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Farmers' perception and economic impacts of climate change during La Niña on Rice Farming in Banyuasin Regency, Indonesia

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Abstract

Climate change has become a major challenge to agricultural sustainability, particularly in rice farming systems that are highly dependent on climatic conditions. Among climate-related phenomena, La Niña has intensified rainfall and flooding in many regions of Indonesia, leading to production losses and reduced farm income. This study aimed to analyze farmers' perceptions of climate change and evaluate the economic impacts of La Niña on rice farming in Banyuasin Regency, South Sumatra, Indonesia. A quantitative survey was conducted involving 30 rice farmers selected through simple random sampling. Primary data were collected using structured questionnaires and interviews. Farmers' perceptions were measured using a five-point Likert scale, while farm income was analyzed by comparing production costs, revenue, and net income under normal climatic conditions (2024) and during the La Niña period (2022). A paired sample *t*-test was employed to determine whether income differed significantly between the two climatic conditions. The results showed that farmers had a very high level of awareness regarding the causes, impacts, adaptation, and mitigation of climate change. During the La Niña period, excessive rainfall and prolonged flooding significantly reduced rice production while increasing production costs. Average farm income declined from IDR 10,389,478 to IDR 2,084,283 per hectare per growing season, representing a decrease of approximately 80%. These findings highlight the importance of strengthening climate adaptation through improved water management, flood-tolerant rice varieties, climate information services, and integrated farming systems to enhance the resilience and sustainability of rice farming in climate-vulnerable swamp ecosystems.

Keywords: Climate Change; La Niña; Farm Income, Farmers' Perception; Rice Farming

1. Introduction

Climate change has become one of the most critical challenges to global agricultural sustainability because it affects weather variability, water availability, crop productivity, and farmers' livelihoods. Rising temperatures and increasingly frequent extreme weather events have intensified production risks, particularly in developing countries where agriculture remains highly dependent on climatic conditions. The Intergovernmental Panel on Climate Change (1) reported that climate change has already reduced agricultural productivity in many regions and is expected to further threaten global food security, especially in tropical countries.

Rice is the staple food for more than half of the world's population and plays a strategic role in food security and rural livelihoods. Indonesia, one of the world's largest rice-producing countries, depends heavily on rice farming to meet domestic food demand. However, rice production is highly sensitive to climate variability because crop growth depends on rainfall distribution, temperature, and water availability (2). Consequently, climate-induced disturbances have become an increasing concern for the sustainability of rice production in Indonesia.

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One of the most influential climate phenomena affecting Indonesia is the El Niño–Southern Oscillation (ENSO). While El Niño is generally associated with drought, La Niña produces above-normal rainfall that often causes flooding, waterlogging, delayed planting, and increased pest and disease outbreaks. These conditions reduce rice productivity by disrupting plant growth and harvesting activities, leading to substantial economic losses for farmers (3)(4). As climate variability becomes more frequent, improving farmers' resilience has become an important priority for ensuring sustainable agricultural production.

Banyuasin Regency, South Sumatra Province, is one of Indonesia's major rice-producing regions characterized by extensive swamp ecosystems. Rice cultivation in this area is highly dependent on seasonal hydrological conditions, making farmers particularly vulnerable to excessive rainfall during La Niña events. Prolonged flooding frequently delays planting, reduces grain yield, and lowers farm income, thereby threatening household livelihoods and regional food production.

Besides its direct impacts on agricultural production, climate change also influences farmers' decision-making. Farmers' perceptions of climate risks determine whether they adopt adaptation strategies such as adjusting planting schedules, selecting flood-tolerant rice varieties, improving water management, or diversifying farming systems. Farmers who have better awareness of climate change are generally more likely to implement adaptive practices that reduce production risks (5)(6). Therefore, understanding farmers' perceptions is essential for designing effective adaptation policies and extension programs.

Although numerous studies have examined either farmers' perceptions of climate change or its impacts on agricultural production, relatively few have integrated both social and economic perspectives, particularly in swamp rice farming systems. Moreover, empirical evidence regarding the economic impacts of La Niña on rice farming in Banyuasin Regency remains limited despite the region's strategic importance for rice production and its high vulnerability to flooding.

Therefore, this study aims to analyze farmers' perceptions of climate change and evaluate the economic impacts of La Niña on rice farming in Banyuasin Regency, Indonesia. Specifically, the study compares rice production and farm income under normal climatic conditions and during the La Niña period. The findings are expected to provide empirical evidence to support climate-resilient agricultural policies and strengthen adaptation strategies for sustainable rice production in swamp ecosystems.

2. Materials and methods

The location of this study was conducted in Sungai Rebo Village, Banyuasin I District, Banyuasin Regency, South Sumatra Province, Indonesia. The study area was purposively selected because it is one of the major rice-producing villages located in a swamp ecosystem that is highly vulnerable to climate variability, particularly flooding associated with La Niña events. Rice farming is the primary livelihood of local households, with farmers generally cultivating rice once a year under rainfed swamp conditions. Data collection was carried out from March to May 2025.

This study employed a quantitative survey approach. Primary data were collected through structured interviews using questionnaires administered directly to rice farmers. A simple random sampling technique was used to select respondents from the population of rice farmers in the village. A total of 30 farmers were interviewed, each representing one farming household.

The study utilized both primary and secondary data. Primary data included farmers' socio-economic characteristics, perceptions of climate change, production costs, rice production, selling prices, and farm income under two different climatic conditions, namely normal rainfall conditions (2024 growing season) and the La Niña period (2022 growing season). Information regarding farmers' perceptions was collected using a structured questionnaire based on six dimensions: (1) causes of climate change, (2) impacts of climate change, (3) adaptation strategies, (4) mitigation practices, (5) financial responsibility for climate adaptation and mitigation, and (6) community participation in addressing climate change.

Farmers' perceptions of climate change were measured using a five-point likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire consisted of 24 statements distributed across six perception dimensions, with four indicators for each dimension.

The total perception score was calculated by summing the responses across all indicators. Perception levels were classified into five categories: very low, low, moderate, high, and very high based on the interval class method. The class interval was determined using the following equation:

$$CI = \frac{Xmax - Xmin}{k}$$

where:

- CI = Class interval
- Xmax = Maximum score
- Xmin = Minimum score
- k = Number of categories (five classes)

Economic performance was evaluated by comparing rice farming under normal climatic conditions (2024) and during the La Niña event (2022). Production costs consisted of fixed costs and variable costs.

Total production cost was calculated as

$$TC = FC + VC$$

where:

- TC = Total production cost (IDR/ha/season)
- FC = Fixed cost (IDR/ha/season)
- VC = Variable cost (IDR/ha/season)

Total revenue was estimated using

$$TR = P\ x\ Q$$

where:

- TR = Total revenue (IDR/ha/season)
- P = Selling price of rice (IDR/kg)
- Q = Rice production (kg/ha)

Farm income was then calculated as

$$FI = TR - TC$$

where:

FI = Farm income (IDR/ha/season)

3. Results and discussion

3.1. Characteristics of Respondents

The respondents in this study consisted of 30 rice farmers from Sungai Rebo Village, Banyuasin Regency. Farmers' demographic and farming characteristics are important because they influence farming decisions, technology adoption, climate risk perception, and adaptive capacity (5)(6). Variables observed included age, education level, farming experience, farm size, and household size.

Table 1 shows that most respondents (70%) were between 41 and 60 years old, indicating that rice farming in the study area is dominated by economically productive farmers. Farmers within this age group generally possess sufficient physical capacity and farming experience while remaining receptive to technological innovations and adaptation strategies. According to FAO (2023) (2), productive-age farmers tend to demonstrate greater flexibility in adopting agricultural innovations, particularly under increasing climate uncertainty.

The educational level of respondents was relatively low, with 57% having completed only elementary school, while only 6% had completed senior high school. Although formal education contributes to farmers' ability to understand

agricultural technologies and climate information, practical farming knowledge accumulated through experience often plays an equally important role in shaping adaptation behavior (6). This finding suggests that extension services and climate information should be delivered using simple and practical approaches that are easily understood by farmers.

Table 1 Characteristics of Respondents

Characteristics	Category	Frequency	Percentage (%)
Age (years)	25–40	5	17.0
	41–60	21	70.0
	61–80	4	13.0
Education	Elementary School	17	57.0
	Junior High School	11	37.0
	Senior High School	2	6.0
Farming Experience (years)	1–15	5	17.0
	16–30	23	77.0
	31–45	2	6.0
Farm Size (ha)	0.50–1.50	20	67.0
	1.51–2.00	7	23.0
	2.01–3.00	3	10.0
Household Size (persons)	1–3	24	80.0
	4–6	6	20.0

Source: Primary data processed (2025).

Regarding farming experience, 77% of respondents had cultivated rice for 16–30 years, indicating substantial accumulated knowledge in managing rice farming under varying climatic conditions. Long-term farming experience enables farmers to recognize changes in rainfall patterns, flooding frequency, and seasonal shifts based on repeated observations over time. Previous studies have shown that experienced farmers are generally better able to identify climate-related risks and adjust farming practices accordingly (1).

Most respondents (67%) cultivated relatively small farms ranging from 0.50 to 1.50 ha. Small farm size may limit farmers' financial capacity to invest in climate adaptation technologies because household income depends heavily on seasonal rice production. Consequently, production losses resulting from flooding during La Niña can have substantial economic consequences for farm households (2). Meanwhile, most respondents (80%) had one to three household dependents, implying that rice farming serves as the primary source of income to support family livelihoods. Under such conditions, declining rice productivity due to climate variability directly threatens household welfare and food security.

3.2. Farmers' Perception of Climate Change

Farmers' perceptions are considered an important determinant of adaptation behavior because farmers are more likely to adopt adaptive measures when they recognize climate change as a significant threat to agricultural production. This study evaluated farmers' perceptions across six dimensions: (1) causes of climate change, (2) impacts of climate change, (3) adaptation, (4) mitigation, (5) funding for adaptation and mitigation, and (6) community participation.

The results demonstrate that farmers exhibited a very high level of awareness across all dimensions of climate change. Overall, respondents recognized that climate change has become an important issue affecting agricultural sustainability and acknowledged the necessity of adaptation and mitigation measures. These findings are consistent with those reported by (7) who found that rice farmers had already perceived changes in rainfall patterns, increasing temperatures, and shifting planting seasons despite having limited scientific understanding of climate change.

Table 2 Farmers' Perception of Climate Change

Dimension	Mean Score	Category
Causes of climate change	18.4	Very High
Impacts of climate change	19.0	Very High
Adaptation strategies	17.1	Very High
Mitigation strategies	18.7	Very High
Funding for adaptation and mitigation	18.2	Very High
Community participation	17.8	Very High

Source: Primary data processed (2025).

Regarding the causes of climate change, farmers strongly agreed that human activities, including fossil fuel consumption, deforestation, and land-use conversion, contribute to climate change. The high perception score indicates that respondents have developed considerable environmental awareness, which may result from direct farming experience, agricultural extension programs, and increasing public exposure to climate-related information. Similar findings were reported by Arbi et al. (2023) (8), who observed that farmers participating in integrated rice-fish farming programs demonstrated relatively high environmental awareness and positive attitudes toward sustainable agricultural practices.

Farmers also perceived the impacts of climate change as highly significant. Respondents agreed that increasing rainfall intensity during La Niña resulted in prolonged flooding, delayed planting, increased pest and disease incidence, and reduced rice productivity. These perceptions closely correspond with observed climatic conditions in Indonesia, where La Niña events frequently increase rainfall intensity and flood risk in lowland agricultural areas (9)(3). The consistency between farmers' perceptions and observed climatic conditions suggests that local knowledge can provide valuable insights for climate adaptation planning.

The perception of adaptation strategies also received a very high score. Farmers strongly supported adjusting planting schedules, selecting flood-tolerant rice varieties, and improving water management systems. Among these strategies, shifting planting time received the highest agreement because farmers considered planting calendar adjustment to be the most practical response to unpredictable rainfall. According to the (10), autonomous adaptation measures based on farmers' experience constitute one of the most effective short-term responses to climate variability in smallholder agricultural systems.

Similarly, respondents expressed strong support for mitigation strategies such as reducing the use of chemical inputs, avoiding residue burning, and promoting environmentally friendly farming practices. Farmers also believed that government institutions, private companies, and environmental organizations should provide financial support for climate adaptation and mitigation programs. Furthermore, respondents emphasized the importance of community participation through farmer education, awareness campaigns, and collaborative adaptation initiatives. These findings indicate that farmers recognize climate change as a collective challenge requiring cooperation among stakeholders rather than relying solely on individual adaptation efforts (11).

3.3. Economic Impacts of La Niña on Rice Farming

The economic performance of rice farming was evaluated by comparing production costs, gross revenue, and net farm income under two contrasting climatic conditions: the normal rainfall season (2024) and the La Niña season (2022). The comparison illustrates the extent to which excessive rainfall affected the profitability of rice farming in Sungai Rebo Village.

Table 3 demonstrates that La Niña substantially reduced the economic performance of rice farming. Production costs increased by approximately 23%, while gross revenue declined by 35.7%. Consequently, average farm income decreased from IDR 10,389,478/ha/season under normal climatic conditions to IDR 2,084,283/ha/season during La Niña, representing an income reduction of nearly 80%. These findings indicate that excessive rainfall simultaneously increased production costs and reduced rice yields, substantially lowering farm profitability.

Table 3 Comparison of Rice Farming Performance under Normal and La Niña Conditions

Variable	La Niña	Normal Climate	Difference	Change (%)
Production Cost (IDR/ha/season)	9,623,217	7,819,189	+1,804,028	+23.1
Gross Revenue (IDR/ha/season)	11,707,500	18,208,667	−6,501,167	−35.7
Net Farm Income (IDR/ha/season)	2,084,283	10,389,478	−8,305,195	−79.9

Source: Primary data processed (2025).

The increase in production costs was mainly driven by higher variable costs resulting from replanting, additional labor, and increased crop management following prolonged flooding. At the same time, excessive soil moisture reduced fertilizer efficiency and impaired crop growth, ultimately decreasing marketable grain production. Similar findings were reported by Hidayati and Suryanto (2015) (12), Athoillah et al. (2017) (3), and Ismail and Chan (2020) (4), who demonstrated that extreme rainfall associated with ENSO events increases production costs while reducing rice productivity. Likewise, the IPCC (2023) (1) emphasized that climate extremes simultaneously increase production costs and reduce agricultural productivity, threatening farm profitability.

The significant decline in farm income reflects the high economic vulnerability of swamp rice farming to climate variability. Similar evidence has been reported in Sub-Saharan Africa and Southeast Asia, where climate shocks substantially reduce farmers' income and limit their ability to invest in adaptation technologies (13)(14). Consequently, strengthening farmers' resilience requires not only technological adaptation but also institutional support through agricultural insurance, climate information services, financial assistance, and improved access to production credit (15)(16).

Although respondents demonstrated a very high level of awareness regarding climate change, high perception alone was insufficient to reduce economic losses. Farmers remained vulnerable because adaptation capacity is constrained by limited financial resources, inadequate infrastructure, and restricted access to climate-resilient technologies. This finding supports Below et al. (2012) (5), who argued that farmers' adaptive capacity depends not only on climate awareness but also on access to financial, institutional, and technological resources. Similarly, Bryan et al. (2013) (6) emphasized that successful climate adaptation requires combining farmers' local knowledge with effective institutional support.

Respondents identified adjusting planting calendars, adopting flood-tolerant rice varieties, and improving water management as the most feasible adaptation strategies. These findings are consistent with the climate-smart agriculture framework promoted by FAO (2023) (2), which recommends integrating climate-resilient technologies with sustainable resource management to maintain agricultural productivity under increasing climate uncertainty. Similar adaptation strategies have also been reported by Aryal et al. (2020) (17), which showed that adopting climate-smart agricultural practices significantly improves farm productivity and resilience to climate-related risks.

Institutional support emerged as another important component of adaptation. Farmers expected government agencies, private companies, and environmental organizations to contribute to financing climate adaptation and mitigation programs. According to the World Bank (2025) (18), effective climate information systems, agricultural extension services, irrigation infrastructure, and financial support significantly enhance farmers' adaptive capacity. Likewise, Campbell et al. (2016) (19) emphasized that institutional interventions are essential for accelerating the adoption of climate-smart agriculture among smallholder farmers.

The findings also have important implications for the sustainability of rice production in swamp ecosystems. Repeated production and income losses may reduce farmers' willingness to invest in rice cultivation and threaten regional food security. One promising adaptation strategy identified by respondents is integrated rice–fish farming (mina padi), which diversifies household income while utilizing seasonal flooding more productively. Previous research by Arbi et al. (2023) A(8) and Bahrgav and Keyni (2025) (20) demonstrated that integrated rice–fish systems improve farm income, increase resource-use efficiency, and enhance resilience under climate variability.

Despite providing important empirical evidence, this study has several limitations. The relatively small sample size and reliance on farmers' recall may limit the generalizability of the findings. Future studies should employ panel data, integrate meteorological observations with remote sensing, and assess the long-term effectiveness of adaptation strategies under different climate scenarios (21).

Overall, this study confirms that La Niña significantly reduces rice farmers' economic performance despite their high awareness of climate change. Strengthening climate resilience therefore requires integrated approaches combining climate-smart technologies, institutional support, improved climate information services, and sustainable farming systems to maintain agricultural productivity and rural livelihoods under increasing climate uncertainty.

4. Conclusion

This study demonstrates that rice farmers in Banyuasin Regency possess a very high level of awareness regarding the causes, impacts, adaptation, and mitigation of climate change. Nevertheless, the La Niña event significantly reduced the economic performance of rice farming by increasing production costs and decreasing rice yields, resulting in an approximately 80% decline in average farm income compared with normal climatic conditions. These findings indicate that farmers' awareness alone is insufficient to minimize climate-related economic losses without adequate institutional, financial, and technological support. Strengthening climate resilience through improved water management, adoption of flood-tolerant rice varieties, climate information services, agricultural insurance, and climate-smart farming systems is therefore essential to sustain rice production in swamp ecosystems. This study provides valuable evidence for policymakers and agricultural stakeholders in designing effective climate adaptation strategies to enhance farmers' livelihoods, strengthen regional food security, and support sustainable agricultural development under increasing climate variability.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Statement of informed consent

Informed consent was obtained from all individual participants involved in this study prior to data collection. Participation was voluntary, and respondents were informed about the purpose of the research, the confidentiality of their responses, and their right to withdraw from the study at any time without any consequences.

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