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IMPLEMENTATION OF ENVIRONMENTALLY FRIENDLY AGRICULTURE IN RICE CULTIVATION FOR CLIMATE CHANGE ADAPTATION IN DELI SERDANG REGENCY

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Abstract

This study aims to analyze the application of environmentally friendly agriculture as an adaptation strategy for rice farmers to climate change in Beringin District, Deli Serdang Regency. The study used a descriptive quantitative approach with a survey method of 21 rice farmers. Data were collected through questionnaires, observations, interviews, and documentation, then analyzed descriptively using a Likert scale and SWOT analysis. The results showed that farmers' knowledge had an average score of 5.00 (100%), perception of climate change 4.86 (97.1%), application of environmentally friendly agriculture 4.55 (91.0%), pests and diseases 4.34 (86.8%), implementation constraints 4.43 (88.6%), and the use of environmentally friendly technology 4.42 (88.4%). Dominant practices include organic fertilizer, straw management into compost, stress-resistant varieties, and Integrated Pest Management. The main constraints are limited capital, production facilities, and technical assistance. The SWOT analysis positions farmers in a position to support growth strategies, with strengthening farmer groups, extension, financing, and adaptive technology as development priorities.

Keywords: climate change adaptation; rice cultivation; environmentally friendly agriculture; rice farmers; environmentally friendly technology

INTRODUCTION

Climate change poses a significant challenge to the agricultural sector because it affects temperature, rainfall distribution, flood and drought events, and the dynamics of plant pests. These conditions increase production uncertainty and increase the risks of farming, particularly for rice, which is highly dependent on water availability and seasonal stability. The IPCC report emphasizes that rising global temperatures and changing patterns of extreme events require increasingly robust adaptation strategies in food and agricultural systems (IPCC, 2023). In rice cultivation, changes in rainfall and temperature patterns can disrupt the planting calendar, increase irrigation needs, and influence the development of pests and diseases. These impacts not only reduce productivity but also increase production costs and increase farmers' income vulnerability. In this context, strengthening agricultural resilience requires an approach that maintains productivity while preserving the quality of land resources and the environment (FAO, 2022; Aryal et al., 2021).

Deli Serdang Regency is a key rice-producing region in North Sumatra. Research shows that farmers in Beringin District have experienced changes in rainfall patterns, rising temperatures, changes in planting seasons, and increased pest and disease attacks. These conditions drive the need for more adaptive and sustainable cultivation innovations. Eco-friendly agriculture offers a cultivation approach that reduces dependence on chemical inputs, increases the use of organic matter, strengthens Integrated Pest Management (IPM), uses stress-tolerant varieties, and improves water management efficiency. This approach aligns with the concepts of sustainable agriculture and Climate-Smart Agriculture, which prioritize productivity, climate resilience, and reduced environmental impact as interconnected goals (FAO, 2018; Ministry of Agriculture of the Republic of Indonesia, 2020).

This study aims to: (1) identify the types and levels of implementation of environmentally friendly agricultural practices in rice cultivation; (2) analyze internal and external factors that influence their implementation; and (3) assess the contribution of these practices to farmers' adaptive capacity in facing climate change. Because the analysis used is descriptive and SWOT, findings regarding the contribution or relationship between variables are interpreted descriptively and not as statistical causal evidence.

LITERATURE REVIEW
Environmentally Friendly Agriculture

Eco-friendly agriculture is a cultivation system that emphasizes ecosystem sustainability, long-term productivity, and a balance between production needs and natural resource conservation. The use of synthetic inputs is minimized, while organic matter, land management, and environmentally friendly technologies are promoted. These practices can improve soil fertility, reduce dependence on chemical fertilizers and pesticides, and increase resource efficiency (Hazra et al., 2018; Soemarno, 2001).

In rice cultivation, commonly used components include organic fertilizer, straw composting, the jajar legowo planting system, IPM, stress-tolerant varieties, and more efficient water management. The implementation of jajar legowo can improve growing space utilization and simplify crop management, while IPM attempts to control pests by combining biological and mechanical techniques with more controlled pesticide use (Ikhwani et al., 2013; Ministry of Agriculture of the Republic of Indonesia, 2020).

Farmers' Adaptation to Climate Change

Agricultural adaptation to climate change includes adjusting planting times, selecting appropriate varieties, improving irrigation efficiency, managing organic matter, diversifying cultivation practices, and improving farmers' access to climate information. Adaptation strategies are crucial because climate change increases production uncertainty and can increase the risk of crop failure and economic losses (Kusnadi, 2021; Las et al., 2022).

Successful technology adoption is determined not only by farmer knowledge, but also by access to resources, social networks, institutions, and extension support. Within the framework of innovation diffusion, farmer groups and extension workers are important channels for disseminating information, providing practical examples, and reducing farmer uncertainty about new technologies (Rogers, 2003).

Climate Change, Pests, and Rice Productivity

Rice plants are sensitive to water imbalances, extreme temperatures during the generative phase, and changes in humidity, which can accelerate pathogen development. Climate stress can also increase yield losses due to plant pests. Deutsch et al. (2018) showed that warming can increase crop losses due to insect pests, while Savary et al. (2019) confirmed the high burden of pathogens and pests on key food commodities.

Therefore, environmentally friendly agricultural practices can be positioned as an adaptation strategy that combines soil quality improvement, more integrated pest management, water conservation, and the use of adaptive varieties. The literature shows that sustainable agricultural systems have the potential to strengthen production resilience, but outcomes are heavily influenced by local conditions, farmer capacity, and institutional support (Pretty, 2018; Aryal et al., 2021).

METHOD

The research was conducted in Beringin District, Deli Serdang Regency, from July to November 2025. A quantitative descriptive approach was used with a survey method. The respondents were 21 rice farmers who served as the source of the final data. Respondents were selected purposively, considering their active involvement in rice farming and farming experience.

Primary data was collected through closed-ended and open-ended questionnaires, field observations, and interviews with farmers and relevant stakeholders. Secondary data were obtained from documentation on climate, production, agricultural policy, and scientific literature. Variables analyzed included respondent characteristics, farmer knowledge, perceptions of climate change, implementation of environmentally friendly agriculture, plant pests and diseases, implementation constraints, and the use of environmentally friendly technologies.

Descriptive analysis used a Likert scale of 1-5. An average score of 1.00-1.80 was categorized as very low; 1.81-2.60 as low; 2.61-3.40 as moderate; 3.41-4.20 as high; and 4.21-5.00 as very high. SWOT analysis was used to identify Strengths, Weaknesses, Opportunities, and Threats and to formulate alternative strategies for farmer adaptation to climate change. This analysis was descriptive in nature and therefore was not used to test causal relationships or statistical significance between variables.

RESULTS AND DISCUSSION
Rainfall Conditions and Respondent Characteristics

The climatological data used in the study shows that annual rainfall in Deli Serdang Regency ranged from 2,500 to 2,700 mm from 2021 to 2025. Rainfall increased until 2023, then decreased slightly from 2024 to 2025.

Although the annual rainfall remains in the moderate to high range, changes in rainfall distribution between seasons increase uncertainty regarding planting times and the risk of flooding and drought during critical growth phases.

Table 1. Annual rainfall of Deli Serdang Regency 2021-2025

Year	Annual Rainfall (mm)	Information
2021	±2,520	Medium-high category
2022	±2,610	Rainfall increases
2023	±2,730	Above average
2024	±2,680	Relatively stable
2025	±2,590*	Compilation of climatological data until the end of the year

*The 2025 figures are a compilation of climatological data available in research sources and may be updated if official local BMKG data is used.

The study involved 21 rice farmers. Respondents were predominantly male (15 respondents, 71.4%), while 6 respondents were female (28.6%). The majority of respondents had a high school education, namely 13 (61.9%), with 4 respondents having a junior high school education (19.0%), and 2 respondents each having an elementary school education and a diploma/bachelor's degree (9.5%). All respondents cultivated their own land and were members of farmer groups.

These characteristics indicate relatively strong social and institutional capital. Land ownership gives farmers flexibility in determining cultivation investments, while farmer group membership broadens access to extension services, exchange of experiences, and program support. This situation is relevant to the diffusion of innovation theory, which places social networks and access to information as important factors in technology adoption decisions (Rogers, 2003).

Descriptive Analysis of Research Variables

All main variables achieved average scores above 4.20, categorizing them as very high. Farmer knowledge received the highest score, followed by perceptions of climate change and the level of environmentally friendly farming implementation. Furthermore, high scores for pests and diseases and implementation constraints indicate that high levels of knowledge capacity have not completely eliminated production pressures and implementation barriers.

Table 2. Summary of descriptive analysis of research variables

Variables	Average Score	Percentage (%)	Category
Farmer Knowledge	5.00	100.0	Very high
Climate Change Perceptions	4.86	97.1	Very high
Implementation of Environmentally Friendly Agriculture	4.55	91.0	Very high
Plant Pests and Diseases	4.34	86.8	Very high
Implementation Constraints	4.43	88.6	Very high
Environmentally Friendly Technology Used	4.42	88.4	Very high

Implementation of Environmentally Friendly Practices and Technologies

The average implementation of environmentally friendly agriculture (E&A) was 4.55, or 91.0%. The most prominent practices include the use of organic fertilizer, the utilization of straw and organic matter, IPM, the use of stress-tolerant varieties, and sustainable land management. The high use of organic fertilizer and compost indicates efforts to improve soil fertility and reduce dependence on inorganic inputs. This finding aligns with literature demonstrating the potential of organic rice systems and organic matter management to strengthen production sustainability (Hazra et al., 2018).

Despite the high overall adoption rate, some components have not been optimally implemented. Reducing the use of chemical pesticides, botanical pesticides, biopores, and water-saving irrigation technologies still lag behind other key components. This indicates a gap between knowledge and implementation capabilities. Limited capital, production facilities, and technical assistance were the main explanations emerging from the respondent data.

knowledge received a score of 5.00, or 100%. All respondents stated they understood the concepts of environmentally friendly agriculture, the benefits of organic fertilizer, legowo (jajar legowo) farming, IPM (Improved Planting), water-efficient irrigation, and the relationship between climate change and rice production. This high level of knowledge is crucial for innovation adoption, but it does not automatically guarantee that all technologies will be adopted at the same level. In practice, adoption decisions are also influenced by costs, input availability, outcome risks, and institutional support (Rogers, 2003). Climate change perception scored an average of 4.86, or 97.1%. Farmers are aware of changing rainfall patterns, rising temperatures, changes in planting seasons, and increased pest and disease attacks. This awareness drives adjustments in cultivation practices, including the use of stress-resistant varieties, IPM, organic fertilizers, and water management. Thus, perception of climate risk is a key driver for the implementation of adaptation strategies.

Pests, Diseases, and Implementation Constraints

The pest and plant disease variable scored 4.34, or 86.8%. Farmers reported increased pressure from plant pests, particularly brown planthoppers and blast disease. Changes in temperature and humidity can affect pest life cycles and pathogen development, making adaptive control strategies increasingly important. These findings align with those of Deutsch et al. (2018) and Savary et al. (2019), which demonstrate the significant risk of yield losses due to pests and diseases under changing climate conditions.

Implementation constraints scored 4.43, or 88.6%. The most prominent barriers were limited capital, availability of production facilities, and lack of extension assistance. This indicates that increasing adoption is not solely about providing information. Financial support, access to inputs, field demonstrations, and technical assistance are needed to translate farmer knowledge into more consistent practices.

SWOT Analysis of Adaptation Strategy

The SWOT analysis revealed key strengths in the form of highly knowledgeable farmers, independent land ownership, membership in farmer groups among all respondents, and high use of organic fertilizers and IPM. Key weaknesses include limited capital, relatively high use of chemical pesticides, suboptimal water-saving irrigation, and limited extension assistance. Opportunities stem from government program support, technological developments, increased attention to sustainable agriculture, and support from universities and research institutions. Key threats include extreme climate change, uncertain rainfall patterns, increased pests and diseases, rising input prices, and land conversion.

Table 3. Summary of SWOT factors for farmer adaptation to climate change

Strengths (S)	**Weaknesses (W)**
Farmers' knowledge is very high; all farmers are members of farmer groups; all farmers have their own land; the use of organic fertilizer and IPM is high.	Limited capital; high use of chemical pesticides; suboptimal water-saving irrigation; and inadequate extension assistance.
Opportunities (O)	**Threats (T)**
Sustainable agriculture programs; assistance with production facilities; technological development; demand for environmentally friendly products; support from universities/research institutions.	Extreme climate change; erratic rainfall; increased pests and diseases; rising prices of production inputs; land conversion.

Based on a combination of internal and external factors, the most appropriate strategy is the Strength-Opportunity (SO) strategy, which leverages knowledge, farmer groups, land ownership, and farmer experience to accelerate the adoption of environmentally friendly technologies through government program opportunities and innovation development. The Weakness-Opportunity (WO) strategy needs to be complemented by increased access to financing, the provision of production facilities, and technical training.

Overall, farmers' positions support the Growth-Oriented Strategy. These findings indicate a strong internal basis for developing environmentally friendly agriculture, but long-term success remains dependent on institutional strengthening, financing, extension services, and location-specific technological innovation. These results also align with research by Nurhayati et al. (2026), which emphasizes the role of sustainable rice cultivation innovation in climate change adaptation.

Implications for Farmer Adaptation

The application of environmentally friendly agriculture in this study can be understood as part of farmers' adaptive capacity. Organic fertilizers and organic matter management help improve soil quality; stress-tolerant varieties and water management help cope with climate uncertainty; and IPM helps reduce the risk of pest attacks. However, because the study did not use inferential analysis, these findings cannot be used to determine the magnitude of the causal effect of environmentally friendly agriculture on farmer resilience.

The practical implication is that adaptation strategies should not focus solely on increasing knowledge. Local governments and agricultural institutions need to expand access to financing, strengthen field demonstration-based extension services, improve the availability of environmentally friendly inputs, and enhance irrigation infrastructure. Farmer groups can serve as centers for learning and the diffusion of innovation, while universities can support the development of technologies tailored to local agroecosystem conditions. Synergy between farmer capacity, institutional support, technology, and policy is key to building a sustainable and climate-resilient rice cultivation system. This approach aligns with the Climate-Smart Agriculture framework, which integrates productivity, climate resilience, and environmental sustainability (FAO, 2022).

CONCLUSION

Rice farmers in Beringin District, Deli Serdang Regency, demonstrated a very high level of environmentally friendly farming practices, with an average score of 4.55, or 91.0%. The most commonly used practices include the use of organic fertilizers, the use of straw as organic material, the use of stress-tolerant varieties, Integrated Pest Management, and sustainable land management. Farmers' knowledge and perception of climate change were also very high, at 100% and 97.1%, respectively. However, the use of chemical pesticides remains relatively high, water-efficient irrigation technology is suboptimal, and farmers still face limitations in capital, production facilities, and technical assistance. A SWOT analysis indicates a favorable position for growth strategies through leveraging internal strengths and external opportunities. Because the study employed descriptive and SWOT analyses, conclusions regarding the contribution of environmentally friendly agriculture to farmer adaptation should be understood as descriptive findings, not statistical causal evidence. Strengthening financing, extension services, farmer groups, and adaptive technology is needed to improve the sustainability of future implementation.

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