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THE IMPACT OF SMALL RESERVOIRS (EMBUNG) ON RICE PRODUCTION IN BANYUMAS REGENCY, 2017–2025

Esti[1*], Barokatuminalloh[2], Lilis Siti Badriah[3], Atik Munggiarti[4]

[1-3]Economics, University Jenderal Soedirman, Indonesia
[4]Regional Development Planning, Research, and Innovation Agency (Bapperida) of Banyumas Regency, Indonesia

[*]Email corresponding author: esti@mhs.unsoed.ac.id

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Abstract

Rice is a strategic agricultural commodity that plays a vital role in supporting food security in Indonesia. In recent years, rice production at both the national and regional levels has shown a declining trend. As a crop highly dependent on the stability of irrigation systems, limited water availability, particularly during the dry season, has become a major constraint. To address this issue, the government has implemented various measures to improve agricultural productivity, one of which is the construction of farm reservoirs (embung). These reservoirs are designed to enhance irrigation water availability, especially during the dry season, thereby supporting the sustainability of rice production. This study aims to analyze the effect of farm reservoirs on rice production in Banyumas Regency during the period 2017–2025, while also considering harvested area and agricultural institutions as influencing factors. The study employs a quantitative approach covering 27 sub-districts in Banyumas Regency. Secondary data were obtained from Statistics Indonesia (BPS), the Banyumas Regency Agricultural Office, and the Banyumas Regency Public Works Office. Data were analyzed using panel data regression methods. The results indicate that areas equipped with farm reservoirs tend to have lower rice production compared to areas without reservoirs. This finding can be explained by the fact that reservoir development policies are primarily targeted at regions with high vulnerability to water shortages, such as rainfed agricultural areas. Meanwhile, harvested area has a positive and significant effect on rice production. In contrast, agricultural institutions, measured by the number of farmer groups, do not have a significant effect on rice production, suggesting that the quantity of institutions has not yet been accompanied by improvements in their effectiveness in enhancing agricultural output.

Keywords: Reservoirs, Rice Production, Harvested Area, Agricultural Institutions, Panel Data Regression.

INTRODUCTION

Rice is a strategic agricultural commodity that plays a crucial role in supporting food security in Indonesia. As the staple food for the majority of the population, the availability of rice is a key factor in maintaining economic stability and social welfare. Therefore, increasing and sustaining rice production has become one of the primary priorities in the development of the national agricultural sector.

In recent years, rice production in Indonesia has shown a declining trend. According to Statistic Indonesia (2025), national rice production decreased from 59.20 million tons in 2018 to 53.14 million tons in 2024. This decline was accompanied by a reduction in harvested area, which is one of the most important determinants of production levels. This condition has become a serious concern because it may affect national food availability and threaten efforts to achieve sustainable food self-sufficiency.

The decline in rice production has occurred not only at the national level but also in Central Java Province. As one of Indonesia's major rice-producing regions, Central Java ranks as the second-largest rice producer after East Java. Nevertheless, rice production in Central Java decreased by 2.12 percent in 2024 compared to the previous year (Statistik Indonesia, 2025). Given the province's significant contribution to national rice production, a decline in output in this region may have implications for national food security.

One of the key factors influencing rice production is water availability. Rice is highly dependent on an adequate water supply, particularly during its vegetative and reproductive growth stages. Water shortages caused by prolonged dry seasons, changing rainfall patterns, and the increasing frequency of extreme climate events can hinder plant growth and reduce yields. Therefore, effective water resource management is essential for sustaining rice production.

To address these challenges, the government has developed various water conservation infrastructures, one of which is the construction of farm reservoirs (*embung*). According to the Ministry of Public Works and Housing (PUPR), farm reservoirs serve several important functions, including increasing irrigation water supply, reducing farmers' dependence on rainfall, improving cropping intensity, and minimizing the risk of crop failure. Furthermore, the development of farm reservoirs forms part of the government's strategy to strengthen national food security, particularly for strategic commodities such as rice. This program is also aligned with Government Regulation No. 38 of 2017 on Regional Innovation, which encourages innovation in local governance to improve development effectiveness.

The development of farm reservoirs also represents an implementation of global commitments under the Sustainable Development Goals (SDGs), particularly Goal 2 (Zero Hunger) and Goal 6 (Clean Water and Sanitation). Farm reservoirs are expected to improve irrigation water availability, reduce drought risks, increase cropping intensity, and enhance agricultural production (Dewi & Wahidin, 2020). Similarly, Dangnga et al. (2019) found that farm reservoirs help farmers optimize land utilization, thereby contributing positively to increased agricultural production.

Banyumas Regency is one of the regions in Central Java Province with considerable potential for rice cultivation. To support water availability for agricultural land, the local government has constructed several farm reservoirs distributed across various sub-districts. However, according to publications from the Banyumas Regency Communication and Information Office, rice production in Banyumas has continued to fluctuate over time. Since 2021, rice production has experienced a gradual decline, reaching its lowest level in 2024 at approximately 238 thousand tons, representing a decrease of around 18 percent compared to the production peak recorded in 2021. This situation raises questions regarding the effectiveness of farm reservoir development in supporting rice production in the region.

In addition to water availability, rice production is influenced by other factors, including harvested area and agricultural institutions. Harvested area is a production factor that directly determines the volume of output generated. The larger the harvested area, the greater the quantity of rice produced (Defriyanti, 2019). Meanwhile, agricultural institutions, such as farmer groups, function as platforms for learning, cooperation, and strengthening farmers' access to technology, information, and agricultural inputs, all of which contribute to rice production (Nilasari & Muhamad, 2022).

Previous studies have produced mixed findings regarding the impact of farm reservoirs on the agricultural sector. Nardi et al. (2021)and Asri & Falihin (2022) found that farm reservoirs positively affect agricultural production and water availability. In contrast, Nuardiansyah & Hayati (2025) argued that farm reservoirs are not always effective in mitigating drought or improving agricultural productivity, as their effectiveness depends on various technical and management factors. These differing findings indicate the existence of a research gap concerning the effectiveness of farm reservoirs in supporting rice production.

Based on the foregoing discussion, this study aims to analyze the effect of farm reservoirs on rice production in Banyumas Regency during the period 2017–2025, while also considering harvested area and agricultural institutions as additional explanatory factors. The findings are expected to provide empirical evidence regarding the effectiveness of farm reservoir development and serve as a reference for policymakers in formulating water infrastructure development strategies and agricultural sector policies in Banyumas Regency.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

Production theory explains how various production factors are combined to generate optimal output. According to Sukirno (2016), production refers to activities undertaken to create or increase the utility of goods and services in order to satisfy human needs. The production process requires various production factors, including capital, labor, land, technology, and other supporting resources. The relationship between these production factors and the resulting output is known as the production function. One of the most widely applied production functions in agricultural research is the Cobb–Douglas production function developed by Cobb and Douglas (1928). This function explains that output is generated through the interaction of various production inputs, each contributing to the level of production achieved (Debertin, 2012).

In the agricultural sector, particularly in rice farming, production is influenced not only by conventional production factors such as land and labor but also by the availability of water resources and institutional support. Rice is the primary food crop in Indonesia and is highly dependent on adequate water availability, especially during the vegetative and reproductive growth stages. Water shortages during these critical phases can hinder plant development and reduce crop yields (Ezward et al., 2018).

One of the government's efforts to ensure water availability for agriculture is the construction of farm reservoirs (*embung*). Farm reservoirs are water storage structures designed to collect and store rainfall and surface runoff for use during the dry season. According to the Water Resource Agency (2025), farm reservoirs serve as supplementary irrigation water sources for agricultural land. Their existence is expected to increase water availability, reduce drought risk, improve cropping intensity, and ultimately enhance agricultural production. Dewi and Wahidin (2020) found that farm reservoirs contribute to improving water availability for agricultural activities, while Dangnga et al. (2019) reported that reservoir development increases cropping intensity and supports higher agricultural production.

In addition to water availability, harvested area is another factor that directly determines rice production. Harvested area is defined as the total area of crops successfully harvested within a given period. Unlike cultivated land area, harvested area includes only the portion of land that actually produces output, making it a more accurate indicator of actual production levels. Within production theory, harvested area represents the land factor, which is one of the primary inputs in agricultural production. Defriyanti (2019) found that harvested area has a positive and significant effect on rice production. Similar findings were reported by Handajani et al. (2024) and Saleh Modjo et al. (2025), who demonstrated that increases in harvested area are associated with higher rice production.

Another factor influencing rice production is agricultural institutions. Agricultural institutions are organizations established by and for farmers to improve farming efficiency and strengthen farmers' positions within the agribusiness system. These institutions may include farmer groups (Poktan), associations of farmer group (Gapoktan), and Water User Farmer Associations (Perkumpulan Petani Pemakai Air or P3A). According to Nuryanti & Dewa (2011), agricultural institutions function as platforms for cooperation that strengthen farmers' collective actions in accessing technology, information, agricultural inputs, and financial resources. Through active institutional participation, farmers can gain better access to agricultural innovations, government assistance programs, and more effective water resource management. Nilasari & Muhamad (2022)

demonstrated that agricultural institutions play an important role in enhancing farmers' productivity through stronger collaboration and the dissemination of agricultural technology.

Based on the theoretical framework and previous empirical findings, the research hypotheses are formulated as follows:

H1: Areas equipped with farm reservoirs have higher rice production than areas without farm reservoirs.

H2: Harvested area has a positive effect on rice production in Banyumas Regency during the period 2017–2025.

H3: Agricultural institutions have a positive effect on rice production in Banyumas Regency during the period 2017–2025.

RESEARCH METHODS

This study employs a quantitative approach using panel data regression analysis to examine the effects of farm reservoirs (*embung*), harvested area, and agricultural institutions on rice production in Banyumas Regency. The unit of analysis consists of 27 sub-districts in Banyumas Regency observed over the period 2017–2025. The use of panel data enables the integration of both cross-sectional and time-series dimensions, thereby providing more comprehensive information for explaining variations in rice production across regions and over time.

The study utilizes secondary data obtained from Statistics Indonesia (BPS), the Banyumas Regency Agriculture and Food Security Office, and the Banyumas Regency Public Works Office. The research variables consist of rice production as the dependent variable, while farm reservoirs (*embung*), harvested area, and agricultural institutions serve as the independent variables.

Table 1 Operational Definition of Variables

Variable	Symbol	Operational Definition	Unit
Rice Production	Prod	Total rice production in each district per year	tons
Small Reservoir (Embung)	E	Presence of a small reservoir (embung) in a district	Dummy (1 = district has an embung; 0 = otherwise
Harvested Area	HA	Total harvested area of rice	Hectares
Agricultural Institutions	AI	Number of farmer groups	Units

The empirical model employed in this study is specified as follows:

$$\ln_\text{Prod}_{it} = \alpha + \beta_1_E_{it} + \beta_2 \ln_HA_{it} + \beta_3 ln_AI_{it} + \varepsilon \quad \text{.....(1)}$$

Where:

Prod	= Rice Production
α	= Constant
ln	= Natural Logarithm
E	= Embung Dummy Variable (1 = district has an embung; 0 = otherwise)
HA	= Harvested Area
AI	= Agricultural Institutions
$\beta_1, \beta_2, \beta_3$	= Regression Coefficients
i	= District
t	= Time Period
ε	= Error Term

The selection of the appropriate panel data model was conducted using the Chow test, Hausman test, and Lagrange Multiplier (LM) test. Subsequently, classical assumption tests were performed to ensure that the estimated model satisfies the criteria of the Best Linear Unbiased Estimator (BLUE).

The normality test was not conducted in this study based on the Central Limit Theorem, which states that when the sample size or total number of observations is sufficiently large generally exceeding 30 or 100 observations the sampling distribution of the regression estimator will approximate a normal distribution regardless of the original distribution of the raw data.

The autocorrelation test was also not performed because this test is primarily intended for time-series data. Applying it to cross-sectional or panel data is considered unnecessary, as panel data generally possess stronger cross-sectional characteristics (Basuki & Prawoto, 2021). Therefore, to ensure that the model can be appropriately analyzed and produce reliable results, the classical assumption tests conducted in this study were limited to the multicollinearity test and the heteroscedasticity test.

The final stage of the analysis involved statistical testing through the coefficient of determination (R^2), the F-test, and the t-test at a 5 percent significance level. These tests were conducted to evaluate the explanatory power of the model and to determine the individual and joint effects of the independent variables on rice production.

RESULTS AND DISCUSSION

Overview of the Study Area and Research Variables

Banyumas Regency is one of the regencies in Central Java Province, Indonesia, where the agricultural sector serves as a major pillar of the regional economy. Administratively, Banyumas Regency consists of 27 sub-districts and covers an area of approximately 1,327 km². The regency exhibits diverse topographical characteristics, ranging from lowland areas to hilly regions, resulting in variations in water resource availability across sub-districts.

Agriculture plays a significant role in the economic development of Banyumas Regency, particularly the food crop subsector. Rice is the primary agricultural commodity cultivated by local farmers and serves as an important source of household income. Nevertheless, rice production in Banyumas Regency continues to face several challenges, particularly regarding the availability of irrigation water during the dry season. Many agricultural areas are still dominated by rainfed rice fields that depend heavily on rainfall, making them vulnerable to production declines during periods of drought.

To improve water availability for agricultural activities, the government has constructed 31 farm reservoirs (embung) distributed across 15 sub-districts in Banyumas Regency. These reservoirs function as water storage facilities that collect rainfall and surface runoff, which can subsequently be utilized as supplementary water sources during the dry season. In addition to supporting agricultural activities, farm reservoirs also contribute to water resource conservation and drought risk reduction.

Harvested area is one of the production factors that directly determines the level of output generated in rice farming. This variable is measured in hectares and represents the area of rice fields successfully harvested in each sub-district. According to the Banyumas Regency Communication and Information Office (2026), harvested area in Banyumas Regency during the period 2017–2025 exhibited considerable variation across sub-districts. Areas characterized by extensive rice-growing land generally recorded larger harvested areas than those dominated by urban development. Such variation reflects differences in land resource potential among regions.

Farmer groups constitute one form of agricultural institution that functions as a platform for learning, cooperation, and capacity building among farmers. The number of farmer groups varies across sub-districts in Banyumas Regency, reflecting differences in the level of farmer organization within each area. The presence of farmer groups is expected to improve farmers' access to information, agricultural technologies, government assistance programs, and various agricultural development initiatives.

Data Analysis

a. Panel Data Regression

Panel data regression analysis was employed to examine the effects of farm reservoirs (embung), harvested area, and agricultural institutions on rice production in Banyumas Regency during the period 2017–2025. The analysis was conducted using EViews 9 software.

The heteroscedasticity test indicated that the variables Harvested Area and Agricultural Institutions did not satisfy the homoscedasticity assumption. To address this issue and obtain robust parameter estimates, the White Cross-Section Standard Errors and Covariance correction method was applied. This approach adjusts the standard errors to account for heteroscedasticity across cross-sectional units, thereby improving the reliability of statistical inference. The results of the panel data regression estimation are presented as follows:

Table 2 Comparison of Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) Estimation Results

Variabel	CEM	FEM	REM
Coefficient	2.021205	6.524462	2.460793
X1_E	0.091712	-0.067514	0.065074
lnX2_HA	0.802782	0.295116	0.690856
lnX3_AI	0,292411	0.139733	0.395536
R-Squared	0.897334	0.940282	0.800597
Adjusted R-squared	0.896045	0.932151	0.798094
F-statistic	696.3091	115.6469	319.8597
Prob(F-statistic)	0.000000	0.000000	0.000000

Source: Processed EViews Output, 2026

The estimation results indicate that the choice of estimation method can influence the regression outcomes. Therefore, model selection testing is necessary to identify the most appropriate model for further analysis and to ensure reliable parameter estimation.

b. Model Selection

The selection of the most appropriate panel data estimation model was conducted using the Chow test, Hausman test, and Lagrange Multiplier (LM) test. The Chow test was employed to determine the preferred model between the Common Effects Model (CEM) and the Fixed Effects Model (FEM). The Hausman test was used to compare the Fixed Effects Model (FEM) and the Random Effects Model (REM), while the Lagrange Multiplier test was designed to select between the Random Effects Model (REM) and the Common Effects Model (CEM).

Based on the Chow test results, the probability value of the Cross-section F statistic was 0.0000, which is lower than the significance level of 0.05 (0.0000 < 0.05). Therefore, the Fixed Effects Model (FEM) was selected as the preferred model according to the Chow test.

The next stage involved the Hausman test. The results indicated that the probability value of the Cross-section Random statistic was 0.0000, which is also lower than the significance level of 0.05 (0.0000 < 0.05). Consequently, the Fixed Effects Model (FEM) was preferred over the Random Effects Model (REM). Thus, based on both the Chow test and the Hausman test, the Fixed Effects Model (FEM) was selected as the most appropriate model for estimating the relationship between the study variables.

c. Classical Assumption Tests

Based on the multicollinearity test results, the Variance Inflation Factor (VIF) values for the Farm Reservoir Dummy variable, Harvested Area, and Agricultural Institutions were 1.092062, 2.146507, and 2.214178, respectively. Since all VIF values were below the threshold value of 10,

the model was considered free from multicollinearity problems. Therefore, the analysis proceeded to the heteroscedasticity test.

The heteroscedasticity test was conducted using the Glejser method. The results indicated the presence of heteroscedasticity in the initial regression model, as evidenced by the probability values of the Harvested Area variable (0.0000) and the Agricultural Institutions variable (0.0004), both of which were below the 5 percent significance level. To address this issue and ensure that the estimated coefficients retained the properties of the Best Linear Unbiased Estimator (BLUE), the study applied the White Cross-Section Standard Errors and Covariance correction when estimating the Fixed Effects Model (FEM) (Gujarati & Porter, 2009).

By employing this robust standard errors approach, the problem of non-constant error variance was automatically corrected by the estimation procedure. As a result, the t-tests (partial significance tests) and F-test (overall significance test) derived from the final model remain valid, unbiased, and scientifically interpretable without requiring further data transformation.

d. Statistical Tests

Based on the estimation results, the coefficient of determination (R^2) was found to be 0.940282. This indicates that approximately 94.02% of the variation in rice production in Banyumas Regency can be explained by the farm reservoir dummy variable, harvested area, and agricultural institutions included in the model. The remaining 5.98% is explained by other factors not incorporated into this study.

The estimation results also show that the F-statistic value is 115.6469, which exceeds the critical F-value of 2.6423 (115.6469 > 2.6423). This finding indicates that the farm reservoir dummy variable, harvested area, and agricultural institutions jointly have a statistically significant effect on rice production in Banyumas Regency.

The critical t-value used in this study is 1.971. The calculated t-statistics for each independent variable are presented as follows:

Table 3 t-Test Results

Variabel	t-statistic	t-tabel	Prob	Keterangan
X1_E	-2,090650	1,652	0.0377	Signifikan
LNX2_HA	2,021628	1,652	0.0445	Signifikan
LNX3_AI	0,894609	1,652	0.3720	Tidak Signifikan

Source: Processed EViews Output, 2026

From the table, it can be concluded that the “Reservoir” variable has a significant negative effect, the “Harvested Area” variable has a significant positive effect, and the “Agricultural Institutions” variable has no significant effect on rice production in Banyumas Regency during the 2017–2025 period.

Discussion

a. The Effect of the “Embung” Variable on Rice Production in Banyumas Regency, 2017–2025

The results of the study indicate that the presence of reservoirs has a significant negative impact on rice production in Banyumas Regency during the 2017–2025 period. This finding appears to contradict the theory that water availability is one of the key factors in rice farming. These results can be explained by the characteristics of reservoir construction sites, which are generally not located in areas with already good irrigation conditions, but rather in areas with limited water resources. The construction of reservoirs is essentially a form of government intervention aimed at reducing vulnerability to drought in agricultural lands, particularly rain-fed rice fields; consequently,

reservoirs are more commonly found in areas that naturally have relatively lower productivity levels compared to regions with well-established technical irrigation networks.

This situation is evident in several subdistricts in Banyumas Regency that have reservoirs, such as Rawalo, Purwojati, Wangon, and Tambak. These areas are dominated by rain-fed agricultural land and have limited access to surface water sources. Subdistricts with reservoirs do not necessarily produce higher rice yields than those without reservoirs. For example, Pekuncen Subdistrict, which does not have a reservoir, actually recorded the highest rice production in 2022. This indicates that reservoirs serve primarily as a means of supporting water availability and mitigating drought risk rather than as a factor that directly increases rice production. Rice production remains influenced by various other factors, particularly harvested area, which in this study was found to have a positive and significant effect on rice production.

Furthermore, the benefits of constructing reservoirs tend to be medium- to long-term in nature. Reservoirs serve as rainwater storage facilities used to meet irrigation needs during the dry season; thus, their role is more prominent as a tool for mitigating drought risk than as a factor that directly increases production in the short term. Several studies indicate that the effectiveness of reservoirs depends heavily on their storage capacity, the availability of distribution networks, and farmers' water management capabilities. Consequently, the presence of reservoirs does not necessarily lead to an immediate increase in production if they are not supported by an optimal water distribution system and adequate management.

The results of this study must also be understood in the context of the climate dynamics that occurred during the observation period. In 2019, Banyumas Regency experienced an increase in the area of land affected by drought and crop failure due to a relatively long dry season. A similar phenomenon occurred again in 2024 when El Niño caused rainfall to decrease and the dry season to last longer. The impact of El Niño on the agricultural sector was not limited to Banyumas but was felt nationwide through a decline in harvested area and rice production due to reduced availability of irrigation water. Data from the Central Statistics Agency indicate that the decline in rice production in 2024 was primarily caused by a reduction in harvested area as a consequence of the El Niño-induced drought.

In the Cobb-Douglas production function theory, agricultural production is the result of a combination of various factors of production, such as land, labor, capital, technology, and water resources. Reservoirs serve only as one component in the water supply system; therefore, their contribution to increased production will depend on their interaction with other factors of production. Therefore, the presence of reservoirs cannot be expected to automatically increase rice production if other constraints remain, such as limited harvestable area, poor-quality irrigation networks, or extreme weather events.

The results of this study are consistent with the research by Nuardiansyah & Hayati (2025), which showed that the presence of reservoirs has not yet provided optimal benefits in Banyumas Regency. Although they used different dependent variables, both studies indicate that the construction of reservoirs alone is not sufficient to improve the performance of the agricultural sector. The study by Hidayat et al. (2024) found that reservoirs are not always effective in meeting the water needs of rice fields. These conditions suggest that the presence of reservoirs alone does not guarantee increased rice production, as their effectiveness is influenced by storage capacity, climatic conditions, and the ability to distribute water to agricultural land. Thus, the benefits of reservoirs for rice production are highly dependent on the quality of their management and utilization. Therefore, increasing rice production requires support from integrated irrigation infrastructure and agricultural institutions so that the benefits of reservoirs can be fully realized.

b. The Effect of Harvested Area on Rice Production in Banyumas Regency, 2017–2025

The regression results indicate that the harvested area variable has a positive and significant effect on rice production in Banyumas Regency during the 2017–2025 period. This finding suggests

that an increase in harvested area tends to be followed by an increase in rice production. Theoretically, rice production is the result of the interaction between harvested area and land productivity. Therefore, the larger the area successfully harvested, the greater the production, assuming that productivity levels remain relatively constant. Harvested area is an important indicator because it reflects the amount of land that successfully produces paddy in each growing season.

This relationship is reflected in the trend of rice production in Banyumas Regency during the study period. In 2018, the harvested area increased from 66,209.7 hectares to 69,973.8 hectares, or by approximately 5.69%, followed by a rise in rice production from 368,301.41 metric tons to 406,070.88 metric tons, or by approximately 10.25%. Conversely, in 2019, the harvested area decreased to 63,973.4 hectares, and rice production also fell to 364,948.72 metric tons. The same pattern reoccurred in 2024 when the harvested area shrank by 9.25%, followed by a 9.13% decline in production. In 2025, an increase in harvested area once again drove an increase in rice production. This pattern indicates that changes in harvested area are generally followed by changes in rice production moving in the same direction.

At the subdistrict level, areas with large harvested areas tend to have high rice production. The subdistricts of Cilongok, Sumbang, Pekuncen, and Kemranjen had the highest average production during the study period, supported by relatively large harvested areas. Conversely, subdistricts in urban areas such as West Purwokerto, East Purwokerto, and South Purwokerto have smaller harvested areas, resulting in lower rice production. These findings indicate that the availability of arable land remains a key factor in determining rice production levels across regions in Banyumas Regency.

These findings are consistent with the research by Saleh Modjo et al. (2025) and Syawaludin & Alfiyani (2025), who found that harvested area has a positive and significant effect on rice production. These findings reinforce the results of this study, which indicate that increasing harvested area is a key factor in boosting rice production, particularly when supported by good land productivity.

a) The Effect of Agricultural Institutional Variables on Rice Production in Banyumas Regency, 2017–2025

The regression results show that the agricultural institutional variable—measured by the number of farmer groups—has a positive but insignificant effect on rice production in Banyumas Regency during the 2017–2025 period. These results indicate that the existence of farmer groups generally provides a positive direction for the development of farming enterprises, but has not yet been able to significantly increase rice production. This situation suggests that an increase in the number of farmer groups is not necessarily accompanied by improvements in institutional quality, organizational effectiveness, or the groups' ability to promote the adoption of agricultural innovations and technologies.

The lack of impact of agricultural institutions can be attributed to various structural constraints still faced by the agricultural sector in Banyumas Regency. One of the main constraints is the limited number of agricultural extension workers, which is not commensurate with the number of villages under their supervision; as a result, a single extension worker often has to assist several villages at once. This situation prevents extension activities, technology transfer, cultivation guidance, and farmer group development from being carried out optimally and sustainably.

In addition, the low rate of farmer succession is also a factor affecting the effectiveness of agricultural institutions. Most farmers are still in the older age group, so their ability to accept and adopt agricultural innovations is relatively limited. As a result, farmer groups often function more as administrative vehicles for the distribution of government aid rather than as forums for learning, cooperation, and the development of farming businesses capable of increasing agricultural productivity.

This situation is reflected in the differences in the number of farmer groups and rice production levels across subdistricts in Banyumas Regency. In 2025, Gumelar Subdistrict had 117 farmer groups but produced only 12,566.11 metric tons of rice. In contrast, Jatilawang Subdistrict, with 76 farmer groups, was able to produce 21,407.40 metric tons. A similar phenomenon is observed in Ajibarang Subdistrict, which has 104 farmer groups and a production of 18,308.11 metric tons, whereas Tambak Subdistrict, with only 64 farmer groups, was able to produce 21,905.82 metric tons. These findings indicate that the number of farmer groups does not necessarily reflect the institutional effectiveness in increasing rice production.

The results of this study are consistent with those of Adiaksa et al. (2024), who found that farmer groups do not automatically increase farm productivity if they do not function optimally as a platform for learning, cooperation, and the dissemination of innovations. These findings are also supported by Anantanyu (2011), who explains that the success of farmer institutions is more determined by organizational capacity, group leadership, member participation, and agricultural extension support. Therefore, increasing rice production requires not only an increase in the number of farmer groups but also the strengthening of institutional capacity, the quality of extension services, and the enhancement of farmers' ability to adopt agricultural innovations and technologies.

CONCLUSION

This study aims to analyze the effects of reservoirs, harvested area, and agricultural institutions on rice production in Banyumas Regency from 2017 to 2025. Based on the results of panel data regression analysis, it was found that reservoirs have a significant negative effect on rice production. These results indicate that areas with reservoirs tend to produce lower rice yields compared to areas without reservoirs. Meanwhile, harvested area has a positive and significant effect on rice production. Agricultural institutions, as measured by the number of farmer groups, do not have a significant effect on rice production.

The results of this study imply that local governments need to optimize reservoir management through routine maintenance, increased storage capacity, and improvements to the water distribution system so that the benefits of reservoirs to the agricultural sector can be maximized. Furthermore, efforts to protect agricultural land and increase harvested area must continue, given that harvested area has been proven to be a significant factor influencing rice production. Strengthening agricultural institutions should also focus on improving the quality and effectiveness of farmer groups through training, mentoring, and increased access to agricultural technology and information rather than merely focusing on increasing the number of farmer groups.

This study has several limitations. The reservoir variable was measured using a dummy variable that only indicates the presence or absence of a reservoir in a subdistrict; thus, it is not yet capable of describing the characteristics of reservoirs in greater detail, such as the number of reservoirs, water storage capacity, irrigation service area, utilization rate, and physical condition. Furthermore, this study only included reservoirs, harvested area, and agricultural institutions as explanatory variables; thus, other factors that could potentially influence rice production such as rainfall, fertilizer use, irrigation conditions, and agricultural technology were not analyzed. Therefore, future research is recommended to use more comprehensive reservoir indicators and include other relevant variables to provide a more in-depth explanation of the factors influencing rice production.

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