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THE EFFECTS OF IRRIGATION, RAINFALL AND FERTILIZER ACCESS AS DETERMINANTS ON WAQF RICE YIELDS AND FOUNDATION ECONOMIC INDEPENDENCE

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ABSTRACT

This study examined the effect of irrigation systems, rainfall, and fertilizer access on waqf rice field yields and their implications for the economic independence of the Nuruddin Karangjongkeng Foundation in in Karangjongkeng Village, Brebes Regency, Central Java, Indonesia. The study addressed the low and fluctuating productivity of productive waqf rice fields, which limited their contribution to foundation financing. A quantitative approach with a causal explanatory design was used. The respondents consisted of 22 farmers who cultivated waqf rice fields, selected through total sampling. Data were collected using a five-point Likert scale questionnaire and analyzed through multiple linear regression. The findings showed that the irrigation system had a significant but negative effect on rice field yields, indicating that existing irrigation conditions had not supported productivity effectively. Rainfall had a positive and significant effect and became the most dominant factor affecting yields. Fertilizer access did not have a significant effect on yields, which indicated that fertilizer availability had not yet translated into productive efficiency. Simultaneously, irrigation systems, rainfall, and fertilizer access had a significant effect on rice field yields, with a coefficient of determination of 64.5 percent. The study concluded that climate adaptation, targeted irrigation rehabilitation, and fertilizer efficiency evaluation were needed to improve sustainable yields and strengthen the economic independence of the foundation.

1. INTRODUCTION

Productive waqf is one of the Islamic economic instruments with strong potential to improve community welfare because it functions not only as a form of social worship but also as a driver of the real sector (Hadyantari, 2022). Unlike consumptive waqf, whose physical benefits are used directly, productive waqf requires the economic and professional management of waqf assets so that the returns can be used sustainably for socio-religious purposes, such as education, health, and community economic empowerment (Syarifuddin, 2024). In Indonesia, waqf land in the form of agricultural land, including rice fields, dominates total waqf assets and accounts for more than 80% of the total area of national waqf land (Badan Wakaf Indonesia, 2024). However, the productivity of waqf rice fields remains relatively low compared with privately owned rice fields. This condition results from limited technical assistance, restricted capital, and weak management systems by nadzir, so the economic potential has not been optimized (Priyadi et al., 2023).

The Nuruddin Karangjongkeng Foundation in Brebes Regency, Central Java, is one waqf management institution, or nadzir, that owns 96,460 m^2 of waqf rice fields spread across several villages (Karangjongkeng., 2025). This makes the foundation one of the medium-scale productive waqf managers in the region. These rice fields are cultivated by tenant farmers using a profit-sharing system that has been practiced for generations, but without standardized operating procedures. Based on the foundation's annual report, harvest income from waqf rice fields fluctuated between IDR 70,000,000 and IDR 130,000,000 per year during the 2022 to 2024 period (Karangjongkeng., 2025). This shows an annual income gap of IDR 60,000,000 between the lowest and highest harvest income. The fluctuation indicates that waqf rice field productivity remained unstable and difficult to predict as a source of foundation financing.

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The income generated from these waqf rice fields is important because it supports the foundation's socio-religious activities, including madrasah diniyah, mosque activities, and community social programs. Therefore, unstable rice field yields do not only affect agricultural performance, but also influence the foundation's ability to strengthen internal financing through productive waqf assets. Several main problems have been identified in the field, including poor irrigation systems, especially in rainfed rice fields that depend only on rainfall, monotonous rainfall-based planting patterns, namely rice planting during the rainy season and fallow land during the dry season, and limited fertilizer access due to expensive prices and restricted working capital among tenant farmers (Karangjongkeng., 2025). These conditions show that agricultural input management is closely related to the sustainability of waqf-based institutional financing.

Previous studies have examined productive waqf management from legal, managerial, and fiqh muamalah perspectives (Anwar et al., 2022; Hadyantari, 2022). Studies on Islamic social finance have also discussed waqf financing models, productive waqf business models, and the contribution of waqf to social welfare (Priyadi et al., 2023; Sukmana et al., 2024; Syarifuddin, 2024). Meanwhile, agricultural productivity studies generally focus on privately owned farms, conventional rice production systems, irrigation efficiency, climate risk, or fertilizer management in non-waqf farming contexts (Ansari et al., 2023; Santosa et al., 2024). These studies provide important insights, but they have not specifically examined how technical agricultural factors affect rice field yields in productive waqf assets managed by a foundation.

This study differs from previous research in three ways. First, it focuses on productive waqf rice fields rather than privately owned agricultural land. Second, it examines technical farm-level factors, namely irrigation systems, rainfall, and fertilizer access, which are rarely discussed in waqf management and Islamic social finance studies. Third, it connects rice field productivity with foundation economic independence, which is an important issue for waqf-based social institutions. By integrating agricultural productivity and Islamic economic perspectives, this study provides a more specific explanation of how productive waqf assets can support sustainable institutional financing.

From the perspective of maqasid al-shari'ah, waqf asset management must align with the protection of wealth (hifz al-mal) and the protection of life (hifz al-nafs) (Rusydiana et al., 2022). In this context, the optimization of waqf rice field yields is not only related to agricultural output, but also to the welfare of tenant farmers and the continuity of social programs funded by the foundation. Productive waqf assets should not merely be preserved physically. They should also be managed productively so that their benefits can reach wider communities in a sustainable way.

This study aims to examine the effect of irrigation systems, rainfall, and fertilizer access on waqf rice field yields at the Nuruddin Karangjongkeng Foundation in Brebes Regency. Specifically, this study tests the partial effect of each independent variable on crop yield, examines the simultaneous effect of the three variables, and identifies the most dominant factor affecting yield. The results are expected to provide practical recommendations for nadzir, farmers, the Indonesian Waqf Board, and policymakers in optimizing agriculture-based productive waqf assets through targeted irrigation improvement, rainfall-based planting adaptation, and more efficient fertilizer management.

2. METHODS

This study used a quantitative approach with a causal explanatory design. The design was selected because the study examined the causal relationship between irrigation systems, rainfall, fertilizer access, and waqf rice field yields. The research was conducted at the Nuruddin Karangjongkeng Foundation in Karangjongkeng Village, Brebes Regency, Central Java, Indonesia. This location was chosen because the foundation manages productive waqf rice fields that directly support social and religious activities. The design allowed the study to test the partial and simultaneous effects of the independent variables on crop yield in a specific productive waqf context.

The population consisted of all farmers who actively cultivated waqf rice fields managed by the Nuruddin Karangjongkeng Foundation in 2025. The total population was 22 farmers. Because the population was small and fully accessible, this study used saturated sampling. All farmers in the population were included as respondents, so the sample size was also 22 respondents. This sampling technique was used to avoid sampling error and to obtain a complete description of the farming conditions in the waqf rice fields.

The respondents were farmers who had direct experience in managing the waqf rice fields. They were involved in daily farming activities, including water management, planting schedule adjustment, fertilizer use, and harvest activities. Their experience made them relevant sources of information for measuring the variables in this study. The study also considered the variation in farmer characteristics, such as age, education, farming experience, and cultivated land area. These characteristics were used to provide descriptive information about the respondents before the hypothesis testing was conducted.

Variables and Measurement

The dependent variable in this study was crop yield. Crop yield was measured based on rice field productivity per hectare per planting season and was converted into a five point Likert scale. The independent variables were irrigation system, rainfall, and fertilizer access. Each variable was measured through indicators that reflected actual farming conditions in the waqf rice fields. The operational definition, indicators, measurement scale, and Likert scores for each variable are presented in Table 1.

Tabel 1. Variables and Measurement

Variable	Code	Definition	Indicator	Scale	Likert Score
Crop Yield	Y (Dependent)	Productivity of dry harvested grain per hectare per planting season, converted into a perception scale	Productivity (tons/ha)	< 3 tons/ha	1 (Very Low)
Crop Yield	Y (Dependent)	Productivity of dry harvested grain per hectare per planting season, converted into a perception scale	Productivity (tons/ha)	3 - 4 tons/ha	2 (Low)
Crop Yield	Y (Dependent)	Productivity of dry harvested grain per hectare per planting season, converted into a perception scale	Productivity (tons/ha)	4 - 5 tons/ha	3 (Moderate)
Crop Yield	Y (Dependent)	Productivity of dry harvested grain per hectare per planting season, converted into a perception scale	Productivity (tons/ha)	5 - 6 tons/ha	4 (High)
Crop Yield	Y (Dependent)	Productivity of dry harvested grain per hectare per planting season, converted into a perception scale	Productivity (tons/ha)	> 6 tons/ha	5 (Very High)
Irrigation System	X1 (Independent)	Quality and quantity of rice field water supply	Water availability throughout the year	Scale 1-5: very unavailable (1) to very available (5)	1 to 5
Irrigation System	X1 (Independent)	Quality and quantity of rice field water supply	Planting frequency per year	1 time = score 1; 2 times = score 3; 3 times = score 5	1, 3, or 5
Irrigation System	X1 (Independent)	Quality and quantity of rice field water supply	Irrigation cost relative to income	Scale 1-5: very expensive (1) to very cheap (5)	1 to 5

Irrigation System	X1 (Independent)	Quality and quantity of rice field water supply	Physical condition of irrigation channels	Severely damaged (1) to very good (5)	1 to 5
Rainfall	X2 (Independent)	Rotation and arrangement of crop types within one year	Crop rotation	No rotation (1); rotation of 1 type (3); rotation of 2 or more types (5)	1, 3, or 5
Rainfall	X2 (Independent)	Rotation and arrangement of crop types within one year	Land use during the dry season	Left fallow (1); simple secondary crops (3); intensive secondary crops (5)	1, 3, or 5
Rainfall	X2 (Independent)	Rotation and arrangement of crop types within one year	Suitability of planting schedule with the season	Scale 1-5: very unsuitable (1) to very suitable (5)	1 to 5
Rainfall	X2 (Independent)	Rotation and arrangement of crop types within one year	Diversification level, or number of crop types per year	1 type (1); 2-3 types (3); more than 3 types (5)	1, 3, or 5
Fertilizer Access	X3 (Independent)	Ease of obtaining fertilizer, both subsidized and non-subsidized	Availability of subsidized fertilizer, as percentage quota of needs	<20%=1; 20-40%=2; 41-60%=3; 61-80%=4; >80%=5	1 to 5
Fertilizer Access	X3 (Independent)	Ease of obtaining fertilizer, both subsidized and non-subsidized	Fertilizer price relative to income	Scale 1-5: very expensive (1) to very cheap (5)	1 to 5
Fertilizer Access	X3 (Independent)	Ease of obtaining fertilizer, both subsidized and non-subsidized	Distance to fertilizer kiosk (km)	>10 km=1; 7-10 km=2; 4-6 km=3; 1-3 km=4; <1 km=5	1 to 5
Fertilizer Access	X3 (Independent)	Ease of obtaining fertilizer, both subsidized and non-subsidized	Capital assistance from nadzir for fertilizer	Never (1); rarely (2); sometimes (3); often (4); always (5)	1 to 5

Table 1 shows that crop yield was categorized from very low to very high based on productivity per hectare. The irrigation system variable was measured through water availability, planting frequency, irrigation cost, and the physical condition of irrigation channels. The rainfall variable was measured through crop rotation, dry season land use, planting schedule suitability, and crop diversification. The fertilizer access variable was measured through subsidized fertilizer availability, fertilizer price, distance to fertilizer kiosks, and capital assistance from the nadzir. All indicators used a five point Likert scale, where a higher score indicated better farming conditions or higher crop yield.

Instruments and Data Collection

Primary data were collected using a closed questionnaire. The questionnaire was prepared based on the indicators presented in Table 1. Each respondent answered the questionnaire based on the actual conditions experienced in cultivating waqf rice fields. The questions covered irrigation conditions, rainfall-based planting practices, fertilizer access, and crop yield categories. The questionnaire was distributed directly to the farmers with assistance from the researcher and foundation administrators to ensure that each item was understood clearly.

Secondary data were collected to support and verify the questionnaire results. The secondary data were obtained from the annual reports of the Nuruddin Karangjongkeng Foundation from 2019 to 2024. These reports provided information on waqf rice field area, annual harvest income, operational constraints, and the use of rice field income for foundation activities. Additional field information was obtained through preliminary interviews with foundation administrators and farmer group representatives. This verification process helped ensure that the quantitative data reflected the real farming and institutional conditions of the foundation.

Validity and Reliability Tests

The validity test was conducted using Pearson Product Moment correlation. A questionnaire item was considered valid when the calculated correlation value was higher than the r-table value of 0.423 at a significance level of 0.05. This test was used to ensure that each item measured the variable that it was intended to measure. The reliability test was conducted using Cronbach's Alpha to examine the internal consistency of the questionnaire items. An instrument was considered reliable when the Cronbach's Alpha value was higher than 0.60. These validity and reliability tests were conducted before the data were used in the regression analysis.

Data Analysis Technique

Data analysis was carried out using SPSS version 25. The first stage was descriptive analysis, which was used to describe respondent characteristics and the distribution of each research variable. Respondent characteristics included gender, age, education level, farming experience, and cultivated land area. The descriptive analysis also helped explain the general condition of waqf rice field cultivation before inferential testing was conducted. This stage provided an empirical overview of the research subjects and supported the interpretation of the regression results. The second stage was the classical assumption test. The normality test was conducted using the Kolmogorov-Smirnov test, with a significance value above 0.05 indicating normally distributed residuals. The multicollinearity test was examined using tolerance and variance inflation factor values. A tolerance value above 0.10 and a variance inflation factor value below 10 indicated that multicollinearity did not occur. The heteroscedasticity test was conducted using the Glejser test, with a significance value above 0.05 indicating that heteroscedasticity did not occur.

The third stage was hypothesis testing using multiple linear regression analysis with the model Y = alpha + beta1X1 + beta2X2 + beta3X3 + epsilon. In this model, Y represented crop yield, X1 represented irrigation system, X2 represented rainfall, and X3 represented fertilizer access. The partial effect of each independent variable was tested using the t-test with a significance level of 0.05. The simultaneous effect of all independent variables was tested using the F-test with the same significance level. The coefficient of determination was used to measure the proportion of crop yield variation explained by irrigation systems, rainfall, and fertilizer access.

The regression results were reported completely to answer the research hypotheses. The reported output included unstandardized coefficients, standard errors, standardized coefficients, t-values, and significance values for each independent variable. The model results also included the F-test and R-square value to explain the simultaneous effect and explanatory power of the model. The results of the classical assumption tests were reported before the regression interpretation to show that the model met the required assumptions. This reporting structure was used to make the analysis transparent, systematic, and consistent with the causal explanatory design of the study.

3. RESULTS AND DISCUSSIONS

Results

Respondent Characteristics

This study involved 22 farmers who cultivated waqf rice fields managed by the Nuruddin Karangjongkeng Foundation. Of the total respondents, 18 were male, representing 81.9%, while 4 were female, representing 18.1%. The average age of respondents was 50 years, with an age range between 35 and 65 years. The education levels consisted of elementary school at 50%, junior high school at 25%, senior high school at 15%, and higher education at 10%. The average experience in cultivating waqf rice fields was 7.5 years, while the average cultivated land area was 0.85 hectares per farmer.

The respondent characteristics show that most farmers had direct experience in managing waqf rice fields, although their formal education levels were relatively diverse. The dominance of elementary and junior high school education indicates that technical farming knowledge was mostly developed through practical experience rather than formal agricultural training. This condition is important for interpreting the results because the effectiveness of irrigation, rainfall adaptation, and fertilizer use depends not only on input availability, but also on farmers' technical understanding. The average cultivated land area of 0.85 hectares indicates that most respondents managed small-scale rice field plots. Therefore, changes in crop yield at the plot level could directly affect the contribution of waqf rice fields to foundation income.

Instrument Test and Classical Assumption Test

The validity test results showed that all questionnaire items were valid. The questionnaire consisted of 18 statement items, including 4 items for Irrigation System, 4 items for Rainfall, 4 items for Fertilizer Access, and 6 items for Crop Yield. All items had r-count values above the r-table value of 0.423 and were significant at $p < 0.05$. This result indicates that all questionnaire items were suitable for measuring the intended variables. Therefore, all items were included in the next stage of analysis. The reliability test was conducted using Cronbach's Alpha. The results showed that the Cronbach's Alpha value for Irrigation System was 0.684, Rainfall was 0.751, Fertilizer Access was 0.716, and Crop Yield was 0.860. All values were above 0.60, so the instrument was declared reliable. This means that the items used in each variable had acceptable internal consistency. The summary of validity and reliability test results is presented in Table 2.

Tabel 2. Validity and Reliability Test Results

Variable	Number of Items	Validity Result	Cronbach's Alpha	Description
Irrigation System	4	All items valid, r-count > 0.423	0.684	Reliable
Rainfall	4	All items valid, r-count > 0.423	0.751	Reliable
Fertilizer Access	4	All items valid, r-count > 0.423	0.716	Reliable
Crop Yield	6	All items valid, r-count > 0.423	0.860	Reliable

Source: *SPSS Version 25 Data Processing, 2026*

The classical assumption tests consisted of normality, multicollinearity, and heteroscedasticity tests. The normality test showed an Asymp. Sig. value of 0.892, which was higher than 0.05. This result indicates that the residuals were normally distributed. The multicollinearity test showed VIF values of 1.118 for X1, 1.731 for X2, and 1.658 for X3, all below 10. The tolerance values were 0.894 for X1, 0.578 for X2, and 0.658 for X3, all above 0.10. Therefore, multicollinearity did not occur among the independent variables. The heteroscedasticity test using the Glejser test showed a significance value of 0.799, which was higher than 0.05. This result indicates that heteroscedasticity did not occur.

Tabel 3. Classical Assumption Test Results

Test	Indicator	Result	Criteria	Description
Normality	Asymp. Sig.	0.892	> 0.05	Normal
Multicollinearity X1	VIF / Tolerance	1.118 / 0.894	VIF < 10; Tolerance > 0.10	No multicollinearity
Multicollinearity X2	VIF / Tolerance	1.731 / 0.578	VIF < 10; Tolerance > 0.10	No multicollinearity
Multicollinearity X3	VIF / Tolerance	1.658 / 0.658	VIF < 10; Tolerance > 0.10	No multicollinearity
Heteroscedasticity	Glejser Sig.	0.799	> 0.05	No heteroscedasticity

Multiple Linear Regression Analysis

Multiple linear regression analysis was used to examine the effect of Irrigation System, Rainfall, and Fertilizer Access on Crop Yield. The regression results show that Irrigation System had a negative coefficient, Rainfall had a positive coefficient, and Fertilizer Access had a negative coefficient. The complete regression results are presented in Table 4. The table includes unstandardized coefficients, standard errors, standardized coefficients, t-values, and significance values. These results were used to determine the partial effect of each independent variable on waqf rice field yields.

Tabel 4. Classical Assumption Test Results

Model	Unstandardized Coefficients	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
Model	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	33.659	9.342		3.603	0.002
X1 (Irrigation System)	-0.431	0.190	-0.346	-2.272	0.036
X2 (Climate)	0.596	0.167	0.552	3.565	0.002
X3 (Fertilizer Access)	-0.387	0.195	-0.307	-1.985	0.063

Source: SPSS Version 25 Data Processing, 2026

Crop Yield = Crop Yield = 33.659 - 0.431X1 + 0.596X2 - 0.387X3 + ε

The constant value of 33.659 indicates that when Irrigation System, Rainfall, and Fertilizer Access are constant, Crop Yield is estimated at 33.659 units. The coefficient of Irrigation System was -0.431, meaning that each one-unit increase in the irrigation system variable decreased crop yield by 0.431 units. The coefficient of Rainfall was 0.596, meaning that each one-unit increase in rainfall conditions increased crop yield by 0.596 units. The coefficient of Fertilizer Access was -0.387, meaning that each one-unit increase in fertilizer access decreased crop yield by 0.387 units. However, the significance value of Fertilizer Access was above 0.05, so this effect was not statistically significant.

The partial test showed that Irrigation System had a t-value of -2.272 with a significance value of 0.036. Since the significance value was below 0.05, Irrigation System had a significant effect on Crop Yield. However, the direction of the effect was negative. This means that the result did not support the expected positive direction of the irrigation hypothesis. The negative coefficient should not be interpreted as evidence that irrigation itself reduced rice productivity. Instead, it indicates that the existing irrigation condition in the waqf rice fields had not functioned effectively to support crop production.

The negative effect of Irrigation System may be related to poor irrigation quality, irregular water distribution, damaged irrigation canals, and inefficient water management in several cultivated plots. Field conditions indicated that water did not always flow evenly to all rice field areas. Some plots may have received insufficient water, while other plots may have experienced excessive water accumulation. Excess water can disturb root growth, increase soil moisture beyond crop needs, reduce oxygen availability in the root zone, and cause nutrient leaching. Damaged canals can also reduce water delivery efficiency and create uneven planting conditions across plots. Therefore, the negative effect of irrigation was more likely caused by technical and management problems in the irrigation system rather than by the existence of irrigation infrastructure itself.

The partial test also showed that Rainfall had a t-value of 3.565 with a significance value of 0.002. Since the significance value was below 0.05, Rainfall had a positive and significant effect on Crop Yield. The standardized coefficient value of 0.552 was the highest among the independent variables. This result indicates that Rainfall was the most dominant factor affecting waqf rice field yields in this study. It also shows that rice field productivity at the Nuruddin Karangjongkeng Foundation still depended strongly on seasonal water availability and rainfall-based planting patterns. Therefore, H2 was supported.

The Fertilizer Access variable had a t-value of -1.985 with a significance value of 0.063. Since the significance value was higher than 0.05, Fertilizer Access did not have a significant effect on Crop Yield. This result indicates that easier access to fertilizer did not automatically increase productivity. The negative coefficient may be related to unsuitable fertilizer types, improper dosage, limited soil testing, weak technical assistance, or inefficient fertilizer application. This finding shows that fertilizer availability must be supported by proper knowledge and application methods. Therefore, H3 was not supported.

Simultaneous Test (F-test) and Coefficient of Determination

The simultaneous test was used to examine whether Irrigation System, Rainfall, and Fertilizer Access jointly affected Crop Yield. The F-test showed an F-count value of 24.567 with a significance value of 0.000. Since the significance value was below 0.05, the three independent variables simultaneously had a significant effect on Crop Yield. This result indicates that waqf rice field yields were shaped by the combined role of water management, seasonal rainfall conditions, and fertilizer access. Therefore, H4 was supported.

Tabel 5. Model Summary and F-Test Results

Model	R	R Square	Adjusted R Square	F-count	Sig.
Regression Model	-	0.645	-	24.567	0.000

Source: SPSS Version 25 Data Processing, 2026

The coefficient of determination showed an R-square value of 0.645. This means that 64.5% of the variation in waqf rice field yields could be explained by Irrigation System, Rainfall, and Fertilizer Access. The remaining 35.5% was explained by other variables outside the model. These variables may include seed quality, pest and disease control, soil fertility, labor quality, farming technology, land size, farmer skills, and government policies related to agricultural inputs and harvest prices. This result indicates that the model had a strong explanatory contribution, although other agricultural and institutional factors still need to be considered in future studies.

Discussion

The regression analysis summarized in Table 4 shows that irrigation systems, rainfall, and fertilizer access simultaneously have a significant effect on waqf rice field yields, with an F-count value of 24.567 and a significance value of 0.000 < 0.05. The coefficient of determination (R^2) of 0.645 indicates that 64.5% of the variation in crop yield can be explained by the three variables, while 35.5% is influenced by other factors outside the model. From the theory of agricultural productivity, this result confirms that rice yield is shaped by the interaction between production inputs, environmental conditions, and farm management practices. Irrigation, rainfall, and fertilizer access are not isolated factors because water availability affects fertilizer absorption, rainfall affects planting decisions, and fertilizer use affects crop growth only when water and soil conditions are suitable. This finding provides an important basis for assessing how the optimization of production factors in waqf rice fields contributes to the economic independence of the Nuruddin Karangjongkeng Foundation.

The Effect of Irrigation Systems on Crop Yield and Its Implications for Economic Independence

Based on the partial test, the irrigation system has a negative regression coefficient of -0.431, with a t-count of -2.272 and a significance value of 0.036 (<0.05). This result confirms that the irrigation system has a significant effect, but in a negative direction. This means that each one-unit increase in the irrigation system actually decreases crop yield by 0.431 units. In the theory of agricultural productivity, irrigation should support crop yield by stabilizing water supply, reducing drought risk, and enabling more reliable planting cycles. However, the result of this study shows that irrigation infrastructure does not automatically increase productivity when its quality, distribution, and management are not effective.

This phenomenon needs to be interpreted carefully. In the context of the Nuruddin Foundation, possible causes include inefficiency or technical incompatibility in the existing irrigation system, such as excess water or over-irrigation that causes plant roots to become waterlogged, root decay, or nutrient leaching. Damage to poorly maintained irrigation channels may also cause uneven water distribution. This means that the negative effect is more likely related to poor irrigation quality, irregular water flow, damaged canals, flooding in certain plots, or inefficient water management. Therefore, the problem is not the presence of irrigation itself, but the inability of the irrigation system to function as a productive input.

From the perspective of waqf asset optimization, a suboptimal irrigation system threatens the productive value of waqf land. Productive waqf assets should not only be preserved physically, but also managed to generate stable and sustainable economic returns. If irrigation infrastructure exists but fails to improve yield, then waqf land has not been fully transformed into an income-generating asset. This condition weakens the production dimension, particularly the yield sustainability index, which is the ratio of actual yield to maximum land potential. A decline in crop yield due to poor irrigation will reduce the contribution of the productive waqf sector to the foundation's total income, causing the waqf revenue dependency ratio to remain low.

As a result, the foundation tends to remain dependent on external donations, and the self-sufficiency ratio becomes difficult to raise above 100%. Therefore, targeted irrigation system improvement, not merely water availability, becomes a prerequisite for increasing production stability across seasons. The foundation should not only repair physical canals, but also improve water allocation, drainage control, maintenance schedules, and coordination among farmers. These actions can reduce the coefficient of variation in harvest results and lower the risk of crop failure that can disrupt funding flows to madrasah diniyah, mosques, and community social activities. This finding partly differs from Yan et al. (2022), who reported that supplementary irrigation under rainfed rice cultivation can increase grain yield and resource use efficiency when combined with appropriate nitrogen management. It also differs from Gharsallah et al. (2023), who showed that alternate wetting and drying can support more sustainable rice irrigation. The difference in this study may occur because the irrigation system measured in the field reflects technical problems, uneven distribution, and possible over-irrigation, not simply better water availability.

The Effect of Rainfall on Crop Yield and Its Implications for Economic Independence

The rainfall variable shows a positive coefficient of 0.596, with a t-count of 3.565 and a significance value of 0.002 (<0.05). This means that each one-unit increase in supportive rainfall conditions increases crop yield by 0.596 units. The standardized coefficient (Beta) of 0.552 is the highest among the three variables, indicating that rainfall has the most dominant effect on waqf rice field yields at the Nuruddin Foundation. From the perspective of climate adaptation, this result shows that rice field productivity depends strongly on farmers' ability to adjust planting schedules, land use, and crop rotation to local rainfall patterns. Rainfall is not only an environmental background factor, but also a production condition that directly shapes rice growth and harvest stability.

Within the framework of economic independence, stable and predictable rainfall conditions strongly determine the production dimension, especially production stability across seasons. When crop yield increases consistently, the operational break-even point becomes easier to reach because income from rice fields can cover core operational costs. Surplus harvest can then be converted into sustainable social programs through a high zakat-surplus conversion rate. In the field, increased crop yield due to favorable rainfall conditions will strengthen funding flows to madrasah diniyah, mosques, and social activities in Karangjongkeng Village. This allows the foundation to reduce its reliance on external donations in carrying out its social mission.

This finding is consistent with Ansari et al. (2023), who showed that climate change affects rice production in Indonesia through changing agro-climatic conditions. It is also in line with Al Mamun et al. (2023), who found that climatic variability has implications for rice yield. The similarity confirms that rainfall and climate conditions are direct determinants of rice productivity. The difference is that this study applies the climate-yield relationship to waqf rice fields managed by a religious foundation. Therefore, climate adaptation in this study is not only relevant for farmers, but also for waqf institutions that depend on agricultural income.

The dominance of rainfall also shows that productive waqf rice fields need stronger adaptation strategies. Farmers should not depend only on traditional rainy-season planting patterns because seasonal shifts can increase production uncertainty. Planting schedules, crop diversification, and dry-season land use should be adjusted to local rainfall patterns. This adaptation can support a sustainable rural economy because stable harvests can protect farmer income, maintain foundation financing, and sustain community-based social services. In this sense, rainfall management is connected not only to crop yield, but also to the long-term resilience of rural Islamic economic institutions.

The Effect of Fertilizer Access on Crop Yield and Its Implications for Economic Independence

Fertilizer access has a negative regression coefficient of -0.387, with a t-count of -1.985 and a significance value of 0.063 (>0.05). Statistically, fertilizer access has no significant effect on crop yield at the 95% confidence level. The negative direction of the coefficient indicates that increased fertilizer access tends to reduce crop yield, although this effect is not statistically strong enough. From the theory of agricultural productivity, fertilizer should increase yield when it supplies the right nutrients in the right dose, at the right time, and under suitable soil and water conditions. However, this study shows that access alone is not enough to improve productivity.

This finding is interesting because it contradicts the general logic that fertilizer should increase productivity. In the context of the Nuruddin Karangjongkeng Foundation, several explanations can be proposed. First, the fertilizer accessed may be of low quality or unsuitable for the needs of waqf rice field soil, such as unbalanced fertilizer. Second, over-fertilization may occur, causing soil damage or suboptimal plant growth. Third, easier fertilizer access may not be followed by adequate technical knowledge among land managers. Fourth, other factors such as pests or plant diseases that are unrelated to fertilizer may prevent increased fertilizer access from having a significant effect.

This result differs from Chen et al. (2024), who found that balanced nitrogen and potassium application can improve fertilizer use efficiency, rice yield, and grain quality. It also differs from Hu et al. (2024), who showed that localized nitrogen supply can support rice yield and nitrogen use efficiency through better root-zone distribution. The difference suggests that access to fertilizer alone does not automatically improve yield when the fertilizer type, dose, timing, and farmer knowledge are not aligned with local soil and water conditions. Therefore, fertilizer management in waqf rice fields should move from input availability toward input efficiency.

From the perspective of waqf asset optimization, the non-significant effect of fertilizer access indicates that fertilizer expenditure has not yet become an efficient productive investment. This can hinder the financial dimension because operational costs for fertilizer are not proportional to additional crop yield. The foundation needs to evaluate fertilizer types, doses, and application methods so that own-source revenue from the waqf sector truly increases. Otherwise, dependence on subsidies or external fertilizer assistance may weaken the self-sufficiency ratio because the foundation remains dependent on outside resources for production inputs. In relation to sustainable rural economy, fertilizer support should be combined with farmer training, soil testing, and extension services so that input use improves both productivity and cost efficiency.

Simultaneous Implications for the Economic Independence of the Nuruddin Karangjongkeng Foundation

Simultaneously, the three variables have a significant effect on crop yield. The R^2 value of 0.645 shows that 64.5% of the variation in crop yield is explained by irrigation systems, rainfall, and fertilizer access. This means that optimizing the three production factors has strong potential to increase waqf rice field yields. From the theory of agricultural productivity, the simultaneous result confirms that yield improvement requires an integrated input system rather than a single production factor. Water management, rainfall adaptation, and fertilizer efficiency need to work together to produce stable harvest outcomes.

In turn, this will directly affect the foundation's economic independence through three dimensions. In the production dimension, stable increases in crop yield with a low coefficient of variation will improve the yield sustainability index. Waqf rice fields can then make a regular contribution to the foundation's operational needs. In the financial dimension, higher crop yield will increase the waqf revenue dependency ratio, or the percentage of income from the productive waqf sector. The foundation will be able to reach its operational break-even point and even generate surplus that can be converted into social programs, such as funding for madrasah diniyah, mosques, and community social activities in Karangjongkeng Village. In the institutional dimension, dependence on external donations will decrease, giving the foundation greater resource allocation autonomy. Income-generating units, such as waqf rice fields, can be managed more professionally by the foundation itself, strengthening long-term independence.

This simultaneous result is consistent with Yan et al. (2022), who found that rainfall-adapted supplementary irrigation and nitrogen management can improve rice yield, water productivity, and nitrogen use efficiency. It also aligns with Deng et al. (2022), who showed that water and nitrogen management affect yield, grain quality, nutrient uptake, and use efficiency. The similarity lies in the view that rice yield is shaped by combined production factors rather than a single input. However, this study differs because it places those production factors within productive waqf management and links them to the economic independence of a foundation. This makes the findings relevant not only for agricultural production, but also for Islamic social finance and rural institutional sustainability.

The findings also relate to the theory of sustainable rural economy. Productive waqf rice fields can support rural economic sustainability when they create stable agricultural output, strengthen local farmer income, and generate internal financing for social institutions. In this study, improved yields could increase the foundation's own-source income and reduce dependence on external donations. This income can support education, religious activities, and social programs in the local community. Therefore, agricultural productivity in waqf rice fields has a broader function than farm-level output. It also contributes to the sustainability of rural social welfare through productive Islamic economic assets.

The remaining 35.5% of the variation in crop yield is explained by other variables outside the model, such as agricultural technology, including superior seeds and agricultural machinery, human resource management, including the quality of land managers, plant pests and diseases, and government policies related to subsidies and harvest prices. These variables also require attention to achieve more comprehensive economic independence. This can be seen in the study by Uliana. (2024), which analyzed production factors for paddy rice in Central Sulawesi. The Cobb-Douglas production function analysis showed that land area, seeds, urea fertilizer, phoska fertilizer, and labor simultaneously had a significant effect on rice production, with an R Square value reaching 97.8%. Partially, land area, seeds, and urea fertilizer had significant effects, while phoska fertilizer and labor had no significant effect. This study proves that factors other than fertilizer, such as land area and seed quality, also strongly determine crop yield.

4. CONCLUSION

This study concluded that irrigation systems, rainfall, and fertilizer access simultaneously affected waqf rice field yields at the Nuruddin Karangjongkeng Foundation. Partially, the irrigation system had a significant but negative effect on yields, indicating that the existing irrigation system had not been managed effectively. Rainfall had a positive and significant effect and became the most dominant factor, showing that rice field productivity still depended strongly on seasonal water availability. Meanwhile, fertilizer access had no significant effect on yields, suggesting that fertilizer availability alone did not improve productivity without proper dosage, quality control, soil suitability, and technical assistance.

Improved waqf rice field yields can strengthen the economic independence of the foundation by increasing internal income from productive waqf assets. Higher and more stable harvests can enlarge the contribution of rice field income to foundation financing, reduce dependence on external donations, and support routine operational needs more sustainably. This income can be used to finance madrasah diniyah, mosque activities, and community social programs managed by the foundation. Therefore, increasing rice field productivity is not only an agricultural objective, but also a strategy to strengthen the foundation's financial self-reliance through productive waqf management.

Based on these findings, the Nuruddin Karangjongkeng Foundation is advised to improve irrigation management through canal rehabilitation, better water distribution, and regular maintenance so that irrigation can support rather than reduce productivity. The foundation and farmers are also advised to adjust planting schedules to rainfall patterns and develop climate adaptation strategies to reduce yield fluctuation. In addition, fertilizer support should be accompanied by technical guidance from agricultural extension officers so that farmers can use the right type, dose, and timing of fertilizer application. These practical actions are intended to increase waqf rice field yields, strengthen foundation income, and support the financing of religious education, mosque activities, and social programs more sustainably.

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