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Analysis of The Impact of Rainfall and Temperature on Rice Productivity in The Pamona Puselemba District of Poso Regency, Central Sulawesi

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Abstract

Changes in rainfall patterns and increased temperatures are climate phenomena that will affect agricultural activities, especially rice farming. The purpose of this study is to analyze the impact of rainfall and temperature on rice productivity using multiple linear regression analysis in Pamona Puselemba District, Poso Regency. Data collection techniques were carried out through literature studies, document studies, and interviews. Based on the results of the study, the independent variables, namely rainfall and temperature, have a negative effect on rice production. This can be seen from the regression coefficient values in the analysis results, which show that for rice production, the rainfall variable has a value of -2.825 and the temperature variable has a value of -10784.004. However, the rainfall variable does not have a significant effect, because its significance value is 0.066 > 0.05, while the temperature variable has a significant effect with a significance value of 0.008 < 0.05. Rainfall and temperature also have a negative effect on the area of rice fields, as seen from the regression coefficient, where the rainfall variable has a value of -0.925 and the temperature variable has a value of -2304.966. The variables of rainfall and temperature both have a significant effect on land area, as shown by the significance value of rainfall of 0.020 < 0.05 and the temperature variable of 0.006 < 0.05. Interviews with farmers also showed that rainfall and temperature affect rice productivity, such as the rainy season and long dry seasons which reduce rice/grain production, lower the quality of the harvest, increase pest and disease attacks, and even affect processing methods and the use of certain rice varieties.

Keywords: Climate, Rainfall, Temperature, Rice Productivity

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1. Introduction

Rice is the most dominant agricultural commodity in Indonesia (Ernilawati, Deasy Arisanty, 2017; Harfian et al., 2024; Salasiah et al., 2016). However, regions in Indonesia have different climatic and geographical conditions, which means that not all regions in Indonesia are suitable

for rice cultivation. This situation has resulted in some regions in eastern Indonesia, such as East Nusa Tenggara, which has dry natural conditions, and areas in Papua, such as Merauke, which have low levels of agricultural land suitability, making rice farming unsuitable for cultivation (Killa et al., 2019; Mangera et al., 2024; Megasari & Sodiq, 2023; Nugraha & Fitriana, 2024). Rice productivity in Indonesia can be influenced by several factors, such as seed quantity and quality, fertilizer availability, human resource quality, pest and disease attacks, climate, water availability, and supporting infrastructure (Hidayatullah & Belinda, 2019).

Climate is one of the factors that can affect rice productivity (Aminah, 2023; Anam et al., 2024; Rahman et al., 2017; Saud et al., 2022). Climate change has resulted in a decline in food crop productivity due to changes in rainfall patterns, increased temperatures, flooding, drought, increased pest attacks, and a decline in crop quality (Asyrofi & Suryanto, 2020; Chen et al., 2023; Hartono, 2023; Hua et al., 2024; Ruminta et al., 2018).

Changes in rainfall patterns and rising temperatures are direct impacts of climate change (Anggoro et al., 2023; Rahim et al., 2019). Extreme weather events such as changes in rainfall patterns and rising temperatures will reduce production and quality in rice agriculture. High rainfall will cause rice fields to be flooded, especially during the early growth period of rice plants, which will lead to a risk of reduced production and crop failure. In addition, rice has a certain level of resistance to temperature, but temperatures that are too high or too low can disrupt the growth process of rice plants, as stated in studies by Santoso (2022) and Auliya (2024), which say that rainfall and temperature can affect the productivity of rice plants. Extreme weather events have occurred in Poso Regency in 2024. According to the Central Sulawesi Provincial Government (https://sultengprov.go.id/), extreme weather events such as floods have occurred in Poso Regency, specifically in Meko Village, West Pamona District, where heavy rainfall in the area caused floods with a height of 50-80 cm, On the contrary, according to BMKG (https://gaw-bariri.bmkg.go.id/), they stated that several climate anomalies occur in Central Sulawesi such as the Madden-Julian Oscillation (MJO), Kelvin Waves, and the El Niño-Southern Oscillation (ENSO) which can cause droughts in areas of Central Sulawesi, including Poso Regency..

Central Sulawesi is a region with unique characteristics that make it rich in natural resources (Maliki et al., 2023). This is because Central Sulawesi has diverse climatic conditions, soil types, and topographical elevations, which enable it to produce a wide variety of natural resources. Pamona Puselemba Subdistrict is one of the rice-producing subdistricts in Poso Regency, Central Sulawesi. According to data from the Poso Regency Agricultural Office (2023), the ratio of planted area to rice production in Pamona Puselemba Subdistrict is 1817,4 Ha/7716,68 tons. The agricultural sector in Pamona Puselemba Subdistrict is one of the sectors that has not been spared from the impact of weather instability. When compared to 2023 versus 2022, rice harvest data in Poso Regency only reached 81,8%, while planting data only reached 69,05%. A significant decline in rice harvest and planting data occurred in Pamona Puselemba District, namely -915,8 hectares or only 66,5% for harvest and -1449,5 hectares or only 43,93% for planting (Dinas Pertanian Kabupaten Poso, 2023), This decline was caused by drought and damaged irrigation systems, which resulted in rice fields not getting enough water for rice planting (Dinas Pertanian Kabupaten Poso, 2023).

This decline in rice production continued until 2024, where according to data from the Poso District Agriculture Office (2024), when comparing data from 2024 with data from 2023, the data on the planted area in Pamona Puselemba Subdistrict shows an increase of 153,50 Ha or 113,51%, but the rice harvest data still shows a decrease of -515,5 Ha or only 71,6%, where this decline is caused by drought and damaged irrigation systems.

Changes in rainfall patterns and rising temperatures are climate phenomena that greatly affect agricultural activities, particularly in rice cultivation (Auliya et al., 2024; Santoso et al., 2022). Previous studies have shown that heavy rainfall can lead to waterlogging and even damage rice crops, while suboptimal temperatures can hinder rice plant growth (Jyothsna et al., 2024;

Nurhayanti & Nugroho, 2016). Several studies in Indonesia and Southeast Asia have also reported a decline in rice productivity due to climate change, including increased pest and plant disease attacks (Megasari & Sodiq, 2023; Mousumi et al., 2025).

Research in Central Sulawesi, particularly in Pamona Puselemba, shows a unique climate condition with diverse topography and microclimate conditions influenced by geographical factors such as Lake Poso (Maliki et al., 2023). Historical data indicates fluctuations in rainfall and average temperature over the past few years, impacting the extent of rice fields and rice production in this area (Dinas Pertanian Kabupaten Poso, 2023, 2024). Unlike several studies that emphasize the significant impact of rainfall on rice production, this study found that the influence of rainfall on rice production is not significant, while average temperature has a negative and significant effect on rice production in Pamona Puselemba. In addition, changes in rainfall and temperature patterns also affect farmers' choices of cultivation methods and rice varieties as a form of adaptation to climate change (Aziz et al., 2022; Priyanto et al., 2021).

Thus, this study not only provides empirical evidence regarding the influence of temperature and rainfall on rice productivity in regions with unique climatic and geographic characteristics, but also adds insights into farmers' adaptation to climate change through changes in cultivation techniques and the choice of crop varieties. This underscores the need for a localized approach in designing climate change adaptation strategies in the agricultural sector. The purpose of this study is to analyze the impact of rainfall and temperature on rice productivity in Pamona Puselemba Subdistrict, Poso Regency.

2. Method

This research is located in Pamona Puselemba District, Poso Regency, Central Sulawesi Province. Pamona Puselemba District is divided into 8 villages and 3 sub-districts, including Wera, Leboni, Tonusu, Mayakeli, Soe, Buyumpondoli, Peura, Dulumai, Pamona Sub-district, Tentena Sub-district, and Sangele Sub-district. This research was conducted from June to August 2025.

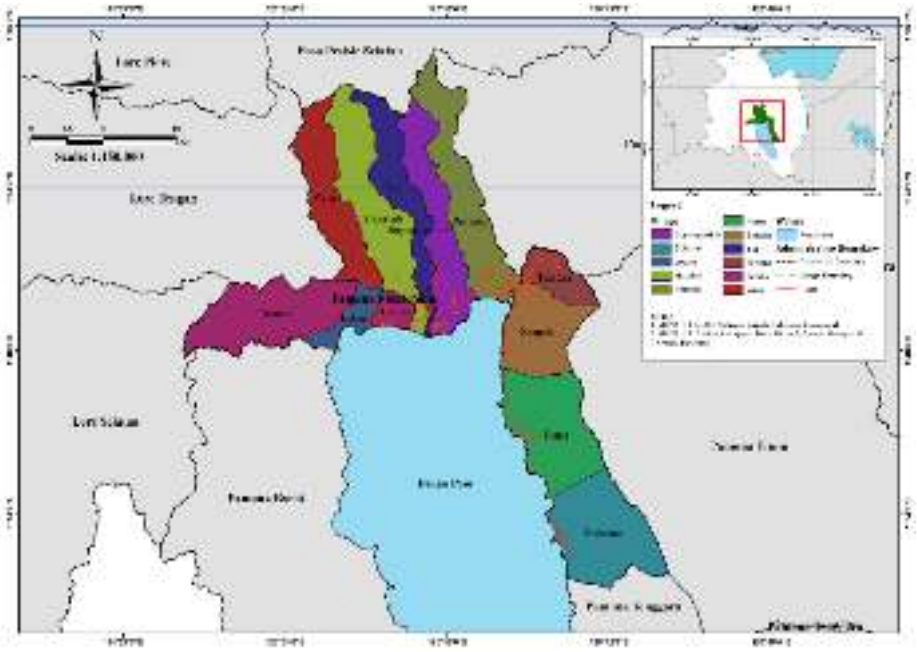

Figure 1. Research Location

The primary data required for this study consists of observations and interviews conducted in the field with farmers spread across Pamona Puselemba Subdistrict. This data covers the impact of rainfall and temperature on the rice farming sector in Pamona Puselemba Subdistrict.

The secondary data needed in this study includes rainfall, temperature, and rice production data for the period 2020 to 2024. The rainfall and temperature data over the five years were obtained from the Meteorology, Climatology, and Geophysics Agency at the Class III Kasiguncu Meteorological Station (Stamet) and the food security and horticulture division of the Poso District Agriculture Office. The data consists of statistical/numerical data processed to obtain information on rainfall, average temperature, rice production, and annual land area, which is then presented in table form.

Table 1. Required Data

Data Name	Source	Year Period	Description
Rainfall	Meteorology, Climatology and Geophysics Agency (the Class III Kasiguncu Meteorological Station (Stamet)	2020-2024	Table Data
Average Temperature	Meteorology, Climatology and Geophysics Agency the Class III Kasiguncu Meteorological Station (Stamet)	2020-2024	Table Data
Rice Production	Poso District Agriculture Office https://bdsp2.pertanian.go.id/	2020-2024	Table Data Report
Rice Field Area	Poso District Agriculture Office https://bdsp2.pertanian.go.id/	2020-2024	Table Data Report

Independent variables are variables that affect dependent variables, therefore the independent variables in this study are the total annual rainfall and the average annual temperature during the period from 2020 to 2024. Meanwhile, the dependent variables in this study are rice production and the area of rice fields in the Pamona Puselemba sub-district during the period 2020-2024.

This study uses a descriptive quantitative method, where the data analysis technique used is multiple linear regression analysis, with the aim of determining the influence or impact of rainfall and average temperature on rice production and the area of rice fields. In this study, the variables studied were rice production and rice field area as dependent variables, with rainfall and average temperature as independent variables. This can be described in a mathematical model as follows.

$$Y = a + b_1X_1 + b_2X_2 + \cdots b_nX_n + e \quad (1)$$

Description:

a = Constant
Y = Dependent Variable
X1,X2,Xn = Independet Variable
b1,b2,bn = Regression Coefficients
e = Error Term

3. Result and Discussion

A. Rainfall

Rainfall is the amount of rainwater that falls to the Earth's surface, measured over a certain period and expressed in millimeters (mm), where 1 millimeter equals 1 liter per square meter. In agriculture, one of the most influential climate elements is rainfall. Rainfall affects water availability, humidity, and temperature conditions on farmland. In the Pamona Puselemba subdistrict, rainfall is influenced by the existence of Lake Poso, which affects the evaporation process in the hydrological cycle.

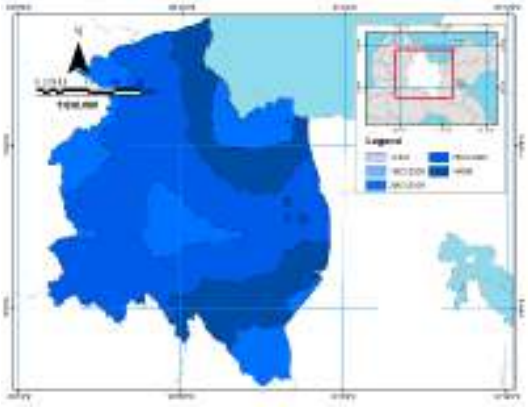

Figure 2. Rainfall in 2020

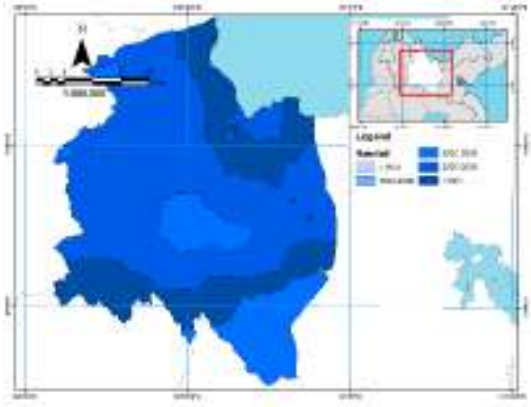

Figure 3. Rainfall in 2021

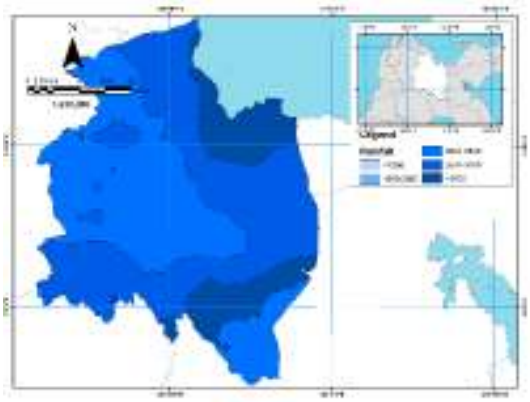

Figure 4. Rainfall in 2022

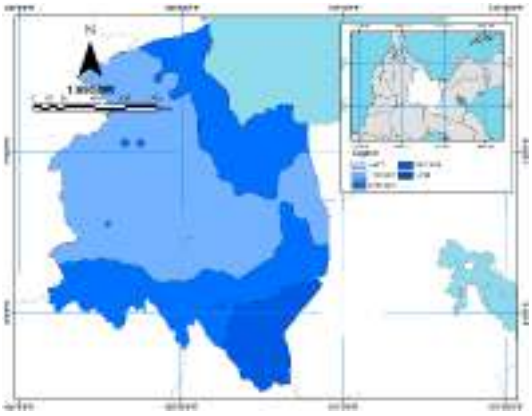

Figure 5. Rainfall in 2023

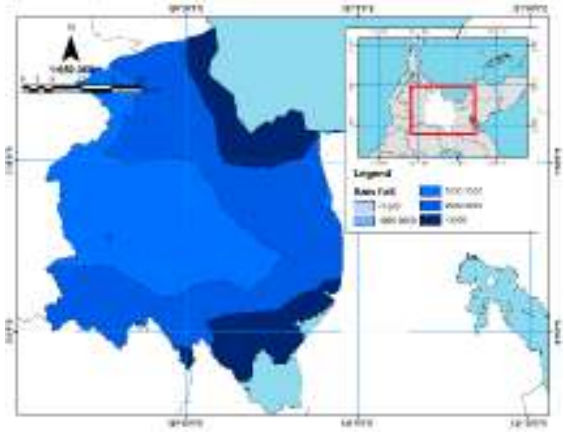

Figure 6. Rainfall in 2024

Table 2. Rainfall Data

Year	Rainfall (mm)
2020	2.807,8
2021	2.443,3
2022	2.696,3
2023	2.157,2
2024	2.984,5

From the table, it can be concluded that from 2020 to 2024, the amount of rainfall experienced varying decreases and increases, starting from 2807.8 in 2020, alternately decreasing and increasing until 2024. In 2023, rainfall experienced its lowest decrease of only 2,157.2 mm/year. This condition was caused by the El Nino phenomenon that hit most of Indonesia in 2023 and 2024. This is in line with the results of interviews conducted with farmers, who reported experiencing prolonged drought in the Pamona Puselemba District in 2023. However, in 2024, rainfall increased again to 2,984.5 mm/year.

B. Temperature

Temperature is an important aspect of agriculture. From the data collected, it can be seen that the average annual temperature in Pamona Puselemba District is around 27°C, which means that Pamona Puselemba District is neither too hot nor too cold. The temperature in Pamona Puselemba District can be influenced by altitude and the presence of Lake Poso, which can affect the microclimate in Pamona Puselemba District.

C. Rice Productivity

Pamona Puselemba Subdistrict is one of the largest rice-producing subdistricts in Poso Regency. Therefore, a decline in annual rice production can cause serious problems for the economy of the people in Poso Regency, especially in Pamona Puselemba Subdistrict, where rice crops can generally be harvested twice a year, resulting in a significant amount of rice production.

Table 3. Rice Production

Year	Production (Tons)
2020	9.197
2021	11.360.9
2022	12.981.7
2023	7.716.6
2024	6.327.2

From the data obtained from the Poso District Agriculture Office as shown in Table 3, above, it can be concluded that the highest rice harvest during the 2020-2024 period was in 2022, with a rice it can be concluded that the highest rice harvest during the 2020-2024 period was in 2022, with a rice production of 12,981.7 tons, while the lowest rice production was in 2024, with a rice harvest of only 6,327.2 tons. The decline in production began in 2023 and continued to decline. This was caused by the El Nino phenomenon, which resulted in a decrease in the area of rice fields that could be cultivated and a shift in the planting schedule.

Land area is one of the factors influenced by climate, where high rainfall will cause rice fields to be flooded by rainwater. Conversely, low rainfall and high temperatures will cause drought, which makes rice fields unable to provide sufficient water supply, making the land unsuitable for rice cultivation. According to data from the Poso District Agriculture Office, during the 2020-2024 period, the area of rice fields experienced alternating increases and decreases, resulting in several factors influencing the increase and decrease in land area.

Table 4. Land Area

Year	Land Area (Ha)
2020	1967.7
2021	2633.5
2022	2733.0
2023	1817.4
2024	1301.9

According to data from Table 4, we can conclude that from 2020, the area of rice fields continued to increase until 2022 by 2,733 hectares, until in 2023 and 2024, the area of rice fields continued

to decline by 1,301.9 hectares. This was caused by the El Nino phenomenon that occurred throughout 2023 and 2024, resulting in prolonged drought that left most rice fields without water, making it impossible to cultivate the land.

D. Multiple Linear Regression Analysis Result

Multiple linear regression analysis is a statistical analysis used to describe the linear relationship or influence between two or more independent variables and one dependent variable. Multiple linear regression analysis was chosen in this study in order to determine the effect of rainfall and temperature on rice production and rice field area in the Pamona Puselemba sub-district.

1) Rice Production

The effect of independent variables on rice production can be seen from the R Square value (Table 5), where we can see that the R Square (R2) value is 0.984, which means that 98.4% of rice production is influenced by the two independent variables (rainfall and average temperature), while 100%–98.4% = 1.6% is influenced by other factors. An R value of 0.992 or 99.2% indicates that the relationship between the independent variables (rainfall and average temperature) and rice production is very strong.

Table 5. Results of Multiple Linear Regression Analysis of Rice Production Variables

Variable	Coefficient (B)	T Calculated	Sig.
Constant	313946.757	11,320	0,008
Rainfall	-2,825	-3,688	0,066
Average Temperature	-10784,004	-10,903	0,008
R	0.992[a]		
R Square	0.984		
F Calculated = 60,473	Sig. F = 0,016[b]		
n = 5	α = 0,05		

Based on the regression coefficient, it can be seen that the rainfall variable has a value of -2.825. Here, the coefficient value is negative, which means that rainfall has a negative effect on rice production, where every increase in rainfall will decrease rice production. Meanwhile, the average temperature variable has a value of -10.784,004, which means that average temperature has a negative effect on rainfall, where every increase in average temperature will decrease rice production.

Based on statistical calculations, it can be seen that the value of the t-table in the current t-test is 4.303 with a confidence level of 5% or 0.05, so it can be concluded that:

a) The rainfall variable (X1) has a t-value of 3.688, which is smaller than the t-table value of 4.303 (t-value 3.688 < t-table 4.303), while the significance value (p-value) is 0.066, which is greater than 0.05 (Sig. 0.066 > 0.05), indicating that the rainfall variable (X1) does not have a significant partial effect on the rice production variable (Y).
b) The average temperature variable (X2) has a t-value of 10.903, which is greater than the t-table value of 4.303 (calculated t-value 10.903 > table t-value 4.303), while the significance value (p-value) is 0.008, which is less than 0.05 (Sig. value 0.008 < 0.05). Therefore, it can be concluded that the average temperature variable (X2) has a significant effect on rice production (Y).

The calculated f value from testing the rice production variable (Y) is 60.473, which is greater than the table f value of 19,000 (calculated f 60.473 > table f 19,000). while the significance value (p-value) of this study is 0.016, which is smaller than 0.05 (Sig. value 0.016 < 0.05). Therefore, it can be concluded that both independent variables (rainfall and average temperature) simultaneously affect the dependent variable (rice production).

2) Land Area

Based on table 6, we can see that R has a value of 0.995 or 99.5%, which indicates that the relationship between the independent variables and the dependent variable is very strong. the coefficient of determination or R Square has a value of 0.990 or 99%, which indicates that 99% of the independent variables (rainfall and average temperature) affect the area of rice fields, while 1% is affected by other factors. Looking at the regression coefficient values, we can see that rainfall has a value of -0.925, while average temperature has a value of -2304.966. Both of these values are negative, which means that rainfall and average temperature have a negative effect on land area, where higher rainfall and average temperature will cause rice production to decline.

Table 6. Results of Multiple Linear Regression Analysis of Land Area Variables

Variable	Coefficient (B)	T Calculated	Sig.
Constant	67999.866	14.088	0.005
Rainfall	-0.925	-6.938	0.020
Average Temperature	-2304.966	-13.390	0.006
R	0.995[a]		
R Square	0.990		
F Calculated = 98.579	Sig. F = 0.010[b]		
n = 5	$\alpha = 0.05$		

Based on the analysis results with a t-table value of 4.303 and a 95% confidence level or 0.05, it can be concluded that:

a) The rainfall variable (X1) has a t-value of 6.938, which is greater than the t-table value of 4.303 (t-value 6.938 > t-table 4.303), while the significance value of 0.020 is less than 0.05 (Sig. value 0.020 < 0.05), so it can be concluded that the rainfall variable (X1) has a significant effect on the land area variable (Y).
b) The average temperature variable (X2) has a t-value of 13.390, which is greater than the t-table value of 4.303 (t-value 13.390 > t-table 4.303). while its significance value is 0.006, which is smaller than 0.05 (Sig. value 0.006 < 0.05). Therefore, it can be concluded that the average temperature variable has a significant effect on the land area variable (Y).

The results of this multiple linear regression analysis are consistent with the responses of farmers and agricultural extension workers from the interviews conducted, in which the farmers stated that changes in rainfall patterns would affect rice productivity and influence both the quantity and quality of rice harvests. This is similar to the study by Mustikaningrum (2025) and Safitri (2015), where statistical data showed results consistent with the farmers' interview responses, as stated in the interview with Mr. Yunius, who mentioned that rainfall and temperature affect the quantity and quality of rice grains, often causing the grains to easily break, thereby reducing their quality.

Meanwhile, in an interview with agricultural extension worker Mr. Esram Lantionga S.P., he said that unstable weather and climate will reduce the amount of rice grain, and continuous rainfall will also cause the planted rice to be submerged, making the harvested rice yellow and less tasty. This is in line with research by Santoso (2022), Chaniago (2023), and Saputro (2025), who stated that high rainfall can reduce rice production.

In addition to rainfall, increased temperatures also have a significant impact on rice plant growth. The optimal temperature for rice plants generally ranges from 20°C to 35°C, where temperatures that are too high or too low can interfere with rice plant growth. As stated in an interview with Mr. Vitra Rantedago S.Pt, he said that temperature also affects rice plants because rice has a specific temperature at which it can grow; if the temperature is not suitable, it can disrupt the productivity of the rice plants. This is in line with research conducted by Nurhayati (2016), Jyothsna (2024) and Makruf (2025), whose findings indicate that minimum and maximum temperatures can affect rice plant growth.

Meanwhile, in interviews with farmers, some farmers believe that temperature has an effect, while others believe that temperature does not have a significant impact on rice plant productivity.

Changes in rainfall patterns and unstable temperatures can also increase pest attacks in rice fields. The distribution and dynamics of pests and diseases can be influenced by climate change (Megasari & Sodiq, 2023; Mousumi et al., 2025; Niaz Morshed et al., 2020; Octaviana & Ekawati, 2022; Sulaminingsi et al., 2024). These results are consistent with an interview conducted with Mr. Alvin, who said that the pests that often attack are usually planthoppers, leafhoppers, and stem borers during the change of seasons.

Meanwhile, in an interview with Mr. Esram Lantionga S.P., an agricultural extension worker, he said that pests usually increase during the rainy season, such as snails and rats, because the land is filled with water, while planthoppers and stem borers usually increase during seasonal changes.

In addition to the increase in pests, changes in rainfall and temperature also trigger farmers to determine the rice field cultivation techniques they apply. Adaptations made by farmers include adding water pumps and irrigation in rice fields (Asyrofi & Suryanto, 2020; Ismail et al., 2025; Ruminta, 2016; Widiarta, 2021). As in an interview with Mr. Marto, where he said that: farmers usually adapt by changing their planting patterns, considering the table planting system (direct seeding) or tapin (transplanting) if the rainy season is more suitable for tapin.

The statement from the father is in line with the response from Mrs. Ni Nyoman Jusminah S.P., an agricultural extension worker in Pamona Puselemba Subdistrict, who said that: in Pamona Puselemba Subdistrict, farmers often use two planting systems, namely tapin and tabela. When rainfall is high, farmers prefer the tapin planting system, while when rainfall is low, rice field cultivation is assisted by certain tools such as water pumps.

In addition to changes in rice field cultivation methods, changes in rainfall and temperature can also affect the types of rice varieties used by farmers, as shown in studies by Priyanto (2021), Algarni (2025) and Aziz (2022), whose research results indicate that the form of adaptation carried out by farmers in facing climate change is to use varieties that are drought-adaptive and resistant to extreme weather. As stated by Mr. Yatu in an interview, he said that the varieties used are short-maturing or fast-harvesting varieties such as Putri Ayu, Cakra Buana, and Super Kuda.

Meanwhile, in an interview with agricultural extension worker Ni Nyoman Jusminah S.P., she said that the varieties used by farmers in facing extreme and unpredictable weather are those with a maturity period of only 85-90 days, such as Cakra Buana, Putri Ayu, Inpari, and others.

The results of interviews with farmers and agricultural extension workers further reinforce that there is a significant impact of rainfall and temperature on rice productivity in the Pamona Puselemba sub-district. In addition to causing droughts or floods that will impact rice fields, unstable rainfall and temperature will also affect the quality of rice produced by farmers, reducing the amount of grain produced and increasing pests and diseases. Furthermore, adaptations such as changes in rice field management techniques and the use of specific rice varieties are efforts made by farmers to cope with changes in rainfall and temperature patterns in order to minimize losses as much as possible.

4. Conclusion

Based on the results of the research that has been conducted, the conclusion of this study is the results of the multiple linear regression analysis conducted on rice production, land area, rainfall, and temperature over a 5-year period from 2020 to 2024, it can be seen that the variables of rainfall and temperature have a negative effect on rice production and land area, which means that every increase in the number of units of rainfall and temperature variables will decrease the number of units of rice production and rice field area. However, the rainfall variable has no significant effect, while the temperature variable has a significant effect. Based on interviews

with farmers and agricultural extension workers, it is known that changes in rainfall and temperature patterns can affect rice productivity by reducing rice/grain production, lowering the quality of the harvest, and even increasing the risk of crop failure due to prolonged drought or flooding caused by high rainfall. This forces farmers to adapt by changing their rice field management practices, increasing operational costs, and using better varieties under the prevailing conditions. Thus, based on the results of the research that has been conducted, farmers must be better prepared to face rainfall and temperature conditions by having a better understanding of the current weather conditions through various media and activities of farmer groups related to efforts to adapt to extreme weather. Agricultural extension workers also play an active role in providing information and solutions for adapting to extreme weather. The weakness of this study is that it only covers a time span of the last 5 years. In future research, it is recommended to use data covering more than 5 years so that the results obtained are more accurate and better reflect the impact of rainfall and temperature over the past several years.

7. Acknowledgment

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