implying that there is no influence between male or female leadership on climate change adaptation decisions (Di Falco et al., 2011; Ali and Erenstein, 2017)

3.2.3. Family Size

In the study conducted Ali and Erenstein (2017), with using probit model estimation show that family size is positively associated with adaptation practices. The relationship between household size and adaptation strategies has been similarly found in other studies that show that family size is positively associated with all of adaptation strategies methods (Di Falco et al., 2011; Amare and Simane, 2018; Mariara and Mulwa, 2019; Gebre et al., 2023). The positive and significant coefficient of farm household size indicates that farmers with larger family sizes employ more strategies to mitigate climate change-related risks. Meanwhile in Rahman et al. (2022), household size has no relationship on farmers' decision to adopt climate change adaptation.

3.2.4. Education

The findings of the study conducted by Ali and Erenstein (2017), indicate a positive correlation between the level of education attained by the head of the household and the implementation of various adaption strategies. Farmers who have had a formal education are more likely to possess a heightened awareness of climate change and advancements in agriculture. Consequently, they may exhibit a greater inclination towards embracing technological solutions and adopting innovative ways in order to effectively manage the risks associated with climatic variability. This result was consistent with Gebre et al. (2023), who found that younger farmers with higher education levels are more likely to use climate change adaptation practices. The similar finding could be found in study conducted by Rahman et al. (2022), which show that the coefficient of the education variable is positive and significant. It means that the higher the education, the more strategies will be adopted. Meanwhile in other studies conducted by Amare and Simane (2018), farmers decision to adopt adaptation options is not significantly influenced by education.

3.2.5. Land Size

According to Ali and Erestein (2017), there is a significant correlation between land holding size and the utilization of all three adaption techniques consisting of adjustments to sowing times, drought-tolerant varieties and shifts to new crops. Farmers who possess extensive landholdings are more inclined to possess greater capacity for experimentation and investment in techniques aimed at mitigating climate risks. This result in line with study conducted by Amare and Simane (2018), the decision to adopt adaptation options is found to be positively influenced by the size of landholding. Gebre et al. (2023), also revealed that farmers who own more hectares of land use more climate change adaptation strategies, possibly because they have more financial resources to invest in more climate change adaptation practices. Large farming household-

ds tend to have higher food demand, so farmers are adopting strategies to respond to climate change in order to increase food supply and meet demand (Diallo et al., 2020).

3.2.6. Livestock Owned

Ali and Erenstein (2017), also show that livestock is positively related to all of adaption methods. Similar with Ogundeji (2022), in his research on smallholder farmers in South Africa also showed that farmers with a more extensive livestock measured by the Tropical Livestock Unit (TLU) were also more likely to take action to mitigate the adverse effects of climate change. When planting, farmers with a sufficient number of donkeys and oxen might easily adjust the dates of their plantings by utilizing the animals to prepare their fields (Diallo et al., 2020). In contrast with Amare and Simane (2018), who found that livestock holdings negatively influence household's decision to adopt adaptation options at 5% probability level. Meanwhile, according to Gebre et al. (2023), livestock ownership does not show a significant influence on climate change adaptation decisions.

3.2.7. Agricultural Extension

In the study conducted by Ali and Eresntein (2017), show that extension services is positively associated with all three adaptation methods. The provision of information by extension services is a significant factor in influencing farmers' decision-making processes on the adoption of climate change. This study suggests that the primary barrier to adaptation could potentially be attributed to limited availability of extension services (Di Falco et al., 2011) Similar results were also found in research conducted by Amare and Simane (2018), that access to extension services has a positive and significant effect on farmers' decisions to invest in adaptation. Having extension service availability raises the likelihood of adopting adaptation alternatives by 22.8%. In study conducted by Gebre et al. (2023), also revealed that there is a positive correlation between the frequency of extension contact and both agricultural diversity and the utilization of early maturing crop varieties. In Mariara and Mulwa (2019), access to general extension services is a strong instrument to adaptation climate change. These finding also in line with study conducted by Rahman et al. (2022), on fishermen in Indonesia which showed that Fisheries extension activity has a positive impact on fishermen's decision to adopt climate change strategies, and the effect is statistically significant at 1%, implying that participating in fisheries extension activity encourages adaptation.

3.2.8. Access of Credit

Research conducted by Di Falco et al. (2011), has shown that farm households that have access to financing are more inclined to engage in adaptive measures in

response to climate change. This findings align with other studies, including those that show the positive effects of access of credit with adaptation of climate change (Ali and Erenstein, 2017). In Rahman et al. (2022), access to credit is positively related and statistically significant at the 5% and 1% levels, indicating that fishers who have access to credit are more likely to adapt as they can purchase the tools needed in the process. Meanwhile, findings from a study conducted by Ogundeji (2022), revealed that access to credit did not emerge as a significant determinant influencing the decisions of farmers regarding the adoption of climate change strategies. These results are also in line with research conducted by Mariara and Mulwa (2019), and Ogundeji (2022), who revealed that access to credit was not statistically significant in influencing farmers' decisions in adopting climate change adaptation strategies.

3.2.9. Climate Information

The role of information seems very crucial. Farmers who are knowledgeable about climate conditions are more likely to adopt adaptation strategies (Di falco et al., 2011). In study conducted by Amare and Simane (2018), revealed that the likelihood of selecting an adaptation choice improves by 5.04% when access to climate warnings about drought and/or flood is available. According to Ogundeji (2022), farmers who had access to climate information or were made aware of changing weather patterns through early warning systems have a higher likelihood of taking actions to cope with climate change. This early warning system most likely aids in farmers' physical and mental preparation for changes in upcoming weather conditions. These findings are also in line with research conducted by Gebre et al. (2023), which revealed that regular access to forecasts regarding rainfall and temperature is positively linked to the adoption of drought-resistant crop types, diversification of crops, and the utilization of early-maturing crop varieties. This connection facilitates farmers in making informed decisions to implement strategies addressing climate change. Furthermore Rahman et al. (2022), also stated that the climate information variable has a positive effect on climate change adaptation and is statistically significant at 5%. The more information fishermen receive, the more likely they are to adopt strategies, so improved information access is necessary.

3.3 The Impact of Climate Change Adaptation Strategies on Food Security

Climate change affects crop and livestock production patterns. Rising global temperatures can alter the climate suitable for the growth of some crops, while unstable rainfall patterns can cause droughts or floods. This can reduce crop yields and threatening food availability in many regions. With a growing global population, food security is a top priority. Climate change adds pressure to the global food system by reducing the availability of resources such as water, land and energy, all of which are essential for food production. In addition, extreme weather events such as storms, floods and droughts can destroy crops and agricultural infrastructure.

Food security, which encompasses food access, food availability, and the use of safe and nutritious food, is becoming increasingly difficult to deal with due to climate change. Vulnerable groups such as smallholder farmers, coastal communities and developing countries are more vulnerable to climate change due to limited resources and dependence on the agricultural sector. The farmer households used various coping strategies when they are unable to access enough food (Dirani et al., 2021). Therefore, various climate change adaptation strategies are needed to support global food security, for example use of drought-tolerant varieties, varying planting dates, improve crop diversity, soil and water conservation, early maturing crop varieties, and livelihood diversification.

The study conducted by Ogundeji (2022), found that agricultural households' food security status is likely to significantly improve when they employ measures to adapt to adverse climatic conditions. Farmers who adapted climate change strategies and had access to extension support, non-farm income, and communication devices such as mobile phones were more likely to reduce their food insecurity status. Furthermore, climate change adaptation had a 12% chance of increasing household food security while decreasing severe food insecurity by 29%. Thus, farming households that used strategies to mitigate the negative effects of climatic conditions fared better in terms of food security than those that did not.

Di Falco et al. (2011), showed that adaptation climate change strategies increases food productivity, and that the farm households that did not adapt would benefit the most from adaptation. In the opposite factual case, farm households that adapted tend to produce more than farm households that did not adapt. Similarity with Amare and Simane (2018), in their research which revealed that farmer households that adopt climate change adaptation will get more benefits which provide compelling evidence for the beneficial impact of adopting climate change adaptations that limit the negative impact of climate change on household livelihoods on alleviating food insecurity in the study area. The return to investments in soil and water conservation, small-scale irrigation, agronomic practices, and diversifying livelihood options. Each produces reliable results, particularly in areas where climate change and variability have a negative impact on agriculture, which is considered the primary source of income for households.

According to Maria and Mulwa (2019), adapting climate change on expected yield, treatment, and heterogeneity effects show that there is a positive difference between adapters and non-adapters, implying that adaptation to climate change has a positive impact on food security.

Land and water are the most important natural resources in agricultural farming systems. Therefore, increasing farm size and land quality, along with adequate water and a proper irrigation system, will improve farm quality and quantity,

and thus household food security (Savari and Zhoolideh, 2021). Awareness-raising related to adaptation needs to be focused on the entire farming community, with special emphasis on farmer groups that have higher levels of age and experience. This group tends to maintain their traditional farming methods, which in turn may compromise the potential for increased production, posing a risk to their food security status (Mariara and Mulwa, 2019).

4. CONCLUSION

Climate change poses a serious threat to the agricultural sector. This is due to the nature of agriculture, which is dependent on natural conditions such as temperature and weather patterns. The impact of climate change on the decline of agricultural productivity, uncertainty of water supply, and increased risk of natural disasters all contribute to the instability of the global food system. Therefore, farmers need to make various mitigation efforts to deal with climate change and maintain the resilience of the global food system.

Various studies have been conducted to look at various factors that influence farmers in adapting to climate change and its impact on food security. Various models have been conducted and widely used approaches are probit regression model, endogenous switching regression model, and propensity score matching approach. In addition, some studies also use the Household Food Insecurity Access Scale (HFIAS) scores approach to determine the level of food security of farmer households.

Based on the results of this study, it can be determined that the factors of gender, education, family size, land size, livestock owned, agricultural extension, access to credit, and climate information are factors that have a positive effect on farmers' decisions to adopt climate change strategies. Meanwhile, several studies reveal that age is a factor that has a negative effect on farmers' decision to adopt strategies because the older the age of farmers, the tendency to adapt decreases. Several studies have also highlighted that the availability of agricultural extension, access to credit, and access to climate information are the main factors influencing farmers' decisions to adopt climate change strategies (Ali and Erenstein, 2017; Di Falco et al., 2011; Gebre et al., 2023; Rahman et al., 2022). Agricultural extension can also provide insight into new technologies, sustainable agricultural practices, and adaptation methods that can be applied in the local context. When farmers have limited access to climate information, they may be less able to anticipate extreme weather changes or understand the long-term impacts of climate change on agricultural production. While access to credit can help farmers invest in the implementation of these strategies.

Based on evaluation of related studies, climate change adaptation has a positive effect on food security. In some cases, farmers who adopt adaptation strategies ex-

perience an increase in agricultural productivity compared to farmers who do not adapt. However, the challenges faced in dealing with climate change indicate the need for collaboration between governments, non-governmental organizations, and communities to create sustainable solutions to ensure food security in the future.

This study only discusses the impact of strategies to deal with climate change carried out by farmers on food security by looking at several socio-economic factors of farmers making these adaptations. As a recommendation for future studies, it is necessary to consider internal and external factors that can cause distress and vulnerability of farmers in making decisions to carry out climate change adaptation strategies, for example by considering the psychological and socio-cultural factors experienced by farmers. In the other hand, further efforts are needed to intensify research and innovation to develop crop varieties that are more adaptive to climate change. Public education and awareness also need to be improved to understand the importance of climate change adaptation in maintaining global food security. One of effective approach is integrating climate change adaptation strategies into school curricula at all levels, from primary school to university by incorporating topics such as sustainable agriculture, water management and biodiversity conservation into the curriculum. Through this approach communities can develop a deeper understanding of the relationship between climate change and food security.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics

This study does not require ethics committee approval.

Author Contribution Rates

Design of Study: NA(%70), MB(%30)

Data Acquisition: NA(%70), MB(%30)

Data Analysis: NA(%70), MB(%30)

Writing up: NA(%70), MB(%30)

Submission and Revision: NA(%70), MB(%30)

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