Climate change impact on rice productivity in the rainfed Merauke District, Papua

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Abstract. Rainfed rice are highly dependent on rainfall resulting limitation on planting period. Meanwhile, the rainfall itself is greatly influenced by climate change. Furthermore, plant growth and quality depend on the interaction between environmental factors and plant genetic factors. This study aims to determine the impact of climate change (rainfall) on rainfed rice productivity in Merauke Regency. The research was conducted in the rainfed area of Merauke Regency as focused production center of rice. The data used in this study were data on rainfall, temperature, solar radiation, humidity, planting area, harvest area and yield. The research method used in this research is descriptive method (descriptive analysis) quantitative and qualitative analyzed by regression correlation. The climate change in 2015 gave a negative effect on rainfed lowland rice production in Merauke Regency due to decreasing of the harvest area that affected on decreasing in rice production.

1. Introduction

Papua province has 54,131.72 ha paddy field [1] and around 80% of area are located in Merauke Regency. This region is always facing problem related to drought and consequently decreasing rice production. The rice production in Merauke presumed reduced until 70% from total production in 2015 due to extreme drought.

Climate is one of the environmental components for the success of a plant cultivation. It plays a very important role in short- and long-term agricultural planning, especially in conditions of climate change or extreme climate events.

Climate change events as projected by 21st century climate models would significantly change production conditions. [2] mentions that the global average rainfall has increased by 2% in the last 100 years. The occurrence of extreme climates has a significant impact on seasonal crops, especially food crops, in this case is rice. One of the climate elements that can be used as an indicator in relation to plants is rainfall.

Rainfall is a climate element with high fluctuation and has a significant effect on crop production. The amount of rainfall is very important in determining the results [3], especially when coupled with an increase in temperature that can reduce yield. An increase in rainfall in an area has the potential to cause flooding, on the other hand, if there is a decrease from normal conditions, there will be a potential drought. Both of these negative impacts influence the metabolism of the plant growth and potentially reduce the production or even harvest failure. According to [4], rainfall has a high correlation with the yield component.

The diversity and climate change are a natural process that occurs dynamically and continuously. This has a negative impact on the environment resulting in the impact of shifting rainfall patterns, the
amount of rainfall, and changes in air temperature. This impact is marked by the delay in the beginning of the rainy season and the lengthening of the dry season which causes drought [5]. Drought is one of the most frequent extreme climate hazards in Indonesia with different frequency and level of risk.

The threat of decreasing food production in various countries by climate change is becoming increasingly real. Climate changes triggers flooding, drought and drought, rising temperatures, decreasing land quality and others [6]. Climate change caused the distribution of rain uneven and even extreme daily rainfall that can reach 234 mm day\(^{-1}\) [7]. Climate change due to global warming brought a broad impact on various aspects of life. Agriculture is the sector that has suffered the most serious impacts. Food crops are the subsector mostly vulnerable to climate change. Harvest failure in one production center can cause shocks in other areas, especially in areas that are not agricultural centers. Changes in rainfall patterns, an increase in extreme climatic events, as well as an increase in air temperature and sea water surface have effect on agricultural production, especially the food crop sub-sector to decline significantly [8].

In time scale, climate change will form a certain pattern or cycle, either daily, seasonal, yearly or cycles of several years. In addition to cyclical patterned changes, human activities caused climate patterns to change in a sustainable manner, both on a global and local scale. Climate change (anomaly) [6] stated that weather changes and global warming can reduce agricultural production by 5-20 percent. This situation will directly or indirectly have an impact on agricultural activities in the Merauke Regency area. Merauke Regency has an area of 46,791.63 KM or 14.67 percent of the total area of Papua province. It is the center of rice development with a rice field area of 58,874.25 ha. most of them work in the agricultural sector (in general). The contribution of the agricultural sector to Gross Regional Domestic Product (PDRB) is high compared to other sectors [9]. Based on the description above, the aim of this study is to determine the impact of climate change on rice productivity in rainfed land in Merauke Regency.

2. Materials and methods

2.1. Study area

The research was conducted in five areas of rice production centers in Merauke Regency, Papua Province, namely Merauke, Semangga, Tanah Miring, Kurik, and Jagebob Districts, from April to July 2020. Climate data used consist of rainfall, temperature and day length, humidity.

2.2. Data

The research method used in this research was descriptive method. Rainfall data and rice production from 2015 to 2019 were used in this research. Rainfall data were acquired from Meteorological, Climatological, and Geophysical Agency Jayapura Office. Data for rice production, planting area, and harvested were collected from annual final report of local assessment in Merauke regency.

2.3. Method

Regression and correlation analysis were used to measure the relationship between two or more variables. In this study, the variables analyzed for correlation and regression were rainfall, temperature, humidity and duration of exposure (independent factors) to production (dependent factors). Linear regression used simple linear regression with the function: \( Y = a + bX + e \). In the \( r \) test on testing the hypothesis: \( H_0: r = 0 \) (which means that there was no relationship or correlation between variable \( X \) and variable \( Y \)). \( H_1: r \neq 0 \) (which means that there was a relationship or correlation between variable \( X \) and variable \( Y \)). Regression and correlation analysis were used to measure the relationship between two or more variables. In this study, the variables analyzed for correlation and regression were rainfall, temperature, humidity and duration of exposure (independent factors) to production (dependent factors). Linear regression used simple linear regression with the function: \( Y = a + bX + e \). In the \( r \) test on testing the hypothesis: \( H_0: r = 0 \) (which means that there was no relationship or correlation between variable \( X \) and variable \( Y \)).
and variable Y). H1: $r \neq 0$ (which means that there was a relationship or correlation between variable X and variable Y).

3. Results and discussion

3.1. Climate characteristics of research areas

Merauke Regency has a very firm climate between the rainy season and the dry season. According to [10], the Merauke Regency area is in the Agroclimatic Zone C zone having wet period between 5-6 months. The Merauke Plain has rather special climatic characteristics where the rainfall is influenced by the Monsoon Wind, both West - Northwest Monsoon (Wet Monsoon) and East - East Southeast Monsoon (Dry Monsoon). It is also influenced by topographic conditions and regional elevation.

The average annual rainfall in Merauke Regency is 1,558.7 mm. The existing data shows that there are differences in the amount of rainfall per year between the South and northern parts of Merauke. In general, there is an increase in annual rainfall from the South Merauke area (1000 - 1500) in the Muting section, then the rainfall with an amount of 1,500-2,000 mm year$^{-1}$ is found in Okaba District and parts of Muting, the rest is getting to the North, the higher the rainfall. The number of wet months is also different, namely the wet period in the northern part is very long, while in the south part is relatively short. This climatic condition give opportunity to the farmer to plant twice.

On the other hand, the long dry season has resulted in a shortage of clean water and irrigation water to the community. Based on climate data released by the Merauke Meteorology and Geophysics Office, it shows that wind speeds are almost stable throughout the year. In the coastal area it blows fastly about 4.5 m s$^{-1}$ and at a depth of about 2 m s$^{-1}$. Average solar radiation in Merauke is 5.5 h d$^{-1}$ in July and the highest is 8.43 hours day$^{-1}$ in September, with a yearly average of 6.62 hours. The humidity level is quite high because it is influenced by the Wet Tropical climate. The average humidity ranges from 78-81%.

There is no correlation between duration of exposure and rice production. The coefficient correlation (R) is not significant, but the correlation coefficient value of the variable relationship is in the sufficient category, which means that solar radiation has a role in decreasing the production of rainfed lowland rice in Merauke Regency. The value of the coefficient of determination ($R^2$) is 0.5559. This shows the ability of solar irradiation (%) to influence the average rice production variable by 55.59%, the remaining 44.41% is fulfilled by other factors.

![Figure 1. The relationship of long exposure to rice production for 5 years (2015-2019).](image)

Sunlight is a source of energy for photosynthesis. The absorption of sunlight by plant canopy is an important factor that determines photosynthesis to produce assimilates for growing flowers, fruits and
seeds [11]. According to [11] light intensity and duration of exposure in photosynthesis have an effect on vegetative and generative growth of plants. In the tropics, the duration of day and night is relatively the same, namely 12 hours, while in areas that have four seasons, the length of the day can reach 16-20 hours. Sufficient solar radiation will help plants in photosynthesis. [12] states that temperature and radiation have a significant impact on the maturation phase of rice plants in tropical or subtropical climates. Longer exposure will provide a greater opportunity for plants to utilize it through the photosynthesis process [13].

3.2. Correlation analysis of rainfall elements with rice production
There was a positive correlation with a determinant coefficient of 0.31 based on the results of the correlation analysis between the independent variable (rainfall) and the dependent variable (rice production). The relationship of climate to rainfed rice production can be seen in figure 2. Generally, the trend of increasing production of rainfed lowland rice with increased rainfall is clearly illustrated. Judging from the correlation value, the variable relationship is in the low category. This shows the ability of rainfall in influencing the average variable of rainfed lowland rice production by 31%, 69% is influenced by other factors.

\[
y = 170.51x - 58887 \\
R^2 = 0.3092
\]

![Figure 2. Relationship between rainfall and rice production for 5 years (2015-2019).](image)

This is in accordance with the results of several other studies which indicate that there has been a change in rainfall patterns in Indonesia [14]. The rainfall distribution pattern for the period 2015 to 2019 shows that rainfall is still low. Additionally, the rainfall pattern greatly affects the availability of ground water, the length of the planting period, the beginning of planting, the planting pattern as well as the selection of food crop commodities in rainfed or dry land. Low rainfall during rice planting will also have a negative impact on crops, due to the lack of water availability and will affect rice production. Plants that experience a lack of water generally have a smaller size than plants that grow normally. Lack of water causes a very significant decrease in yield and even causes death [15].

3.3. Correlation analysis of temperature elements with rice production
It does not show any correlation based on the results of the correlation analysis between the independent variable (rainfall) and the dependent variable (rice production). The graph of the relationship between temperature and rice production can be seen in figure 3.

The trend of the influence of temperature on the production of rainfed rice at the rice development center in Merauke Regency is increasing with a determinant coefficient value of 0.22. The increasing
Temperature is potentially increasing the production of rainfed lowland rice. Judging from the correlation value of the variable relationship, it is categorized as low. This means that temperature does not play a significant role in the increasing the rainfed lowland rice production in the development area in Merauke Regency. The ability of temperature to influence the average variety of rainfed lowland rice production is 22.00%, the result is 78% influenced by other factors.

3.4. Analysis of the correlation of moisture elements with rice production

There is no correlation between the independent variable (humidity) and the dependent variable (rice production) based on the correlation analysis. The graph of the relationship between moisture and rice production can be seen in figure 4.

The relationship between humidity and rainfed lowland rice production is opposite to the climate components of rainfall and temperature. The tendency of increasing humidity will reduce the production of rainfed lowland rice. The determinant coefficient (R) was 0.24. Judging from the correlation value, the variable relationship is in the low category. Thus, it means that humidity has less role in increasing the production of rainfed lowland rice. The ability of humidity to influence the average variable of rainfed lowland rice production is 24% and the remaining 76% decrease in production is influenced by other factors.
3.5. Harvested area and planted area for five years (2015-2019)

Based on the planting and harvested area as shown in the graph below, climate change caused a reduction in rice harvested area in 2015 when compared with the planted area in the same period. Drought on 2015 could possibly influence the decreasing yield. The drought at the time of planting season in July 2015 resulted in many rice plantations in Merauke Regency experiencing crop failure. This is in line with what Latiri et al [4] stated that plant production is highly correlated with rainfall during the growing season. From the information on harvested area and planted area, it can be seen that the rice production center in Papua is Merauke Regency.

![Graph showing planted area and harvested area for rice for 5 years (2015-2019)](image)

**Figure 5.** Planted area and harvested area for rice for 5 years (2015-2019).

4. Conclusions

Climate change in 2015 had a significant effect on the cultivation of rainfed rice, which was showed by decreasing in harvested area compared to the following year. The results of the correlation regression analysis show that there was a negative influence of climate on rainfed rice production in Merauke district.

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