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Farmers' Adaptation to Climate Change: A Review on Strategies and Influencing Factors

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Abstract

Climate change poses significant challenges to the agricultural sector, particularly in regions where farming practices are closely tied to environmental conditions. Farmers are increasingly required to adapt to unpredictable climatic shifts that threaten crop productivity, land quality, and food security. This study aims to explore the various strategies employed by farmers to adapt to climate change, as well as the factors influencing their adaptability. Using a qualitative literature review methodology, the study synthesizes findings from multiple sources to identify key behavioral, technological, and institutional components of adaptation. The analysis reveals that farmers' adaptation strategies are shaped by their experience, knowledge, perceptions, access to technology, and support from government and community institutions. Adaptation occurs both physically, through changes in cropping patterns and infrastructure, and socially, through education, group activities, and policy interventions. However, limited access to training and resources continues to hinder effective adaptation in many contexts. The findings underscore the importance of integrated support systems and targeted policy measures to enhance farmers' resilience to climate change. Strengthening adaptive capacity at the farm level is essential for safeguarding agricultural sustainability and ensuring food security in the face of environmental uncertainty.

Keywords: Climate Change, Farmer Adaptation, Agricultural Resilience, Adaptation Strategies, Policy Support

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INTRODUCTION

Farmers in their daily activities are very dependent on natural conditions. Climatic conditions will determine the level of success of farming. Climate change has become a natural phenomenon that has a negative impact on the agricultural sector. This climate change can be seen from various phenomena that occur, such as prolonged droughts, floods, rising earth temperatures, storms, and rising sea levels (Liverman, 2008). According to the Agricultural Research and Development Agency (Balai Besar Sumber Daya Lahan Pertanian, 2011), agriculture is the sector that is most easily threatened and vulnerable to the phenomenon of climate change. The three main factors that make the agricultural sector more vulnerable to climate change are biophysics, genetics, and management (ICCSR, 2010). The phenomenon of climate change events has several negative impacts on the agricultural sector, including crop failure, decreased crop production and productivity, damage to agricultural land, increased intensity of pest and disease disturbances in plants (Las, et al. 2008).

Adaptation is also referred to as a process experienced by people in making adjustments to their environment. Adaptation is a process that takes place dynamically with the aim of adjusting the behavior of individuals to their environment (Schneider, 1960). This adjustment can be seen from three perspectives, namely self-adjustment as a form of adaptation, conformity, and mastery. Adaptation is self-adjustment in a subjective

way, this is based on the attitudes and behavior of individuals in presenting a comfortable attitude and behavior to their environment (Hurlock, 1974). Individual adjustment consists of two aspects, (1) personal adjustment, where each individual is able to accept and understand himself, (2) social adjustment, is a process carried out by individuals to the environment they live in and the process of interacting with others public (Atwater, 1983). Adaptation is influenced by various factors including welfare and safety. Therefore, adaptation is also carried out individually on the basis of self-interest, or is structured in government and public actions to protect the population (Adger, et al. 2005).

Every human being has different abilities for making adjustments to their environment. The ability to adapt and how to interact between individuals has become a hereditary habit from generation to generation. The adaptability of each individual or group can be influenced by science and technology which are the most important elements in society (Hilmanto, 2010). There are two aspects that can be used as a rationale in determining an individual's ability to adapt to climate change events, namely the ability to adapt proactively and reactively and privately and publicly. Knowledge and individual adaptability will affect the form of adaptation that will be carried out by individuals in continuing their farming (Grothmann and Patt, 2005).

METHOD

Research Design

This study utilized a literature review methodology to consolidate existing knowledge regarding farmers' adaptive capacity to climate change. A literature review effectively encompasses the extensive range of theoretical and empirical findings from various regions and methodological traditions, particularly considering the intricate and multifaceted characteristics of adaptive capacity and climate risk responses among farmers.

Data Sources

The review depended on peer-reviewed research articles from Google Scholar, ScienceDirect, and Scopus-linked repositories. Official government publications provided more contextual and statistical information. Priority was given to empirical studies that looked at how farming communities adapt, make decisions, and what factors affect their ability to do so. Articles were included if they talked about how farmers adapt, how they see climate risk, how they deal with or adapt to climate change, or how structural factors affect how agriculture responds to climate change.

Data Collection and Procedures

A structured search protocol was utilized to collect pertinent literature. We used different combinations of words like "climate change adaptation," "farmers' adaptive capacity," "behavioral responses," and "risk perception." In the first stage, articles that had been published in well-known peer-reviewed journals and were available in full text were looked at. We looked over abstracts and introductions to see if they were relevant, and then we read the whole studies that we had chosen. Inclusion criteria focused on conceptual clarity, relevance to agricultural adaptation, and empirical foundation, whereas exclusion criteria removed papers that lacked methodological rigor or relevance to adaptation behavior.

The main tool for this study, which is a review of the literature, was a structured data extraction matrix that was made to consistently collect important information from different studies. The matrix recorded ideas, theoretical frameworks, methodological approaches, variables studied, factors influencing adaptation, and results pertaining to adaptive capacity. This method made it possible to systematically compare the behavioral,

institutional, socio-economic, and environmental factors that affect how farmers respond to climate risk.

Data Analysis

The analysis utilized a qualitative synthesis methodology. The extracted data were systematically organized thematically to discern patterns, convergences, and divergences among studies. The themes were organized into larger groups, like behavioral determinants, institutional and governance factors, socio-economic constraints, and environmental conditions. We paid special attention to how adaptive capacity is defined and measured because recent research shows how the focus has shifted from asset-based frameworks to ones that include knowledge, innovation, governance, and agency. The integration of findings from quantitative, qualitative, and mixed methods studies yielded a holistic comprehension of the factors influencing farmers' adaptive strategies.

FINDING AND DISCUSSION

The literature on the adaptability of farmers to climate change explains that adaptation is a process carried out by individuals or groups in aligning themselves with their environment. This adaptability is also supported by knowledge and technological advances that will affect the human environment (Samry, 2019). The adaptability of farmers is carried out based on the experience and knowledge of farmers in carrying out the process of their agricultural activities (Rasmikayati, *et al*. 2015). Farmers have had knowledge of the climate for a long time. However, this knowledge is formed from generation to generation which is used by farmers in carrying out agricultural activities by making a calendar system for planting (Hilmanto, 2010). Along with the phenomenon of uncertainty in climatic conditions, knowledge that is passed down from generation to generation can no longer be applied by farmers in carrying out their agricultural activities. This makes farmers begin to align adaptation with new knowledge obtained from extension and non-governmental groups (Kurniawati, 2012).

Farmers believe that if they have a higher capacity to accept risk, this will also increase the farmer's ability to adapt, so that the adaptation process can run effectively. On the other hand, if farmers have the capacity to accept risks that tend to be low, this will reduce the farmer's intention to adapt, so that adaptation does not work effectively (Dang, 2014). Therefore, the adaptability of farmers in dealing with the phenomenon of climate change is still relatively low. This is due to the limited knowledge of farmers in understanding the phenomenon of climate change. Farmers are only able to adapt to cultivation techniques, but are less able to adapt to climate and environmental changes. Some adaptation strategies carried out by farmers cannot be applied by farmers due to lack of knowledge, high costs, and the unsupportive geographical location of farming (Salampessy, 2018). The lack of knowledge and ability of farmers to adapt to the impacts caused by climate change is caused by lack of training attended by farmers, a lack of support from the government, and a lack of support from community groups (Arbuckle, *et al*. 2013). Lack of training and support from the government will limit the ability and capacity of farmers to implement adaptation options that will be necesarry to overcome these problems (Asante, 2012). Adaptation has the potential that farmers can leverage in aligning themselves with their environment. There are three potentials that farmers have in adapting to climate change (Mardikanto, 2013):

1. Making the phenomenon of climate uncertainty an effort to increase farmers awareness of adaptation. This means that farmers have the ability to participate in thinking about the sustainability of their farming business together.
2. Increasing the potential of farmers to access facilities and infrastructure that relate to their agricultural activities.

3. Establish good social relations with the surrounding community.

Therefore, in adapting to climate change, farmers adapt reactively, namely after the impact on the social, economic, and agricultural environment. Adaptation efforts require an extension process as a process of adopting ideas, practices or objects in the learning process of behavior change starting from knowledge, attitudes and skills and applying the adaptation process (Idawati, *et al.* 2018).

The low knowledge of farmers in understanding climate change will reduce their ability to adapt, so that in overcoming the impacts of climate change farmers still use adaptation strategies in a simple way. Overcoming this problem requires intensive socialization provided by extension institutions to farmer groups. This is related to the impact and adaptation options that will be made by farmers to overcome climate change in order to maintain the sustainability of their farming business (Ichdayati, 2014). This adaptability is important to overcome the impact of changing phenomena that pose a threat to food availability and access. Several literature analyses explain some of the impacts that occur, namely a decrease in crop production, degradation of agricultural land, price increases, negative impacts on livelihoods, and an increase in the percentage of malnutrition.

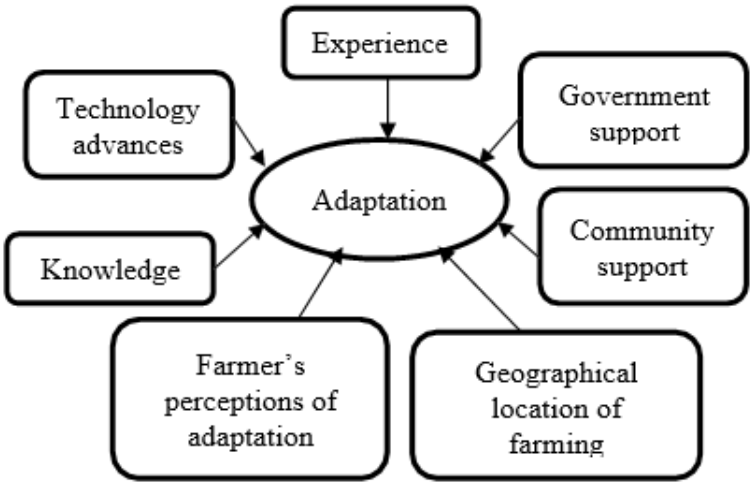
There are four main components in adapting which consist of (Mutekwa, 2009):

1. The level of self-awareness in carrying out environmental adaptation mechanisms,
2. Priority of farmers to interests that can continue their farming business
3. The influence of farmers socio-economic factors,
4. Identifying constraints faced by farmers through reports on the extent to which farmers face impacts.

Self-adjustment can be influenced by external factors for farmers, namely subjective norms in the form of government policy support which can significantly affect the level of adaptation of farmers. This shows that the internal factors of farmers are not enough to increase the adaptability of farmers, but must be supported by external factors to increase their adaptability.

Based on the literature study, it can be explained that adaptation to farmers is influenced by several factors as follows:

Figure 1. Factors influencing farmers adaptation strategies



Factors that can influence farmer adaptation to climate change, based on Figure 1, include farmer knowledge of climate change, technological advances, farmer experience in farming, farmer perceptions of the level of adaptation, the geographic location of

agricultural land, and support from farmer groups and the government. The use of innovative agricultural technologies is crucial to aid adaptation to climate change. For example, the use of water management technology can help address water shortages caused by drought or changes in rainfall patterns. Sensor and monitoring technology can also be used to provide real-time information on soil conditions, weather, and crop needs, enabling farmers to make faster and more accurate decisions.

In addition to adaptation efforts at the farmer level, government support and policies are also crucial in addressing the impacts of climate change. The government can provide incentives and assistance to farmers to adopt sustainable and environmentally friendly agricultural practices. Furthermore, investment in climate-resilient agricultural infrastructure, such as efficient irrigation systems and flood control infrastructure, also needs to be increased.

The purpose of adaptation measures is to increase the system's capacity to withstand external shocks or changes. This can be done by implementing adaptation strategies at the farm level as an important step to provide information that is used in formulating adaptation improvement policies to manage various kinds of risks associated with climate change in agriculture. Important adaptation options in the agricultural sector include: crop diversification, intercropping farming systems, use of different crop varieties, changes in cropping and harvesting schedules, drought-resistant varieties and highly sensitive crops (Bradshaw, 2004).

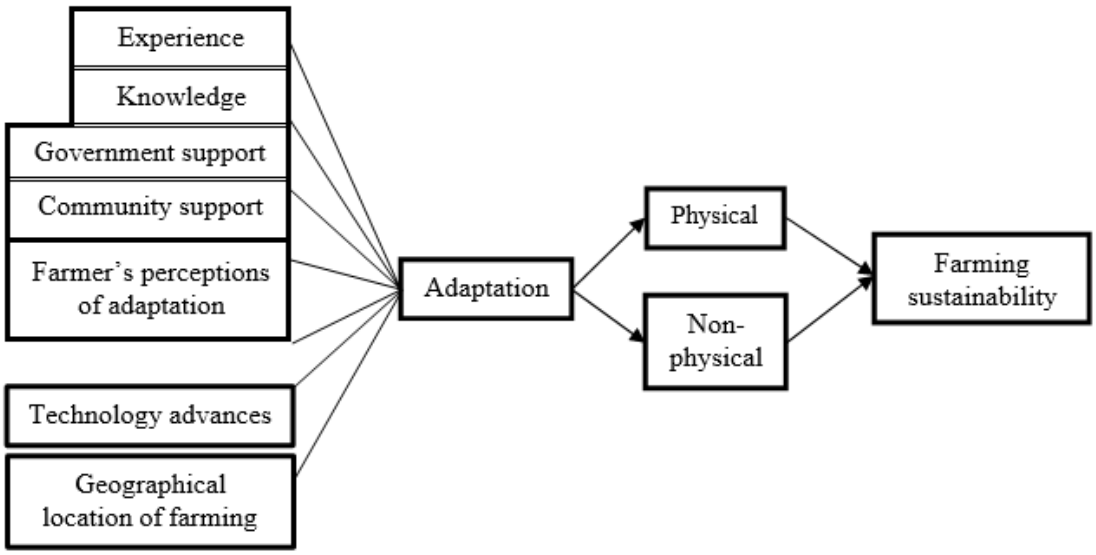
The elements forming adaptation include:

1. Mastery of knowledge in agriculture.
2. Mastery of more productive and adaptive agricultural technology.
3. Agricultural management abilities.
4. Ability to access information.
5. Ability to access agricultural markets.
6. The availability of “risk-sharing” institutions at the farmer level.
7. Availability of conducive infrastructure.
8. The availability of effective institutions to deal with.
9. Government policy.
10. Policy on business protection in the food and agriculture sector.
11. Policies to protect important assets and strategic agricultural food resources.

Farmers will choose the best adaptation action to overcome the impacts of climate change for the sustainability of their farming. Farmers' strategies for adapting can be done with physical and non-physical adaptation. Physical adaptation includes improving cultivation and applying technology to farming, while non-physical adaptation is adaptation to socio-cultural developments including land management systems, improvement of access to agricultural information and farm management (Helida, 2015). So that it will be possible for farmers to choose and combine several adaptation strategies to get the best choice in adapting to climate change. Farmers adapt to climate change by shifting the planting period, changing crop variations, changing cropping patterns, changing planting places and locations, and changing irrigation systems. This is based on their experience of gradual climate change (Miranda, 2011).

Based on literature studies, it can be described that the adaptation framework that can be carried out is as follows:

Figure 2. Adaptation Strategy Framework



A physical adaptation strategy that farmers can implement in response to climate change is crop diversification, which involves planting various types of crops that are resistant to higher temperatures, drought, or increased humidity. This can help farmers mitigate the risks of climate change. Superior varieties have the advantage of being relatively safe, as they do not cause pollution or environmental damage.

Physical adaptation can also be achieved through land resource management through fertilization, which is especially important during the rainy season. Reducing nitrogen fertilizer use, for example, can help farmers reduce the use of rice crops. Crop diversification can also help maintain biodiversity and maintain the resilience of agricultural systems.

Non-physical adaptations undertaken by farmers can include social and economic adaptations. Social adaptation is a survival strategy carried out by establishing relationships, both formal and with the social and institutional environment (Suharto, 2009). Social adaptation undertaken by farmers is examined through their active participation in farmer groups, participation in mutual cooperation activities, and mutual assistance among group members affected by climate problems. Meanwhile, economic adaptation strategies are strategies aimed at increasing family income through various actions. Economic adaptation can be seen from the type of livelihood they engage in. Economic adaptation is carried out by farmers by seeking additional work besides farming (Fitria, 2012).

CONCLUSION

Based on the literature review, it can be seen that the adaptability of farmers in dealing with climate change tends to be influenced by how much impact the climate change phenomenon feels on farmers, so that if farmers feel a greater impact, the ability and capacity of adaptation carried out by farmers will be more effective. Vice versa, if the impact felt by farmers is lower, then the intention of farmers to adapt will also be lower and adaptation will not occur effectively. The factors that influence farmers' adaptation

strategies based on literature review can be seen to be several factors, namely farmers' experience in carrying out agricultural activities, farmers' knowledge about adaptation to climate change, farmers perceptions of adaptation, technological advances that can encourage farmers to adapt, government support in providing counseling and support from the community, and the geographical location of the farming business. Climate change has a huge impact on the agricultural sector, namely crop failure, decreased crop production and productivity, agricultural land degradation, price increases, negative impacts on livelihoods, and an increase in the percentage of malnutrition.

The ability of farmers to adapt is closely related to government and group support, farmers will be better able to adapt when they actively participate in training provided by institutions related to climate change and the adaptation that will be carried out. Adaptations made by farmers can be in the form of physical and non-physical adaptations. Physical adaptation can be done by building good infrastructure to deal with the phenomenon of climate change. Physical adaptation can also be done by means of variations in cropping patterns, and the use of superior seeds that are resistant to climate change. Non-physical adaptation can be in the form of socialization provided through counseling, social activities in farmer groups, and support from the government.

DECLARATION OF CONFLICTING INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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