

Climate Variability and Its Effects on Rice (*Oryza sativa* L.) Productivity, Pest Incidence, and Disease Occurrence in Pematang Setrak Village, Teluk Mengkudu District, Serdang Bedagai Regency, Indonesia

Nurhayati^{1*}, Aranda Muttaqi Hasibuan¹, Murni Sari Rahayu¹

¹ Agricultural Technology, Faculty of Agriculture, University of North Sumatra, Medan, Indonesia

Received: July 21, 2025

Revised: August 27, 2025

Accepted: September 25, 2025

Published: September 30, 2025

Corresponding Author:

Nurhayati

nurhayati@uisu.ac.id

DOI: [10.29303/jppipa.v11i9.11771](https://doi.org/10.29303/jppipa.v11i9.11771)

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Abstract: This study employed a survey method with field data collection to analyze the relationship between rainfall and rainy days on irrigated rice productivity. The analysis was conducted using correlation tests to determine the strength of the relationship between variables, as well as multiple linear regression to examine the influence of climatic variables on productivity. The results indicate that rainfall and rainy days do not have a significant relationship with productivity. This is because the irrigated rice cultivation system is supported by adequate irrigation, so it does not entirely depend on rainfall conditions. Based on interview results, the average farmer owns approximately 1 hectare of land with productivity reaching 7–8 tons/ha using the varieties Inpari 32, Ciherang, and Mekongga. Regression analysis results indicate that rainfall and rainy days together account for 60.57% of the variation in productivity, while 40.43% is influenced by other factors such as fertilization, variety, and crop maintenance. Additionally, an analysis of pests and diseases revealed that some pests showed no significant correlation with climatic variables, while diseases such as blast and leaf spot exhibited a significant relationship with rainfall and rainy days.

Keywords: Climate factors; Rice productivity, Rainfall

Introduction

Rice (*Oryza sativa* L.) constitutes the fundamental staple food for more than fifty percent of the global populace and plays a pivotal role in national food security frameworks, particularly within developing nations (Bandumula, 2017; Rijal & Devkota, 2020). In Indonesia, the cultivation of rice is deemed a strategic imperative within governmental initiatives aimed at achieving sustainable food self-sufficiency and ensuring the stability of domestic food supplies. In addition to traditional white rice, pigmented rice varieties, such as red rice, have garnered heightened interest due to their enhanced nutritional profile, which encompasses elevated levels of antioxidants, dietary fiber, vitamins, and essential minerals (Rebeira et al., 2022). Notwithstanding these benefits, the cultivation and

application of red rice remain comparatively constrained in relation to the extensively cultivated white rice varieties (Ottis et al., 2005). Consequently, the expansion of the production and utilization of nutritionally enriched rice types signifies a significant opportunity to enhance both food security and public health outcomes while concurrently promoting agricultural diversification (Mohidem et al., 2022).

Global climate change has manifested as one of the most critical challenges to agricultural sustainability, particularly within rice-centric agricultural systems (Das & Ansari, 2021). Variations in precipitation patterns, escalating atmospheric temperatures, and the heightened occurrence of extreme weather phenomena, including floods and droughts, have exacerbated uncertainty in sowing timelines and agronomic management strategies (Ebi et al., 2021). These

How to Cite:

Nurhayati, N., Hasibuan, A. M., & Rahayu, M. S. (2025). Climate Variability and Its Effects on Rice (*Oryza sativa* L.) Productivity, Pest Incidence, and Disease Occurrence in Pematang Setrak Village, Teluk Mengkudu District, Serdang Bedagai Regency, Indonesia. *Jurnal Penelitian Pendidikan IPA*, 11(9), 1160–1170. <https://doi.org/10.29303/jppipa.v11i9.11771>

disturbances have a direct impact on water availability, particularly in regions reliant on precipitation or possessing inadequate irrigation facilities, leading to diminished crop development, reduced yields, and an amplified risk of crop failure (Montocchio & Chow-Fraser, 2021; Schmidt et al., 2021; Tiano et al., 2021). Considering the substantial water demands associated with rice cultivation, the susceptibility of paddy production systems to climatic fluctuations is particularly accentuated.

The ramifications of climate change transcend mere biophysical impacts and increasingly affect the socioeconomic dynamics of agricultural communities (Egerer et al., 2021; Nikas et al., 2021; Sawe & Chawla, 2021). Agricultural producers, whose economic well-being is intricately tied to environmental stability, are compelled to perpetually modify their production methodologies to adapt to fluctuating climatic circumstances (Chatzopoulos et al., 2020). This capacity for adaptation is intricately linked to the notion of resilience, which is defined as the capability of individuals and communities to anticipate, withstand, and recuperate from environmental perturbations while preserving the continuity and efficacy of agricultural systems. Within the domain of rice cultivation, resilience incorporates not solely technical adaptation strategies but also encompasses institutional support, indigenous knowledge, and access to resources that empower farmers to uphold their livelihoods amid unpredictable climatic scenarios (Adekomaya & Majozi, 2022).

Among climatic variables, rainfall and temperature are widely recognized as key determinants of rice growth and yield (Chu et al., 2021; Moulick et al., 2021). Rainfall governs water availability, while temperature regulates critical physiological processes such as germination, photosynthesis, flowering, and grain filling. Nevertheless, in irrigated paddy systems, the direct influence of rainfall may be moderated by the availability of managed water supplies. At the same time, productivity is shaped by a complex interaction of climatic and non-climatic factors, including varietal characteristics, soil fertility, fertilization practices, pest and disease management, and cultivation techniques (Rusch et al., 2021; Taylor & Bhasme, 2021). Understanding the relative contribution of these factors is essential for developing more effective and climate-resilient rice production strategies.

In North Sumatra, the impacts of climate change have become increasingly evident through recurrent flooding and prolonged drought events that threaten the stability of rice production systems. These disturbances not only reduce crop yields but also increase the incidence and severity of pest and disease outbreaks, further constraining agricultural productivity. Despite growing concern regarding climate variability, empirical

studies examining the relationships between rainfall characteristics, rainy days, crop productivity, and pest and disease dynamics remain limited in this region. Therefore, this study aims to analyze the influence of key climatic factors, particularly rainfall and the number of rainy days, on rice productivity and the occurrence of pests and diseases in North Sumatra. The findings are expected to provide valuable insights for designing adaptive management strategies and strengthening the resilience of rice farming systems to support sustainable increases in production under changing climatic conditions.

Method

Study Area and Research Design

This study employed a quantitative survey design to investigate the relationship between climatic variables and rice productivity in Serdang Bedagai Regency. The research was conducted in major rice-producing areas within the regency, which is one of the important agricultural centers in North Sumatra. The survey approach was used to obtain both secondary climatic and productivity data and primary information from farmers regarding agronomic practices and local production conditions.

Sampling Procedure

The study locations and respondents were selected using simple random sampling. Sampling was conducted to ensure that each rice-growing area and farmer had an equal probability of being included in the study, thereby minimizing selection bias and improving the representativeness of the data. Respondents consisted of rice farmers actively engaged in paddy cultivation during the study period.

Data Collection

Two categories of data were collected:

1. Secondary Data
 - Monthly rainfall (mm)
 - Number of rainy days (days month⁻¹)
 - Rice productivity (tons ha⁻¹)
 - Rice production (tons)
2. Primary Data
 - Climatic and agricultural production data were obtained from relevant government institutions, including the Meteorology, Climatology, and Geophysics Agency (BMKG), the Central Statistics Agency (BPS), and the local Department of Agriculture.
 - Cultivated land area
 - Plant spacing
 - Fertilizer application rates
 - Planting seasons

- Irrigation systems
- Farmers' production practices

Primary data were collected through structured interviews using questionnaires administered directly to selected respondents.

Data Analysis

Data were analyzed using descriptive statistics, Pearson correlation analysis, and simple linear regression.

Descriptive Analysis

Descriptive analysis was used to summarize the general characteristics of rice farming systems in Serdang Bedagai Regency, including land area, planting distance, fertilizer dosage, cropping season, irrigation systems, and production levels.

Correlation Analysis

Pearson correlation analysis was employed to determine the strength and direction of the relationships between climatic variables (rainfall and number of rainy days) and rice productivity. Correlation coefficients (r) were interpreted to assess whether the relationships were weak, moderate, or strong, and whether they were positive or negative.

Linear Regression Analysis

Linear regression analysis was performed when the correlation analysis indicated statistically significant relationships between climatic variables and rice productivity. The regression model was used to quantify the influence of each climatic factor on rice productivity and is expressed as:

$$Y = a + bX \quad (1)$$

where:

Y = rice productivity (tons ha^{-1}),

X = climatic variable (rainfall or number of rainy days),

a = intercept (constant),

b = regression coefficient.

The regression coefficient (b) indicates the magnitude and direction of the effect of the climatic variable on rice productivity. A positive coefficient suggests that an increase in the climatic variable is associated with higher productivity, whereas a negative coefficient indicates the opposite.

Statistical Significance

All statistical analyses were conducted at a significance level of $\alpha = 0.05$. Relationships were considered statistically significant when the probability value (p-value) was less than 0.05.

Research Framework

The analytical framework consisted of three sequential stages: (1) collection of climatic and productivity data, (2) correlation analysis to identify significant associations, and (3) regression analysis to estimate the magnitude of climatic effects on rice productivity. The results were then interpreted descriptively to provide a comprehensive understanding of how rainfall and rainy days influence rice production performance in Serdang Bedagai Regency.

Result and Discussion

Climate data obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG) and the Central Statistics Agency (BPS) for the period 2016–2021 indicate that the only consistently available climatic variables for the study area were rainfall (CH) and the number of rainy days (HH). These two variables were therefore selected as the principal indicators of climatic variability in this study. Rainfall data represent the total monthly precipitation (mm), whereas rainy days refer to the number of days within a month receiving measurable precipitation.

The study was conducted in Teluk Mengkudu Subdistrict, with a more detailed focus on the villages of Mata Pao Village and Pematang Setrak Village. To provide a comprehensive overview of climatic conditions, rainfall and rainy day data are presented at three spatial scales. Table 1 summarizes annual climatic conditions for Serdang Bedagai Regency, Table 2 presents data for Teluk Mengkudu Subdistrict, and Table 3 provides village-level annual data for Mata Pao and Pematang Setrak.

The selection of rainfall and rainy days as the main climatic variables was determined by data availability. Other important climatic parameters, such as air temperature, relative humidity, and solar radiation, were not available from BMKG for the study location during the observation period. Consequently, the analysis focused exclusively on precipitation-related variables, which are particularly relevant to rice cultivation because they directly influence water availability, planting schedules, and field management practices.

At the village level, the completeness of climatic records also varied. For Pematang Setrak Village, only annual aggregate data were available, which limited more detailed temporal analyses at the monthly scale. Nevertheless, the available datasets were considered sufficient to examine the relationship between rainfall characteristics, the number of rainy days, and rice productivity over the 2016–2021 period. These data provide an essential basis for understanding how

climatic variability affects rice production performance and for identifying adaptation strategies to enhance agricultural resilience under changing climate conditions..

Table 1. Data on monthly rainfall (mm) and number of rainy days in Serdang Bedagai Regency from 2016 to 2021.

Month	2016 CH (mm/ month)	2016 H (day)	2017 CH	2017 H	2018 CH	2018 H	2019 CH	2019 H	2020 CH	2020 H	2021 CH	2021 H
January	70	12	175	17	151	20	100	8	74	4	136	12
February	319	17	60	15	47	6	90	9	126	5	73	8
March	11	6	105	14	41	11	7	2	9	2	118	11
April	30	8	136	15	126	13	57	11	130	9	50	9
May	219	19	158	18	169	17	191	14	197	12	160	12
June	106	15	167	18	170	14	82	10	282	10	43	6
July	207	14	147	10	260	19	168	10	170	14	73	6
August	235	21	242	24	115	12	141	10	45	8	8	3
September	614	25	318	25	272	23	99	14	324	12	217	23
October	323	26	230	16	417	23	288	19	132	15	293	21
November	138	20	172	20	311	22	162	13	338	17	122	15
December	112	19	233	18	352	16	50	10	221	12	66	10
Average	198.7	16.8	173.8	17.5	202.6	16.3	119.6	10.8	170.7	10.1	113.5	11.3
Total	2384	202	2146	210	2431	196	1435	130	2048	121	1359	136

The data presented in the table reveal substantial interannual and seasonal variability in rainfall (CH) and the number of rainy days (H) in the study area during the period 2016–2021. Such variability reflects the dynamic climatic conditions that may significantly influence water availability, planting schedules, and ultimately rice productivity.

Among the six years analyzed, 2018 recorded the highest annual rainfall, reaching 2,431 mm, with an average of 202.6 mm per month. This indicates that 2018 was the wettest year during the study period. Similarly, 2016 exhibited relatively high rainfall, totaling 2,384 mm with a monthly average of 198.7 mm. In contrast, 2021 was the driest year, with only 1,359 mm of rainfall, corresponding to an average of 113.5 mm per month. This represents a decrease of approximately 44% compared with the rainfall observed in 2018, suggesting a marked reduction in water availability.

In terms of rainfall frequency, 2017 had the greatest number of rainy days, totaling 210 days, or an average of 17.5 rainy days per month. Although the total rainfall in 2017 (2,146 mm) was lower than that of 2018, precipitation occurred more frequently throughout the year. Conversely, 2020 recorded the fewest rainy days, with only 121 days (10.1 days per month), indicating that rainfall events were less frequent and likely more concentrated in shorter periods.

At the monthly scale, the most extreme rainfall event occurred in September 2016, when precipitation reached 614 mm over 25 rainy days. This exceptionally high rainfall suggests a period of intense and prolonged precipitation that may have increased the risk of flooding and waterlogging in rice fields. Other notably wet months included October 2018 (417 mm), December 2018 (352 mm), and November 2020 (338 mm). Such high

rainfall periods are beneficial for maintaining water supply but may also create favorable conditions for pest and disease outbreaks.

In contrast, several months experienced extremely low rainfall. The driest conditions were recorded in March 2019, with only 7 mm of rainfall and two rainy days, and August 2021, with 8 mm of rainfall and three rainy days. These conditions indicate severe dry periods that could lead to water stress, especially in areas with limited irrigation infrastructure.

Seasonally, rainfall tended to increase during the period from September to December, which consistently showed higher precipitation totals across most years. These months can be characterized as the principal wet season in the study area. In contrast, March frequently exhibited low rainfall values, suggesting that it represents one of the relatively dry periods within the annual climatic cycle.

A comparison between rainfall totals and the number of rainy days reveals that a greater number of rainy days does not necessarily correspond to higher annual rainfall. For example, 2017 had the highest number of rainy days (210 days) but lower total rainfall than 2018. Conversely, 2018 recorded the highest annual rainfall with fewer rainy days (196 days), indicating that rainfall intensity was generally greater in 2018 than in 2017. This distinction is important because both rainfall amount and rainfall intensity can have different implications for rice growth and field conditions.

Overall, the results demonstrate considerable climatic variability in the study area. 2016 and 2018 can be classified as wet years, while 2019 and 2021 were comparatively dry years. These fluctuations are highly relevant to rice cultivation because they influence irrigation requirements, planting decisions, crop

development, and the risk of pests and diseases. Consequently, rainfall and rainy day data provide critical information for developing adaptive agricultural strategies, optimizing cropping calendars, and improving the resilience of rice production systems under changing climatic conditions.

To provide a clearer overview of annual rainfall variability in the study area, the total annual rainfall recorded from 2016 to 2020 is presented in Figure 1. This figure illustrates fluctuations in precipitation over the five-year observation period and highlights the extent of climatic variability that may influence rice cultivation. Annual rainfall is one of the most important climatic indicators because it determines water availability for crop growth, affects planting schedules, and influences the incidence of pests and diseases. Understanding these trends is essential for assessing the relationship between climate conditions and rice productivity in Serdang Bedagai Regency

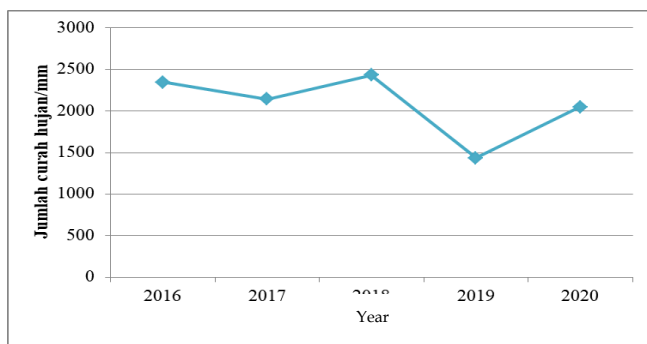


Figure 1. Graph of average rainfall (mm) in Serdang Bedagai

Figure 1 shows that annual rainfall in the study area fluctuated considerably during the 2016–2020 period. Total rainfall was relatively high in 2016, reaching approximately 2,384 mm, and declined slightly in 2017 to 2,146 mm. Rainfall then increased and reached its highest value in 2018 at 2,431 mm, indicating that 2018 was the wettest year during the observation period. In contrast, a sharp decline occurred in 2019, when annual rainfall dropped to approximately 1,435 mm, representing the driest year in the dataset. In 2020, rainfall increased again to 2,048 mm, although it remained lower than the levels recorded in 2016 and 2018.

The pronounced decline in rainfall in 2019 suggests the occurrence of unusually dry conditions that may have reduced water availability for rice cultivation and increased the risk of drought stress. Conversely, the high rainfall observed in 2018 likely provided favorable water conditions but may also have increased the potential for flooding, waterlogging, and disease outbreaks. Overall, the figure demonstrates substantial interannual variability in rainfall, which is likely to affect planting decisions, irrigation requirements, and rice productivity.

These findings emphasize the importance of adaptive agricultural management strategies to mitigate the impacts of climate variability and sustain rice production under changing climatic conditions.

In addition to total annual rainfall, the number of rainy days is an important climatic indicator because it reflects the frequency and distribution of precipitation throughout the year. While annual rainfall indicates the total amount of water received, the number of rainy days provides information about how evenly rainfall is distributed over time. This factor is particularly relevant to rice cultivation, as more frequent rainfall can support stable soil moisture conditions, whereas fewer rainy days may indicate prolonged dry periods or highly concentrated rainfall events. Figure 2 presents the annual number of rainy days in the study area from 2016 to 2020.

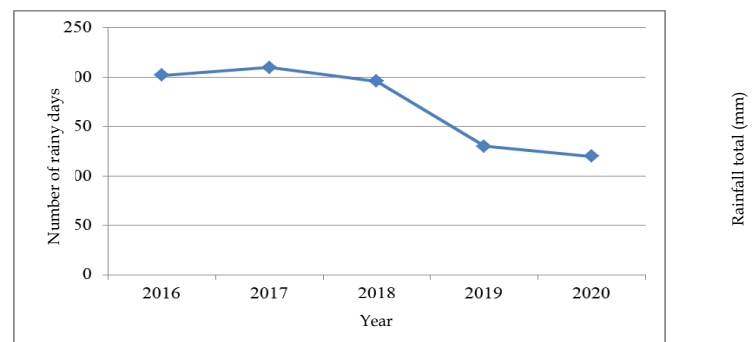


Figure 2. Graph of the average number of rainy days in Serdang Bedagai.

Figure 2 demonstrates a clear fluctuation in the number of rainy days during the 2016–2020 period. In 2016, the study area experienced approximately 202 rainy days. This number increased slightly in 2017 to 210 days, representing the highest rainfall frequency during the observation period. In 2018, the number of rainy days decreased modestly to 196 days, but remained relatively high and still reflected favorable moisture conditions for rice cultivation.

A substantial decline occurred in 2019, when the number of rainy days dropped sharply to 130 days. This reduction of nearly 34% compared with 2018 indicates a significant shift toward drier climatic conditions. The downward trend continued in 2020, with only 121 rainy days recorded, making it the year with the fewest rainy days in the study period. This suggests that rainfall events became less frequent and potentially more irregular.

The decrease in rainy days in 2019 and 2020 may have had important implications for rice production. Fewer rainy days can reduce natural water availability, increase dependence on irrigation, and heighten the risk of drought stress during critical growth stages. On the other hand, years with a greater number of rainy days,

such as 2016–2018, likely provided more stable water conditions and supported better crop growth. Overall, the figure highlights substantial interannual variability in rainfall frequency, emphasizing the importance of considering both rainfall amount and rainy day distribution when evaluating climate impacts on rice productivity and developing adaptive strategies for sustainable agricultural management.

To provide a more detailed understanding of climatic variability at the local scale, monthly rainfall (CH) and the number of rainy days (HH) for the period

2018–2021 are presented in Table 3. The data were collected from the study villages in Teluk Mengkudu Subdistrict and represent the most complete village-level climatic records available during the study period. Rainfall is expressed in millimeters per month (mm month⁻¹), while rainy days are reported as the number of days per month with measurable precipitation. These variables were selected because they directly influence water availability, planting schedules, and crop growth, and are therefore highly relevant to the productivity of rice farming systems.

Table 2. Rainfall data (mm/month) and number of rainy days (RRD) in Teluk Mengkudu Subdistrict for 2018–2021.

Month	2018		2019		2020		2021	
	CH mm/month	HH Day	CH mm/month	HH Day	CH mm/month	HH Day	CH mm/month	HH Day
January	151	20	60	6	60	6	271	13
February	47	6	93	5	93	5	2	2
March	41	11	9	3	9	3	123	7
April	126	13	76	3	76	3	75	10
May	169	17	233	13	233	13	172	9
June	170	14	86	8	86	8	118	12
July	260	19	131	7	131	7	76	4
August	115	12	102	10	102	10	199	14
September	272	23	162	15	162	15	243	9
October	417	23	323	19	323	19	203	9
November	311	22	143	13	143	3	335	17
December	352	16	95	9	95	9	201	11
Amount	2431	196	1513	111	1513	101	2018	117
Average	202.58	16.33	126.08	9.25	126.08	8.42	168.17	9.75

Table 3 presents the monthly rainfall (CH) and number of rainy days (HH) in the study area during the 2018–2021 period, revealing substantial temporal variability in both the amount and frequency of precipitation. Overall, the data indicate that climatic conditions fluctuated markedly from year to year, with important implications for water availability and rice cultivation. Among the four years analyzed, 2018 was the wettest year, recording a total annual rainfall of 2,431 mm and 196 rainy days, equivalent to an average of 202.58 mm of rainfall and 16.33 rainy days per month. Rainfall was relatively well distributed throughout the year, with particularly high precipitation from July to December. The highest monthly rainfall occurred in October, reaching 417 mm over 23 rainy days, followed by December (352 mm) and November (311 mm). These conditions suggest abundant and consistent water availability that was likely favorable for rice growth and development.

Climatic conditions changed considerably in 2019. Annual rainfall declined to 1,513 mm, representing a reduction of approximately 37.8% compared with 2018, while the number of rainy days decreased to 111 days, or an average of 9.25 rainy days per month. Several

months experienced very low rainfall, particularly March, which recorded only 9 mm of rainfall over three rainy days. Nevertheless, moderate to high rainfall still occurred in some months, such as May (233 mm) and October (323 mm). This pattern indicates that precipitation became less frequent and more unevenly distributed, increasing the potential for periods of water deficit during rice cultivation.

In 2020, the annual rainfall total remained at 1,513 mm, identical to that recorded in 2019, but the number of rainy days declined further to 101 days, corresponding to an average of 8.42 rainy days per month. This was the lowest rainfall frequency observed during the study period, indicating that rainfall events became more concentrated and less evenly distributed. Peak rainfall occurred in May and October, each exceeding 230 mm, while March again recorded only 9 mm of rainfall. Such concentrated precipitation patterns may increase both drought risk during dry periods and waterlogging during intense rainfall events.

Rainfall conditions improved in 2021, when annual precipitation increased to 2,018 mm and the number of rainy days rose to 117 days, with monthly averages of 168.17 mm and 9.75 rainy days, respectively. The highest

rainfall was recorded in November (335 mm), followed by January (271 mm) and September (243 mm). However, rainfall distribution remained irregular, as evidenced by extremely dry conditions in February, when only 2 mm of rainfall and two rainy days were recorded. This suggests that although total annual rainfall recovered, precipitation was still unevenly distributed across the year.

Taken together, the results demonstrate a pronounced decline in rainfall and rainy days from 2018 to 2019, persistently low rainfall frequency in 2020, and a partial recovery in 2021. The high and relatively well-distributed rainfall in 2018 likely provided optimal water conditions for rice cultivation, whereas the drier and less predictable conditions in 2019 and 2020 may have increased reliance on irrigation and elevated the risk of drought stress. Although 2021 showed improved rainfall totals, irregular monthly distribution suggests that climatic variability remained a significant challenge. These findings confirm that both rainfall amount and rainfall frequency are highly variable and constitute critical environmental factors influencing rice productivity and the resilience of farming systems in the study area.

To provide a clearer overview of interannual rainfall variability at the village level, the total annual rainfall recorded during the 2018–2021 period is presented in Figure 3. The figure summarizes the cumulative rainfall measured in the study area and illustrates changes in precipitation patterns over four consecutive years. Annual rainfall is a critical indicator in rice cultivation because it directly influences water availability, determines planting schedules, and affects crop growth and productivity. By visualizing annual rainfall trends, the figure facilitates a better understanding of climatic fluctuations and their potential implications for the sustainability of rice production in the study area.

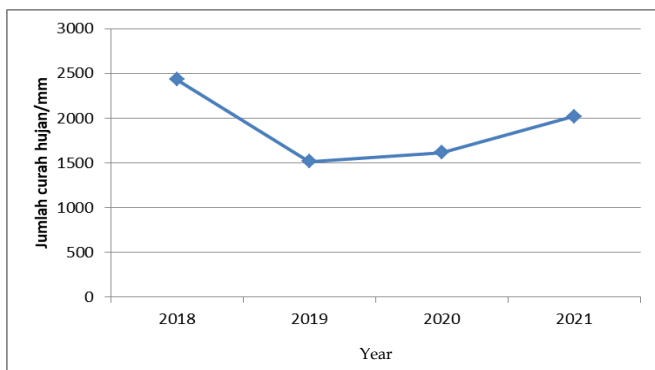


Figure 3. Graph of average monthly rainfall (mm) in Teluk Mengkudu Subdistrict

Figure 3 shows substantial variation in annual rainfall over the 2018–2021 period. The highest rainfall

was recorded in 2018, reaching 2,431 mm, indicating that this year experienced the wettest climatic conditions during the observation period. In 2019, annual rainfall declined sharply to 1,513 mm, representing a decrease of approximately 37.8% compared with 2018. This pronounced reduction reflects a substantial shift toward drier conditions and suggests lower natural water availability for rice cultivation.

In 2020, total rainfall remained relatively unchanged at 1,513 mm (or approximately 1,600 mm as illustrated in the figure), indicating that dry conditions persisted for a second consecutive year. However, rainfall increased again in 2021 to 2,018 mm, reflecting a partial recovery of precipitation levels, although total rainfall remained lower than that observed in 2018. Despite this improvement, the rainfall pattern in 2021 was still characterized by uneven monthly distribution, indicating that climatic variability continued to affect the study area.

Overall, the figure reveals a declining trend in rainfall from 2018 to 2019, followed by stable but relatively low rainfall in 2020 and a moderate recovery in 2021. These fluctuations demonstrate the dynamic nature of local climatic conditions and underscore the importance of adaptive agricultural management. Years with higher rainfall, such as 2018, likely provided more favorable conditions for rice growth, whereas the reduced rainfall in 2019 and 2020 may have increased dependence on irrigation and heightened the risk of drought stress. The results confirm that annual rainfall variability is a key environmental factor influencing rice productivity and the resilience of farming systems in the study area.

In addition to total annual rainfall, the number of rainy days is an important indicator for understanding precipitation patterns because it reflects how frequently rainfall occurs throughout the year. While total rainfall describes the overall amount of water received, the number of rainy days indicates the temporal distribution of precipitation, which is equally important for rice cultivation. A greater number of rainy days generally contributes to more stable soil moisture conditions, whereas fewer rainy days may indicate prolonged dry periods or highly concentrated rainfall events. Figure 4 presents the annual number of rainy days in the study area from 2018 to 2021 to illustrate changes in rainfall frequency over time.

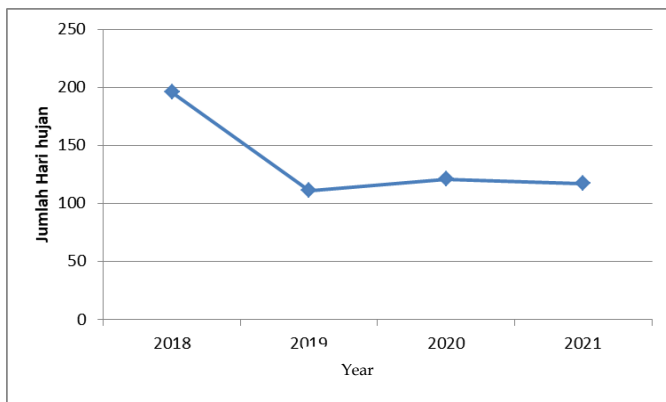


Figure 4. Graph of the average number of rainy days (HH) in Teluk Mengkudu Subdistrict

Figure 4 shows considerable variation in the annual number of rainy days during the 2018–2021 period. The highest number of rainy days was recorded in 2018, totaling 196 days, which indicates that rainfall occurred frequently and was relatively well distributed throughout the year. Such conditions likely provided a stable and reliable water supply for rice cultivation, reducing the need for supplementary irrigation and supporting favorable crop growth.

In 2019, the number of rainy days declined sharply to 111 days, representing a reduction of approximately 43.4% compared with 2018. This substantial decrease indicates a major shift toward drier climatic conditions, with less frequent rainfall and longer intervals between precipitation events. In 2020, the number of rainy days increased slightly to 121 days, suggesting a modest improvement in rainfall frequency; however, the value remained far below the level observed in 2018. In 2021, the number of rainy days decreased marginally to 117 days, indicating that rainfall frequency remained relatively stable but still considerably lower than during the wettest year.

Overall, the figure demonstrates a pronounced decline in rainfall frequency from 2018 to 2019, followed by only slight fluctuations during 2020 and 2021. The consistently lower number of rainy days after 2018 suggests that rainfall became less frequent and potentially more irregular, which may have reduced natural water availability and increased dependence on irrigation systems. These changes are particularly important for rice farming because the timing and frequency of rainfall strongly influence planting schedules, crop development, and productivity. The results confirm that variability in the number of rainy days is a key climatic factor affecting the resilience and sustainability of rice production in the study area.

To complement the analysis of climatic variability, Table 4 presents annual data on rice production, productivity, planted area, and harvested area in Serdang Bedagai Regency from 2015 to 2020. These

indicators provide a comprehensive overview of agricultural performance in the region and help to assess how changes in climatic conditions may influence rice cultivation. Production is expressed as total rice output (tons), productivity as yield per unit area (tons ha⁻¹), and both planted and harvested areas in hectares (ha). Together, these variables reflect not only the biological performance of rice crops but also the extent of land utilized for cultivation and the effectiveness of agricultural management.

Table 3. Data on production, productivity, planted area, and harvested area in Serdang Bedagai Regency from 2015 to 2020.

Year	Production ton/ha	Productivity ton/ha	Planted Area	Harvested Area
2015	406,947	56.02	66,949	72,649
2016	425,946	56.33	76,838	75,619
2017	480,741	57.20	83,157	84,042
2018	494,732	58.64	83,967	84,364
2019	393,951	57.08	71,077	69,018
2020	385,868	62,33	54,808	61,904

The table above shows that rice production from 2015 to 2018 ranged from 406,947 to 494,732 tons per hectare, but dropped to 385,868 tons per hectare in 2019–2020. Productivity data for 2015–2019 ranged from 56.02 to 58.64 tons/ha. However, in 2020, it rose to 62.33 tons/ha.

In the table above, the planted area for rice in Serdang Bedagai was highest in 2018 at 83,967 hectares, and the harvested area was highest in 2018 at 84,364 hectares, therefore, the combined effect of planted area and harvested area resulted in the highest production and productivity in 2018, reaching 494,732 tons/ha and a productivity of 58.64 tons/ha.

To determine the relationship and influence between climate variables and rice productivity and production from 2016 to 2010, correlation tests and linear regression analysis were used; correlation tests to determine the relationship between climate elements and productivity and production, and linear regression to determine the influence of climate variables on productivity

Table 4. Results of the multiple linear regression analysis between Y (productivity), X1 (rainfall), and X2 (number of rainy days).

<i>Regression Statistics</i>	
Multiple R	0.896035274
R Square	0.802879212
Adjusted R Square	0.605758424
Standard Error	1.50274527
Observations	5

Table 5. Results of Multiple Linear Regression Analysis (ANOVA)

Source of Variation	df	SS	MS	F	Significance F
Regression	2	18.39579331	9.197896654	4.07303166	0.197120788
Residual	2	4.51648693	2.258243346	-	-
Total	4	22.91228	-	-	-

Table 6. Regression Coefficient

Variabel	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	58.7817061	4.00111174	14.69134	0.004601	41.5663117	75.9971	41.56631175	75.99710045
X1	0.0056131	0.002681981	2.092894	0.171429	-0.0059265	0.0171527	-0.00592653	0.017152737
X2	-0.0710277	0.024897803	-2.85277	0.104049	-0.1781543	0.0360989	-0.1781543	0.036098893

The results of the t-test analysis show that variable X1 (rainfall) with a value of 0.171 does not significantly affect Y (productivity), and variable X2 (rainy days) with a value of 0.104 also does not significantly affect Y (rice productivity) in Serdang Bedagai Regency. The F-test result is 4.07303 with a significance value of 0.1971. Since this value is greater than the alpha significance level of 0.05, it indicates that there is no statistically significant effect of variables X1 (rainfall) and X2 (rainy days) on Y (productivity).

Based on the multiple linear regression analysis between productivity, rainfall, and rainy days in Serdang Bedagai Regency, the equation obtained is: Productivity = 58.781 + 0.00561 (rainfall) - 0.07102 (rainy days). The positive regression result indicates that the rainfall coefficient (0.00561) means that every 1 mm/year increase in rainfall will increase rice productivity by 0.00561 tons. Meanwhile, the rainy days coefficient (-0.07102) indicates that each additional rainy day will reduce rice productivity by 0.07102 tons. The multiple correlation coefficient (R) between rainfall, rainy days, and productivity is 0.896, which falls into the very strong category. This indicates that rainfall and rainy days have a strong relationship with productivity.

From the regression equation, the coefficient of determination (R²) is 60.57%, meaning that rainfall and rainy days explain 60.57% of the variation in rice productivity, while the remaining 40.43% is influenced by other factors such as fertilizers, varieties, pests, and crop management. This can be explained by the fact that increasing harvested area and stable rainfall generally lead to higher production and productivity, as shown in Table 4. However, in 2020, although the harvested area was relatively low, productivity was high due to factors such as fertilization, crop maintenance, rainfall, and irrigation.

Water is the main component required in every phase of the rice growth cycle, from germination to grain filling. In addition, sunlight is another essential factor after water, as rice plants require light as an energy source for the photosynthesis process.

Conclusion

There is no significant correlation between rainfall and the number of rainy days and rice crop production and productivity in Serdang Bedagai Regency, however, at the production level, the relationship shows a moderate correlation; this is also influenced by the use of technical irrigation in rice fields and the harvested area, so that rice crop requirements do not depend on rainfall and harvested area. There is a significant correlation with productivity of (r) 0.965; as the harvested area increases, both production and productivity increase. The multiple linear regression equation between rainfall, rainy days, and productivity is 60.57%, meaning that rainfall and rainy days account for 60.57% of the variation in irrigated rice productivity, while 40.43% is influenced by other factors such as fertilizer, variety, maintenance, pests, etc.

Acknowledgments

The author would like to express sincere gratitude to all parties who have contributed to the completion of this research. Special thanks are extended to the Department of Agriculture of North Sumatra Province and related institutions for providing the necessary data and information. Appreciation is also given to the farmers in Pematang Setrak Village, Teluk Mengkudu District, Serdang Bedagai Regency, for their cooperation and willingness to participate in the interviews. The author is also grateful to academic supervisors and colleagues for their valuable guidance, suggestions, and support throughout the research process. Finally, the author acknowledges the support from family and friends who have provided encouragement and motivation during the completion of this study.

Author Contributions

Conceptualization, AMH and NR; methodology, AMH; software, AMH; validation, NR and MSR; formal analysis, MSR; investigation, AMH; resources, NR; data curation, AMH; writing – original draft preparation, AMH; writing – review and editing, NR and MSR; visualization, NR; supervision, MSR and NR; project administration, NR; funding acquisition, AMH.

Funding

There is no external funding.

Conflicts of Interest

There is no conflict of interest.

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