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Research Article
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Agribusiness performance associated with Brigade Pangan participation among lowland rice farmers in Barru Regency, Indonesia

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Abstract: Lowland rice farming remains central to Indonesian food security, yet smallholder systems are often constrained by fragmented land management, uneven technology adoption, limited managerial capacity, and weak market leverage. This study provides descriptive-comparative evidence on the association between participation in Brigade Pangan, a farmer-based institutional model for collective agricultural management, and lowland rice agribusiness performance in Mallusetasi District, Barru Regency. Forty-five purposively selected farmers (15 per group) were classified into three groups: Brigade Pangan members, farmers assisted by Brigade Pangan, and non-assisted farmers. These respondents were purposively selected to represent the three study categories and were not intended to be statistically representative of all farmers in Barru Regency. Because the groups were selected purposively, the comparisons are descriptive and are not intended to support population-level or causal inference. Farmer capacity was assessed using five-point Likert indicators of knowledge, attitude, and skill, while farm performance was evaluated using productivity, revenue, production cost, net income, R/C ratio, unit cost, net margin, selling price, and comparison with the Barru Regency productivity benchmark. Brigade Pangan members recorded the highest overall capacity score (4.53), calculated as the mean of the knowledge, attitude, and skill dimension scores, exceeding assisted and non-assisted farmers by 19.4% and 58.8%, respectively. Their productivity reached 72.5 quintal/ha, approximately 34.3% above both the Barru Regency benchmark and non-assisted farmers. They also recorded the most favorable economic outcomes, including IDR 47.125 million/ha in revenue, IDR 34.749 million/ha in net income, an R/C ratio of 3.81, the lowest unit production cost, and the highest grain selling price. These descriptive patterns indicate that greater Brigade Pangan involvement coincided with higher reported farmer-capacity scores, higher land productivity, and more favorable farm-business outcomes, without demonstrating a causal pathway. The study provides locally grounded evidence for evaluating agricultural institutions using integrated capacity, productivity, and economic indicators rather than production volume alone.

Keywords: collective farming, farm profitability, farmer capacity, institutional upgrading, paddy systems, smallholder agriculture

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1. Introduction

Rice farming remains a strategic foundation of national food security, rural employment, and regional economic stability in Indonesia. Rice is not only a staple crop but also an economic anchor for smallholder households whose income depends on seasonal productivity, input affordability, and access to predictable markets. National and regional studies consistently show that rice performance is shaped by land availability, productivity, production cost, and farmers' ability to manage increasingly complex agribusiness systems (Laim & Simamora, 2022; Pramono & Romdon, 2022; Khasanah & Gunanto, 2024). In lowland ecosystems, yield improvement is therefore only one part of a broader development challenge. Farmers must also convert output into farm revenue efficiently, maintain land productivity under environmental pressure, and participate in institutions capable of coordinating production and market access.

The contemporary challenge of rice development is increasingly structural rather than merely technical. Many rice-producing areas still experience fragmented land management, small operating scale, uneven adoption of technology, limited managerial capacity, and weak bargaining power in the grain market. These constraints have been reported in Indonesian rice agribusiness, where modernization is often inhibited by structural and cultural barriers, limited market integration, and socio-economic vulnerability (Sasmita et al., 2023; Nugraha & Kurnia, 2024). International evidence also suggests that rice systems are affected by resource-use inefficiency, land fragmentation, climate risk, and weak coordination among production actors (van Aalst et al., 2023; Touch et al., 2024; Felix et al., 2025). In the study location, the Brigade Pangan model directly provided its formal members with technical training and guidance from mentors or agricultural experts, while assisted farmers received related information indirectly through Brigade Pangan representatives within their farmer groups. Non-assisted farmers did not receive formal Brigade Pangan guidance and primarily relied on their own farming experience. Other potential mechanisms, such as coordinated mechanization, input management, or improved market positioning, are treated in this study as contextual or hypothesized explanations unless directly supported by the observed data.

South Sulawesi provides an important empirical setting for examining this issue because it is one of Indonesia's major rice-producing regions. Barru Regency, located within this production landscape, has substantial rice potential, with a harvested area of 21,213.26 ha and a reported productivity benchmark of 53.98 quintal/ha in 2024 according to Badan Pusat Statistik (BPS) (2025). These figures indicate that the regency possesses a viable rice production base. However, a production base does not automatically imply optimal agribusiness performance. Farmers can operate in a productive agroecological area and still face inefficient input allocation, weak post-harvest management, and limited market leverage. This distinction between agronomic potential and business performance is central to the present study.

At the farm level, this agenda requires a shift from production-centered thinking toward enterprise-centered management. Recent studies on Indonesian rice farming show that management capability is relevant to farm profitability under rising production costs, climate variability, and labor constraints (Nasution et al., 2024; Buna et al., 2025). Similar evidence from broader rice systems indicates that risk, insurance participation, and input allocation affect economic efficiency, even when farmers cultivate the same crop in comparable environments (Azriani et al., 2023; Castro et al., 2023; Helmy et al., 2023). In the present study, farm management was not measured as a separate construct. Farmer institutions are therefore evaluated through observed differences in farmer capacity, productivity, and farm-business outcomes rather than through a direct measure of managerial performance.

Land productivity is the empirical land-related concept examined in this article. Although land optimization can encompass cultivated area, cropping intensity, input efficiency, technology use, and land management, the available data do not measure these dimensions comprehensively. The present study therefore operationalizes the land-related outcome

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specifically as rice productivity per unit of existing cultivated land and compares it with the Barru Regency productivity benchmark. Recent land-use studies in Indonesia show that shrinking paddy fields and changing cropping intensity can threaten rice provisioning services, creating a need for more efficient use of existing agricultural land (Gandharum et al., 2025). This narrower operationalization is consistent with literature showing that land management, irrigation, nutrient management, and cropping intensity are associated with rice productivity (Siddique et al., 2021; Awwal Fuqara & Windi Tanjung, 2023; Yuliani et al., 2024; Akbar et al., 2025).

Agribusiness performance is equally important because productivity gains do not necessarily improve farmer welfare when production costs rise excessively or when farmers receive lower selling prices. Farm performance should therefore be measured through revenue, net income, unit cost, R/C ratio, and margin indicators, not yield alone. Studies of rice profitability and resource-use efficiency have shown that higher returns depend on input allocation, cost control, production systems, and market outcomes (Divya Lekshmi et al., 2021; Lone et al., 2021; Maity et al., 2023). Similar concerns appear in Indonesian research on rice technical efficiency, where intensification and cropping intensity do not always produce synergistic outcomes when resource use is poorly coordinated (Sumaryanto et al., 2023). Accordingly, the present study evaluates whether differences in Brigade Pangan involvement coincide with differences in land productivity and farm-business outcomes, without treating farm management or bargaining power as independently measured constructs.

Institutional innovation has become a prominent response to this problem. The Indonesian Ministry of Agriculture introduced Brigade Pangan as a farmer-based institutional model intended to support modern, area-based, and business-oriented agricultural management. At the program level, Brigade Pangan emphasizes farmer organization, mechanization, training, land management, and upstream-downstream coordination (Pusat Pelatihan Pertanian, 2024; Ramija et al., 2025; Suryana et al., 2025). In the study location, however, the services documented as actually received differed by group. Formal Brigade Pangan members received technical training and guidance directly from mentors or agricultural experts; assisted farmers obtained related information indirectly through Brigade Pangan representatives within their farmer groups; and non-assisted farmers relied primarily on their own farming experience without formal Brigade Pangan guidance. Brigade Pangan members also reported more complete use of agricultural machinery and production inputs, whereas these potential pathways were not independently tested as causal mechanisms. In principle, Brigade Pangan is intended to support a transition from individual and fragmented cultivation toward coordinated agribusiness management. This logic is consistent with evidence from other agricultural institutional models. For instance, farmer participation in Rythu Bharosa Kendras in India was associated with higher technical efficiency and lower cost of cultivation in rice farming (Kumar et al., 2025), while collective irrigation governance has been linked to farm efficiency and knowledge diffusion at the plot level (Yang et al., 2026).

However, the specific empirical, methodological, and contextual gap addressed by this article remains clear. Existing studies have examined rice technology adoption, integrated crop management, mechanization, and resource-use efficiency, but fewer studies have evaluated how a newly formed farmer institution such as Brigade Pangan is associated with measurable differences in farmer capacity, land productivity, price realization, and farm financial performance at the local scale. Existing discussion of Brigade Pangan is also still dominated by program design and policy narrative rather than comparative agribusiness evidence. Accordingly, the present study addresses this gap through a descriptive-comparative assessment of whether farmers with direct, indirect, and no formal Brigade Pangan involvement display different capacity, land-productivity, and farm-business performance patterns. The analysis is intended to characterize these group-level associations rather than establish the independent

causal effect of Brigade Pangan.

The contribution of this study lies in providing locally grounded descriptive-comparative evidence that jointly considers farmer capacity, land productivity, and farm-business performance across different levels of Brigade Pangan involvement. Prior studies have separately examined farmer capacity and production (Fadhilah et al., 2018; Yulia et al., 2024), agricultural technology adoption (Connor et al., 2021; Ruzzante et al., 2021), integrated crop management and productivity (Erythrina et al., 2021; Joka et al., 2025), mechanization and modern land management (Saranya et al., 2024; Ruan et al., 2025), and rice farm profitability (Dey et al., 2023; Pame et al., 2023). Rather than presenting an untested institutional pathway as a novel mechanism, this study integrates these dimensions within a common descriptive comparison to examine whether greater Brigade Pangan involvement coincides with stronger capacity profiles, higher land productivity, and more favorable farm-business outcomes.

Based on this research gap, the study aims to analyse the association between different levels of Brigade Pangan involvement, land productivity, and lowland rice agribusiness performance in Mallusetasi District, Barru Regency. Specifically, it evaluates differences among Brigade Pangan members, assisted farmers, and non-assisted farmers in knowledge, attitude, skill, productivity, revenue, cost, income, R/C ratio, unit cost, net margin, and price realization. The article contributes to agribusiness scholarship by showing how a local farmer-institution model can be evaluated through an integrated set of capacity, land-productivity, and economic indicators without assuming that the observed relationships constitute a tested capacity–management–performance chain. It also offers practical evidence for local governments seeking to strengthen food production through farmer institutions rather than relying only on input subsidies or land expansion.

2. Materials and Methods

2.1 Study design, location, and respondents

This study used a descriptive-comparative design. The descriptive component documented farmer capacity, production indicators, and financial performance, while the comparative component examined differences across three respondent groups. The study was conducted in Mallusetasi District, Barru Regency, in March 2026. The location was selected purposively because it is an active lowland rice production area, contains two Brigade Pangan organizations, and represents a local implementation site of the program. This setting allowed descriptive comparison among farmers with direct, indirect, and no formal involvement in Brigade Pangan.

2.2 Sampling and data collection

The research population comprised lowland rice farmers in the study area. A total of 45 respondents were selected through purposive sampling and divided into three equal groups: 15 Brigade Pangan member farmers, 15 farmers assisted by Brigade Pangan, and 15 non-assisted farmers. Respondent selection was based on predefined institutional-status criteria. Eligible Brigade Pangan respondents were farmers formally included in the organizational structures of the two Brigade Pangan organizations operating in Mallusetasi District. Assisted respondents were selected from members of farmer groups affiliated with Brigade Pangan but whose names were not included in the Brigade Pangan organizational structure. Non-assisted respondents were selected from farmer groups that were not affiliated with Brigade Pangan. Respondents were therefore recruited purposively from farmers meeting these category-specific criteria rather than through random sampling or a statistically representative sampling frame. The allocation of 15 respondents to each group was used to provide a balanced descriptive comparison across the three levels of Brigade Pangan involvement and was not based on a formal statistical power calculation. Brigade Pangan members were farmers formally included in the organizational structure of Brigade Pangan, in which participating farmer groups were

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represented by designated members. Assisted farmers were members of farmer groups affiliated with Brigade Pangan but were not themselves included in the Brigade Pangan organizational structure. Non-assisted farmers were members of farmer groups that were not affiliated with Brigade Pangan. This three-group design was used to capture an institutional gradient. Brigade Pangan members represent direct exposure to the program, including direct technical training and guidance from mentors or agricultural experts; assisted farmers represent indirect exposure through information transferred by Brigade Pangan representatives within their farmer groups; and non-assisted farmers had no formal Brigade Pangan-related guidance and primarily relied on their own farming experience. Production and financial information for all three groups referred to the same production period, namely the second planting season (MT II). The design is not intended to establish population-level causality, and purposive respondent selection may introduce selection bias; the comparisons are therefore interpreted as descriptive group-level patterns rather than representative or causal estimates. Primary data were collected through field observation, structured questionnaires, and interviews with respondents. Secondary data were obtained from regional statistical and agricultural sources used in the study, particularly the Barru Regency productivity benchmark.

2.3 Variables and measurement of farmer capacity

The dataset includes two principal categories. The first concerns farmer capacity, measured through knowledge, attitude, and skill indicators. The second concerns agribusiness performance, including production, selling price, revenue, production cost, net income, R/C ratio, and productivity. Farmer capacity was measured using a five-point Likert scale with five questionnaire items for each dimension, resulting in 15 items in total. Each dimension score was calculated as the mean of its five items, while the overall capacity score was calculated as the mean of the three-dimension scores. Knowledge refers to farmers' understanding of rice cultivation, input management, appropriate improved rice varieties, pest and disease management, and agricultural technology. Attitude refers to farmers' openness to innovation, willingness to participate in training or extension activities, willingness to try new farming methods, and perceptions of the importance of productivity improvement and agricultural assistance. Skill refers to the practical ability to determine fertilizer requirements according to field conditions, apply appropriate planting techniques, operate agricultural machinery when available, and apply knowledge obtained through training or extension. Mean scores were classified using an interval width of 0.80, calculated as (5−1)/5: 1.00–1.80 = very poor, 1.81–2.60 = poor, 2.61–3.40 = fair, 3.41–4.20 = good, and 4.21–5.00 = very good. This operationalization follows the logic that knowledge, attitude, and skill form the behavioral foundation of agricultural innovation and agribusiness upgrading (Fadhilah et al., 2018; Ansori et al., 2022; Yulia et al., 2024). Because the analytical dataset available for this manuscript contains aggregated dimension scores rather than respondent-level item responses, internal consistency statistics such as Cronbach's alpha could not be calculated from the available data. The interpretation is therefore descriptive and should be read as a capacity profile rather than a psychometric validation.

2.4 Land optimization and economic indicators

The land-related outcome was assessed through land productivity rather than a broader measure of land optimization. Productivity was calculated as harvested output per hectare and expressed in quintal/ha. The key comparison was between the productivity of Brigade Pangan farmers, assisted farmers, non-assisted farmers, and the Barru Regency benchmark of 53.98 quintal/ha. Productivity advantage was calculated as the percentage difference between each group and the benchmark or comparator group. Agribusiness performance was measured using standard farm business indicators. The selling price represented the actual price received by farmers for each

kilogram of grain sold during the second planting season (MT II). The financial indicators were calculated as follows: total revenue, $TR = Q \times P$; net income, $\pi = TR - TC$; and the R/C ratio, $R/C = TR/TC$, where Q is harvested output, $P$is the actual selling price per kilogram, and TC is total production cost. An R/C ratio greater than 1 indicates that revenue exceeds production cost. Additional derived indicators were calculated as production cost per kilogram, TC/Q; net margin per kilogram, $P - (TC/Q)$; and break-even yield, TC/P. Total production cost was based on farmers' reported expenditures for production inputs and farm operations during MT II. Because respondents did not always maintain exact itemized expenditure records and in some cases reported approximate amounts, these values are treated as farmer-reported cost estimates rather than audited accounting records. The aggregate cost included expenditures associated with inputs and farm operations such as seed, fertilizer, pesticides, and machinery use, as applicable. Separate estimates for family labor opportunity cost, land rent, depreciation, and capital interest were not available.

2.5 Statistical approach and analytical boundaries

The available dataset consists of group-level summary statistics rather than respondent-level raw observations. For this reason, the study uses aggregate comparative descriptive analysis rather than inferential statistical testing. The analysis calculates means, absolute differences, percentage differences, unit-cost indicators, margin indicators, and benchmark comparisons. Inferential tests such as regression, analysis of variance, or stochastic frontier analysis were not applied because the analytical dataset available for this manuscript does not contain respondent-level observations or within-group variance estimates. In addition, purposive selection of 15 respondents per group may introduce selection bias, and potentially relevant differences in farm and farmer characteristics were not statistically controlled. This limitation is explicitly acknowledged to preserve statistical integrity. The findings should therefore be interpreted as descriptive group-level associations between different levels of Brigade Pangan involvement and observed performance indicators, not as a formal causal estimate of the independent effect of Brigade Pangan.

2.6 Analytical framework

The analytical framework is presented in Figure 1. The framework organizes the variables directly examined in this study: level of Brigade Pangan involvement, farmer capacity, land productivity, and agribusiness performance. Brigade Pangan involvement is represented by three groups, namely, members with direct program exposure, assisted farmers with indirect exposure, and non-assisted farmers without formal Brigade Pangan exposure. Farmer capacity is represented by knowledge, attitude, and skill scores, while land productivity is measured as harvested output per hectare. Agribusiness performance is represented by selling price, revenue, production cost, net income, R/C ratio, unit cost, net margin, and break-even yield. The framework is used to structure descriptive comparisons among these observed dimensions rather than to specify a tested causal or mediation pathway. Farm management, mechanization effects, and bargaining power were not independently measured and are therefore not included as empirical intermediate constructs.

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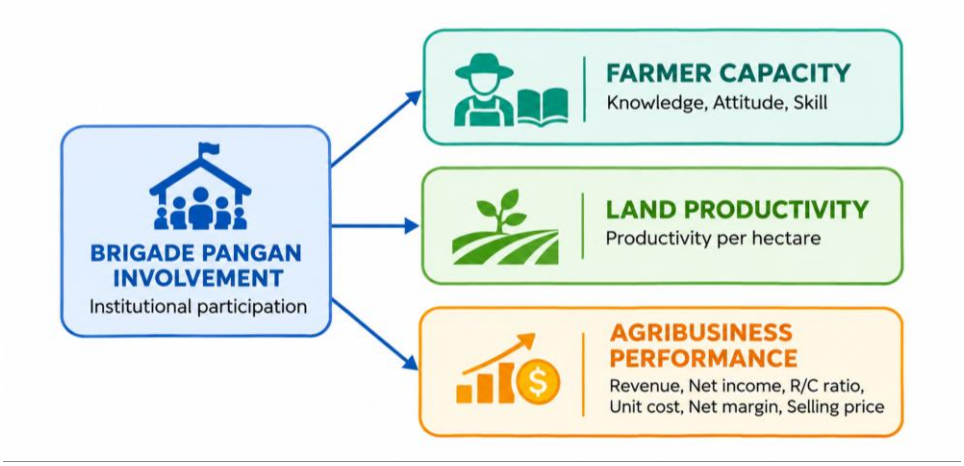

Figure 1. Analytical framework linking Brigade Pangan involvement, farmer capacity, land productivity, and agribusiness performance.

3. Results and Discussion

3.1 Institutional participation and farmer capacity

The first major finding concerns farmer capacity. Table 1 shows a clear difference among the three groups across knowledge, attitude, and skill. Brigade Pangan farmers achieved the highest scores in all dimensions, with an overall capacity score of 4.53, calculated as the mean of the three-dimension scores for knowledge, attitude, and skill, and a qualitative category of very good. Assisted farmers recorded an overall capacity score of 3.79, categorized as good, while non-assisted farmers recorded an overall capacity score of 2.85, categorized as fair. The average capacity of Brigade Pangan farmers was therefore 19.4% higher than that of assisted farmers and 58.8% higher than that of non-assisted farmers. This pattern indicates that greater institutional involvement is descriptively associated with a stronger farmer-capacity profile.

Table 1. Farmer knowledge, attitude, and skill in lowland rice farming.

Variable	Brigade Pangan	Category	Assisted BP Score	Category	Non-assisted Score	Category
Knowledge	4.79	Very good	3.57	Good	2.85	Fair
Attitude	4.51	Very good	4.00	Good	2.85	Fair
Skill	4.28	Very good	3.80	Good	2.85	Fair
Average	4.53	Very good	3.79	Good	2.85	Fair

Note. Field data processed from the available dataset, 2026. Each dimension score was calculated independently as the mean of five Likert-scale items scored from 1 to 5. The overall capacity score was calculated as the mean of the three-dimension scores. Category intervals were 1.00–1.80 = very poor, 1.81–2.60 = poor, 2.61–3.40 = fair, 3.41–4.20 = good, and 4.21–5.00 = very good. The identical mean score of 2.85 for knowledge, attitude, and skill among non-assisted farmers was verified from the study data; each dimension was calculated separately from its respective five items.

Knowledge displayed the largest difference. Brigade Pangan farmers recorded a knowledge score of 4.79, compared with 3.57 among assisted farmers and 2.85 among non-assisted farmers. This gap is important because knowledge is relevant to farmers' ability to understand improved varieties, mechanization schedules, water and nutrient management, pest management, cost calculation, and grain marketing. Studies on technology adoption consistently show that technical and managerial knowledge conditions the successful uptake of agricultural innovation (Ruzzante et al., 2021; Touch et al., 2024). In the study area, Brigade Pangan members received technical training and guidance directly from mentors or agricultural experts, assisted farmers received related information indirectly through Brigade Pangan representatives within their farmer groups, and non-assisted farmers relied primarily on their

own farming experience. The higher knowledge score among Brigade Pangan members is therefore consistent with greater exposure to formal technical guidance, although the descriptive design does not establish that this exposure caused the observed difference.

Attitude and skill further characterize the capacity gradient. Brigade Pangan farmers scored 4.51 for attitude and 4.28 for skill, both in the very good category, while non-assisted farmers also recorded 2.85 for each dimension; these identical values resulted from separate calculations based on the respective attitude and skill item sets. These findings show that the Brigade Pangan group also had more favourable scores for openness to training, innovation, and improved farming practices, as well as for practical farming skills. Evidence from agricultural innovation studies indicates that positive attitudes increase the likelihood of adopting new land-use practices, while operational skill determines whether such practices are implemented correctly (Mathew et al., 2024; Yulia et al., 2024). Taken together, the three capacity dimensions provide a descriptive profile that is consistent with greater Brigade Pangan-related exposure and stronger farmer capacity, although the study does not test capacity as a causal or mediating mechanism.

3.2 Land optimization and productivity performance

The second major finding concerns land productivity. Table 2 shows that Brigade Pangan farmers produced 7,250 kg/ha, equivalent to 72.5 quintal/ha. Assisted farmers produced 6,350 kg/ha, equivalent to 63.5 quintal/ha, while non-assisted farmers produced 5,400 kg/ha, equivalent to 54.0 quintal/ha. The productivity advantage of Brigade Pangan over non-assisted farmers was 18.5 quintal/ha, or 34.3%. Although all groups were located within the same district and were observed during the same planting season, the descriptive comparison does not control for farm-level differences such as land quality, irrigation access, farm size, seed variety, input intensity, planting dates, or other farmer characteristics. The observed productivity gradient should therefore be interpreted as a descriptive contrast among groups with different levels of Brigade Pangan involvement and not as evidence that Brigade Pangan independently improved productivity.

Comparison with the Barru Regency benchmark provides additional context for the observed land-productivity differences. Brigade Pangan productivity of 72.5 quintal/ha was 34.3% above the benchmark of 53.98 quintal/ha. Assisted farmers were 17.6% above the benchmark, while non-assisted farmers were approximately equal to the benchmark. Figure 2 shows the productivity of each group relative to the benchmark. The pattern shows that the Brigade Pangan group recorded higher land productivity than both the regional benchmark and the non-assisted group. However, these descriptive differences cannot be attributed specifically to Brigade Pangan involvement because potentially relevant factors such as land quality, water availability, seed variety, input intensity, planting dates, and farm size were not controlled. This descriptive pattern can be interpreted alongside studies showing that improved management packages, integrated crop management, and site-specific practices can raise yield and profit in Indonesian lowland rice systems (Erythrina et al., 2021; Joka et al., 2025; Isnurdiansyah et al., 2026).

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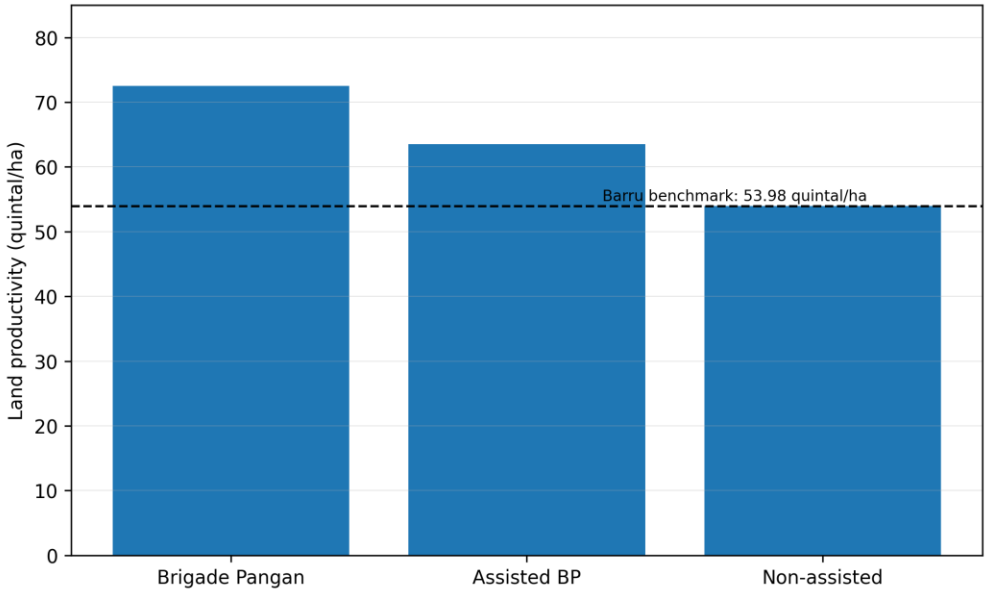

Figure 2. Land productivity of respondent groups relative to the Barru Regency benchmark.

The productivity results show differences in land productivity per unit of cultivated area among the three groups. The analysis is therefore limited to land productivity rather than a broader construct of land optimization. Studies of land suitability and soil capability show that land performance depends on how farmers manage soil properties, water, conservation practices, and cultivation techniques (Al-Hanbali et al., 2022; Asmarani et al., 2023). Rice systems in Southeast Asia also exhibit large yield variation within similar environments, often due to management practices, nutrient management, water control, and varietal adaptation (Fukai & Mitchell, 2026). The observed Brigade Pangan productivity pattern is compatible with this broader literature, while the present descriptive design does not identify which specific management factors or farm characteristics account for the difference.

3.3 Agribusiness performance, efficiency, and market value

The third major finding concerns agribusiness performance. Brigade Pangan farmers generated revenue of IDR 47.125 million/ha, compared with IDR 40.005 million/ha for assisted farmers and IDR 32.940 million/ha for non-assisted farmers. Brigade Pangan revenue was therefore 43.1% higher than that of non-assisted farmers. Because production and revenue are reported on a per-hectare basis, these differences are standardized for cultivated area and do not simply reflect differences in total farm size. The higher revenue coincided with both higher production per hectare and a higher observed selling price. The grain selling price received by Brigade Pangan farmers was IDR 6,500/kg, compared with IDR 6,300/kg among assisted farmers and IDR 6,100/kg among non-assisted farmers. Thus, Brigade Pangan farmers received an observed price difference of IDR 400/kg, or 6.6%, relative to non-assisted farmers. Field information indicated that grain sales by Brigade Pangan members were directly supervised by Babinsa personnel, which helped maintain the selling price, whereas non-assisted farmers were more exposed to price deductions at the point of sale. This contextual difference may help explain the observed price contrast, although the study did not independently estimate the effect of price supervision.

Table 2. Production, financial performance, and derived economic indicators of lowland rice farming per planting season.

Indicator	Unit	Brigade Pangan	Assisted BP	Non-assisted
Average production	kg/ha	7,250	6,350	5,400
Grain selling price	IDR/kg	6,500	6,300	6,100
Revenue (TR)	IDR/ha	47,125,000	40,005,000	32,940,000
Total production cost	IDR/ha	12,376,000	11,099,800	10,466,000
Net income (π)	IDR/ha	34,749,000	28,905,200	22,474,000
R/C ratio	-	3.81	3.60	3.15
Land productivity	quintal/ha	72.5	63.5	54.0
Production cost per kg	IDR/kg	1,707	1,748	1,938
Net margin per kg	IDR/kg	4,793	4,552	4,162
Break-even yield	kg/ha	1,904	1,762	1,716

Note. Field data processed from the available study dataset, 2026. Derived indicators were calculated from the reported production, price, revenue, cost, and income values. All production, revenue, cost, and income values are expressed per hectare. Grain selling price represents the actual price received by farmers for each kilogram of grain sold during the study planting season. Total production cost was based on farmer-reported expenditures for production inputs and farm operations, including seed, fertilizer, pesticides, and machinery use, as applicable. Some respondents reported approximate rather than itemized exact expenditures; therefore, these figures should be interpreted as farmer-reported cost estimates. Separate opportunity costs for family labor, land rent, depreciation, and capital interest were not available. Accordingly, the reported net income represents returns above the recorded production costs and should not be interpreted as comprehensive economic profit. The R/C ratio should likewise be interpreted as a revenue-to-recorded-cost ratio rather than a measure based on full economic costs.

Production cost was also higher for Brigade Pangan farmers, at IDR 12.376 million/ha, compared with IDR 11.100 million/ha among assisted farmers and IDR 10.466 million/ha among non-assisted farmers. However, higher total cost should not be interpreted as inefficiency without examining the output and margin generated by that expenditure. Brigade Pangan production cost was 18.2% higher than that of non-assisted farmers, but revenue was 43.1% higher and net income was 54.6% higher. Field information indicated that the higher production cost among Brigade Pangan farmers coincided with more complete use of production inputs and machinery, including improved seed, calculated fertilizer applications, more complete pest- and disease-control inputs, and machinery such as rice transplanters. In contrast, non-assisted farmers more often relied on simpler or traditional equipment and less intensive input use. Because the expenditure data were based partly on farmers' approximate reports, the contribution of individual cost components could not be quantified separately. This pattern indicates that the higher expenditure observed in the Brigade Pangan group was accompanied by proportionally larger revenue and income outcomes, rather than demonstrating inefficiency on the basis of total cost alone. Similar studies on rice intensification, nutrient management, and best management practices show that higher input or technology use can be economically justified when it raises yield, reduces waste, or improves returns (Ishfaq et al., 2021; Pame et al., 2023; Paramesh et al., 2023).

Net income provides an additional measure of financial performance. Brigade Pangan farmers earned IDR 34.749 million/ha, assisted farmers IDR 28.905 million/ha, and non-assisted farmers IDR 22.474 million/ha. The income advantage of Brigade Pangan over non-assisted farmers was IDR 12.275 million/ha per planting season. In percentage terms, Brigade Pangan income was 54.6% higher. The descriptive results show that the higher productivity observed in the Brigade Pangan group coincided with sufficiently higher revenue to offset its higher production cost, resulting in greater net income. For smallholder households, this difference is highly relevant because income can influence reinvestment capacity, resilience to shocks, and the attractiveness of rice farming as a livelihood.

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The R/C ratio indicates economic feasibility. Brigade Pangan recorded an R/C ratio of 3.81, assisted farmers 3.60, and non-assisted farmers 3.15. All groups were financially feasible because the R/C ratio exceeded 1, but Brigade Pangan had the highest observed revenue-to-cost ratio. Relative to non-assisted farmers, its R/C ratio was 21.0% higher. Derived indicators deepen the analysis: Brigade Pangan had the lowest production cost per kilogram (IDR 1,707/kg) and the highest net margin per kilogram (IDR 4,793/kg). These indicators show that the Brigade Pangan group combined a lower unit cost with a higher net margin per kilogram than the other two groups. This favorable pattern is associated with greater institutional involvement but should not be interpreted as a causal effect of the program.

Figure 3 presents a descriptive comparison of production cost per kilogram and net margin per kilogram across the three respondent groups. This figure is not an efficiency analysis; it visualizes only the relative positions of the three group-level observations on these two derived economic indicators. Brigade Pangan occupies the favorable position of lower production cost per kilogram and higher net margin per kilogram. Non-assisted farmers occupy the less favorable position of higher unit cost and lower margin, while assisted farmers lie between the two. This distribution is consistent with the institutional-gradient pattern observed across the descriptive indicators: greater involvement with Brigade Pangan coincided with stronger capacity scores, higher productivity and selling price, lower unit cost, and higher margin.

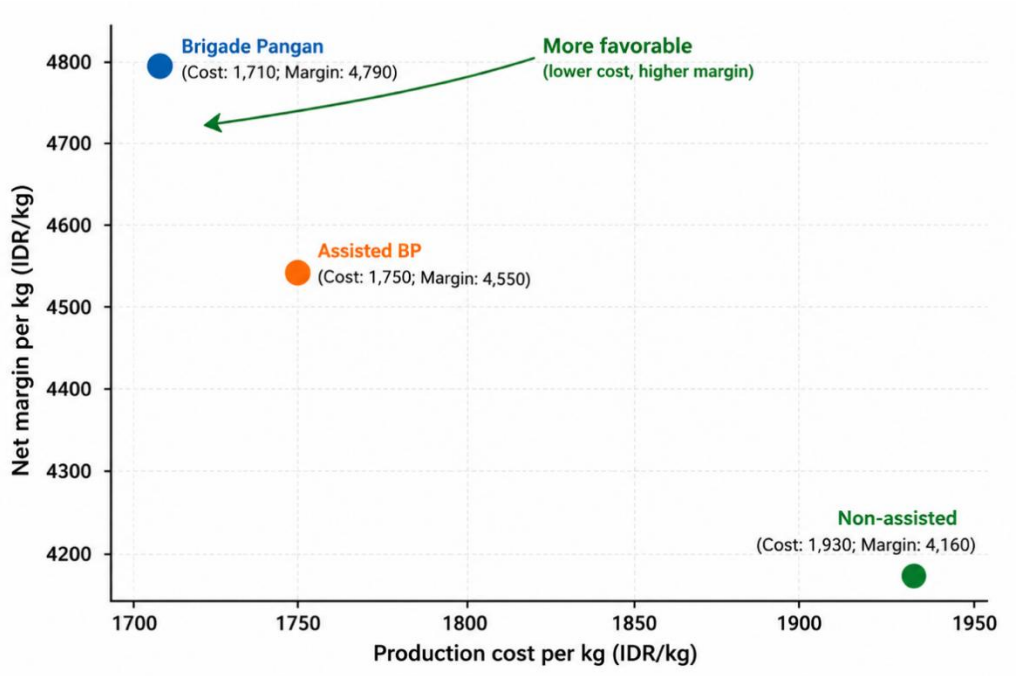

Figure 3. Descriptive comparison of production cost per kilogram and net margin per kilogram across respondent groups.

3.4 Institutional agribusiness upgrading and comparison with previous studies

The findings show consistent descriptive differences associated with different levels of Brigade Pangan involvement across multiple capacity, productivity, and economic indicators. Its observed association is not confined to a single indicator. The group directly involved in Brigade Pangan recorded the highest scores for capacity, productivity, revenue, income, R/C ratio, price realization, net margin, and the lowest unit production cost. This multidimensional pattern provides a coherent descriptive profile of more favorable agribusiness performance among directly involved farmers, although the design does not establish that Brigade Pangan

independently caused these differences. A farm model that raises yield but fails to improve income is agronomically useful but economically incomplete. Conversely, a model that raises income without corresponding improvements in farmer capacity may reflect factors not captured by the present analysis. Accordingly, capacity and management are considered possible explanatory factors for the observed group-level patterns rather than verified mechanisms. The results are compatible with the proposed capacity–management–performance framework, but they do not empirically demonstrate a sequential pathway from institutional participation to capacity, management, and performance because management was not independently measured as a mediating variable.

The capacity results are especially important because they provide one possible interpretation of the observed performance differences rather than direct evidence of an underlying mechanism. Knowledge, attitude, and skill are relevant to how farmers select inputs, coordinate labor, adopt machinery, manage water, maintain crop quality, and respond to market opportunities. International studies of technology adoption in rice and broader agriculture show that adoption is strongly influenced by capacity, information access, institutional support, and extension exposure (Cotter et al., 2020; Ruzzante et al., 2021; Touch et al., 2024). The present findings are consistent with this broader literature in the local context of Barru Regency. In the study area, direct Brigade Pangan members received technical guidance and training more directly than the other groups, which may help contextualize their higher capacity scores. However, the present design does not verify that this exposure caused either the capacity differences or the observed differences in farm performance.

The productivity difference of 34.3% above both the Barru Regency benchmark and non-assisted farmers is broadly consistent with evidence from integrated management studies. Improved lowland rice practices in Indonesia have raised productivity and profitability by combining varieties, nutrient management, water access, and farmer participation (Erythrina et al., 2021). Integrated crop management in semi-arid West Timor improved technical efficiency and yield among higher adopters (Joka et al., 2025), while climate-smart rice cultivation in East Java increased technical efficiency relative to non-adopters (Isnurdiansyah et al., 2026). These studies suggest that technical gains can be associated with coordinated packages of practices and institutional support rather than isolated interventions. Brigade Pangan is conceptually consistent with this type of coordinated support, although these studies provide contextual explanation rather than evidence that the same mechanisms operated in the present sample. The current data do not isolate which program components, farm characteristics, or management practices account for the observed productivity difference.

Mechanization is another important dimension of the institutional model considered in this study. The Brigade Pangan concept emphasizes modern machinery and organized field management. Evidence from China indicates that machinery rice transplanting and centralized seedling cultivation can save seedling-field area and increase aggregate cultivation potential (Ruan et al., 2025). In Indonesia, farmer decisions between animal power and tractors are shaped by motivation, land area, innovation openness, risk-taking, and capital constraints (Rozaki et al., 2024). Drone-based input services have also been reported to reduce cultivation costs and improve net income among paddy farmers by improving cost-time management (Saranya et al., 2024). These studies provide contextual evidence on the potential relevance of mechanization but do not explain the between-group differences observed in the present study. Although field information indicated more complete machinery use among Brigade Pangan farmers, the study did not isolate mechanization, integrated crop management, or other individual program components; their independent contributions to productivity or financial performance therefore cannot be determined from the present data.

The higher selling price observed among Brigade Pangan farmers is consistent with the possibility that institutional coordination may support different marketing conditions, but the

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price difference should not be interpreted as direct evidence of stronger bargaining power. Farmers often lose value after harvest because they sell individually, have limited information, or lack bargaining power. Collective arrangements may reduce transaction costs and improve negotiating position. The rice estate community literature argues that collective land management can improve farm efficiency and bargaining power, although social and legal obstacles may limit full consolidation (Rachman et al., 2023). Evidence on collective irrigation also suggests that governance arrangements can enhance resource-use efficiency through peer effects and coordinated action (Yang et al., 2026). In the study area, field information indicated that grain sales by Brigade Pangan members were supervised by Babinsa personnel, whereas non-assisted farmers were more exposed to price deductions at the point of sale. This difference in selling arrangements provides a possible contextual explanation for the observed price pattern, but the study did not directly measure bargaining power, transaction costs, collective marketing behavior, or the independent effect of price supervision.

3.5 Sustainability trade-offs, limitations, and future research

These limitations directly qualify the observed between-group differences in farmer capacity, land productivity, selling price, revenue, net income, R/C ratio, unit cost, and net margin reported in this study. The sample was selected purposively and consists of 45 farmers in one district. The selection of 15 respondents per group may introduce selection bias and limits the generalizability of the descriptive comparisons. The dataset provides group-level summaries rather than individual-level observations, so respondent-level inferential testing is not possible with the available data, and causal effects cannot be formally estimated. Unobserved factors such as land quality, irrigation access, farmer age, education, farm size, capital, and prior motivation may also influence performance. Although the three groups were observed during the same second planting season (MT II), these potentially confounding characteristics were not statistically controlled. Future studies should collect respondent-level panel data and apply multivariate techniques such as stochastic frontier analysis, data envelopment analysis, or treatment-effect models, as used in rice efficiency studies elsewhere (Castro et al., 2023; Dey et al., 2023; Kumar et al., 2025). Such data and analytical approaches would support a stronger assessment of whether Brigade Pangan has an independent effect on farm performance and which specific program components, if any, account for the observed differences.

Overall, the evidence indicates that greater involvement in Brigade Pangan is associated with a more favorable profile of farmer capacity, land productivity, and agribusiness performance in Barru Regency. These findings are best interpreted as a multidimensional institutional pattern rather than evidence of a system-level causal effect. Brigade Pangan is designed to combine farmer learning, land management, production coordination, mechanization access, and market engagement, but the present study does not independently estimate the contribution of each component. This interpretation is consistent with Rhofita's (2022) broader argument that agricultural resource optimization requires institutional mechanisms capable of connecting resources to national food-security outcomes. For local policy, the findings suggest that attention should extend beyond replicating the Brigade Pangan label to strengthening and evaluating the quality of technical guidance, institutional coordination, and other program services actually delivered to farmers, while recognizing that the independent effects of mechanization and market-related components were not estimated in this study.

4. Conclusion

This study identified a consistent descriptive association between greater Brigade Pangan involvement and higher reported farmer-capacity scores, greater land productivity, and more favorable farm-business outcomes in Mallusetasi District, Barru Regency. Directly involved

Brigade Pangan farmers recorded the most favorable results across the three groups for capacity scores, land productivity, selling price, revenue, net income, revenue-to-cost ratio, production cost per kilogram, and net margin per kilogram. However, these differences should be interpreted cautiously because the study used a small purposive sample from one district, relied on group-level descriptive data, and did not control for potentially confounding farm and farmer characteristics. The findings therefore indicate local descriptive associations rather than independent or causal effects of Brigade Pangan participation. Within the local study context, Brigade Pangan may represent a potentially useful institutional approach for strengthening smallholder rice agribusiness, but the present evidence is insufficient to support broader adoption without further evaluation. The specific contributions of mechanization, collective marketing, farmer capacity development, and other program components were not independently measured. Future research should use larger and more diverse respondent-level samples across multiple locations, apply inferential or causal analytical methods, and incorporate environmental sustainability indicators to test the robustness, mechanisms, and generalizability of the observed associations.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. The dataset available for the present analysis contained aggregated respondent-group summaries; respondent-level raw observations were not available for the analysis and are not publicly available.

Author Contributions

Bahrul Ulum: Investigation, data curation, formal analysis, writing – original draft, and visualization. **Iradhatullah Rahim:** Conceptualization, methodology, Writing – review & editing, and supervision. **Andi Sitti Halimah:** Writing – review & editing, and supervision. **Andi Nuddin:** Validation, conceptualization, and methodology.

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Conflicts of Interest

The authors declare no financial or non-financial interests that could be perceived as influencing the work reported in this article.

Ethics Statement

This study involved interviews and questionnaires with farmers. The data were analyzed in aggregated form and did not report identifiable personal information. Informed consent was obtained from respondents before data collection.

References

Akbar, G., Islam, Z., & Khalil, S. H. (2025). Effect of land and water management on rice yield and water productivity in silty loam soil. Plant and Soil, 508(1), 179–191. https://doi.org/10.1007/s11104-024-06790-9

Al-Hanbali, A., Shibuta, K., Alsaaideh, B., & Tawara, Y. (2022). Analysis of the land suitability for paddy fields in Tanzania using a GIS-based analytical hierarchy process. Geo-Spatial Information Science, 25(2), 212–228. https://doi.org/10.1080/10095020.2021.2004079

Ansori, M., Rivai, A., Pusnita, I., & Patima, P. (2022). Peningkatan kapasitas SDM kelompok petani dalam mendukung program lumbung pangan di Desa Telang Sari Kecamatan Tanjung Lago Kabupaten Banyuasin. Aktivasi: Jurnal Pemberdayaan Masyarakat, 4(1), 35–39. https://doi.org/10.37858/aktivasi.v4i1.440

Asmarani, S., Semedi, J. M., & Rustanto, A. (2023). Investigating spatial relationship of soil capability and agricultural land management in Cugenang District, Cianjur Regency. IOP Conference Series: Earth and Environmental Science, 1190(1), 012051. https://doi.org/10.1088/1755-1315/1190/1/012051

Awwal Fuqara, F., & Windi Tanjung, Y. (2023). Strategi peningkatan produksi padi lahan suboptimal. Jurnal Sosial Ekonomi Pertanian, 19(2), 129–138. https://doi.org/10.20956/jsep.v19i2.26721

Azriani, Z., Budiman, C., & Hidayat, R. (2023). Rice farming business risk analysis in Padang City. IOP Conference Series: Earth and Environmental Science, 1160(1), 012063. https://doi.org/10.1088/1755-1315/1160/1/012063

Badan Pusat Statistik Kabupaten Barru. (2025). *Kabupaten Barru dalam angka 2025* (Vol. 17). https://barrukab.bps.go.id

Buna, A., Ahmad, S. L., Walaji, S., & Moilo, R. (2025). Manajemen usahatani padi sawah di Kabupaten Bone Balango. Agricultural Socio-economic Empowerment and Agribusiness Journal, 4(1), 1–7. https://doi.org/10.20961/agrisema.v4i1.93993

Castro, M., Reyes Duarte, A., Villegas, A., & Chanci, L. (2023). The effect of crop insurance in Ecuadorian rice farming: A technical efficiency approach. Agricultural Finance Review, 83(3), 478–497. https://doi.org/10.1108/AFR-10-2022-0122

Connor, M., de Guia, A. H., Pustika, A. B., Sudarmaji, Kobarsih, M., & Hellin, J. (2021). Rice farming in Central Java, Indonesia—Adoption of sustainable farming practices, impacts and implications. Agronomy, 11(5), 881. https://doi.org/10.3390/agronomy11050881

Cotter, M., Asch, F., Abera, B. B., Andre Chuma, B., Senthilkumar, K., Rajaona, A., Razafindrazaka, A., Saito, K., & Stuerz, S. (2020). Creating the data basis to adapt agricultural decision support tools to new environments, land management and climate change—A case study of the RiceAdvice App. Journal of Agronomy and Crop Science, 206(4), 423–432. https://doi.org/10.1111/jac.12421

Dey, S., Abbhishek, K., & Swain, D. K. (2023). Resource use efficiency estimation and technology verification trial for sustainable improvement in paddy production: An action-based research. International Journal of Plant Production, 17(2), 337–352. https://doi.org/10.1007/s42106-023-00243-6

Divya Lekshmi, U., Venkataramana, M. N., & Gaddi, G. M. (2021). Profitability and resource use efficiency of rice-based cropping systems—Evidences from Kerala. Economic Affairs, 66(4), 643–649. https://doi.org/10.46852/0424-2513.4.2021.18

Erythrina, E., Anshori, A., Bora, C. Y., Dewi, D. O., Lestari, M. S., Mustaha, M. A., Ramija, K. E., Rauf, A. W., Mikasari, W., Surdianto, Y., Suriadi, A., Purnamayani, R., Darwis, V., & Syahbuddin, H. (2021). Assessing opportunities to increase yield and profit in rainfed lowland rice systems in Indonesia. Agronomy, 11(4), 777. https://doi.org/10.3390/agronomy11040777

Fadhilah, M. L., Eddy, B. T., & Gayatri, S. (2018). Pengaruh tingkat pengetahuan, sikap dan keterampilan penerapan sistem agribisnis terhadap produksi pada petani padi di Kecamatan Cimanggu Kabupaten Cilacap. Agrisocionomics: Jurnal Sosial Ekonomi Pertanian, 2(1), 39–49. https://doi.org/10.14710/agrisocionomics.v2i1.1327

Felix, K. T., Govindarajan, P. L., & Rashtrarakshak, V. P. (2025). Optimizing resource use efficiency for sustainable paddy production in South India—A regional study. Frontiers in Sustainable Food Systems, 9, 1665774. https://doi.org/10.3389/fsufs.2025.1665774

Fukai, S., & Mitchell, J. (2026). Rice-based cropping systems in Southeast Asia. In I. A. Ciampitti, D. V. Bustos-Korts, D. F. Calderini, & V. O. Sadras (Eds.), *Crop physiology: Applications for genetic improvement and agronomy in diverse cropping systems* (3rd ed., pp. 3–34). Academic Press. https://doi.org/10.1016/B978-0-443-30208-4.00018-6

Gandharum, L., Hartono, D. M., Sadmono, H., Sanjaya, H., Sumargana, L., Kusumawardhani, A. D., Alhasanah, F., Sencaki, D. B., & Setyaningrum, N. (2025). Advancing land use modeling with rice cropping intensity: A geospatial study on the shrinking paddy fields in Indonesia. Geographies, 5(3), 31. https://doi.org/10.3390/geographies5030031

Helmy, E., Sulistyowati, L., Noor, T. I., & Setiawan, I. (2023). Economic efficiency of rice farming: A performance difference among agricultural insurance participant and non-participant farmer. AGRARIS: Journal of Agribusiness and Rural Development Research, 9(1), 30–47. https://doi.org/10.18196/agraris.v9i1.108

Ishfaq, M., Akbar, N., Zulfiqar, U., Ali, N., Jabran, K., Nawaz, M., & Farooq, M. (2021). Influence of nitrogen fertilization pattern on productivity, nitrogen use efficiencies, and profitability in different rice production systems. Journal of Soil Science and Plant Nutrition, 21(1), 145–161. https://doi.org/10.1007/s42729-020-00349-0

Isnurdiansyah, N. P., Saputra, S. G., Mahastian, P. W., Khasanah, N., & Leimona, B. (2026). Climate-smart practices for sustainable rice farming: Impacts on farm technical efficiency and income in Pasuruan, East Java, Indonesia. IOP Conference Series: Earth and Environmental Science, 1608(1), 012043. https://doi.org/10.1088/1755-1315/1608/1/012043

Joka, U., Nubatonis, A., Nino, J., Tabenu, O., & Ludji, D. G. (2025). Impact of integrated crop management on rice farming efficiency in semi-arid West Timor, Indonesia. International Journal of Tropical Drylands, 9(2), 148–158. https://doi.org/10.13057/tropdrylands/t090205

Khasanah, N. N., & Gunanto, E. Y. A. (2024). Pengaruh luas panen padi, produktivitas lahan, pertumbuhan harga beras dan jumlah penduduk terhadap ketersediaan beras di Indonesia tahun 1990–2022. Diponegoro Journal of Economics, 13(2), 67–79. https://doi.org/10.14710/djoe.44900

Kumar, K. N. R., Shafiwu, A. B., & Mahama, I. (2025). Economic impact of Rythu Bharosa Kendras (RBKs) in Andhra Pradesh, India. SN Business & Economics, 5(1), 6. https://doi.org/10.1007/s43546-024-00775-7

Laim, C. O. R., & Simamora, L. (2022). Analisis faktor-faktor yang mempengaruhi produktivitas dan kelayakan usahatani padi sawah. Mimbar Agribisnis: Jurnal Pemikiran Masyarakat Ilmiah Berwawasan Agribisnis, 8(1), 75–88. https://doi.org/10.25157/ma.v8i1.5887

Lone, F. A., Nanda, A. M., Rather, J. A., Bhat, M. S., & Kant, T. A. (2021). Resource use efficiency of rice farming in Jammu and Kashmir, India. Agricultural Research Journal, 58(3), 521–526. https://doi.org/10.5958/2395-146X.2021.00075.2

Maity, S., Sinha, A., Rath, M. K., & Barlaskar, U. R. (2023). Resource use efficiency and cleaner agricultural production: An application of technical inefficiency effects model for paddy producing zones of West Bengal. AGRIS On-line Papers in Economics and Informatics, 15(2), 55–68. https://doi.org/10.7160/aol.2023.150205

Mathew, J. A., Jamali, M. H. B., Kaly Sitthan, V., Tagang, R. R., & Ibrahim, M. H. (2024). Farmers' perception towards agroforestry practices in Siburan. Borneo Journal of Resource Science and Technology, 14(2), 210–216. https://doi.org/10.33736/bjrst.6954.2024

Nasution, M., Purnama, S., & Sekaranom, A. B. (2024). Climate change adaptation in Batang Hari, Jambi: A case study of rainfed paddy farmers. Indonesian Journal of Geography, 56(3), 409–417. https://doi.org/10.22146/ijg.90325

Nugraha, A., & Kurnia, G. (2024). Mendorong keberlanjutan usahatani padi: Tantangan sosial ekonomi di Kabupaten Tasikmalaya. Agricore: Jurnal Agribisnis dan Sosial Ekonomi Pertanian Unpad, 9(2), 183–191. https://jurnal.unpad.ac.id/agricore/article/view/61536

Pame, A. R. P., Vithoonjit, D., Meesang, N., Balingbing, C., Gummert, M., Van Hung, N., Singleton, G. R., & Stuart, A. M. (2023). Improving the sustainability of rice cultivation in Central Thailand with biofertilizers and laser land leveling. Agronomy, 13(2), 587. https://doi.org/10.3390/agronomy13020587

Paramesh, V., Kumar, P., Bhagat, T., Nath, A. J., Manohara, K. K., Das, B., Desai, B. F., Jha, P. K., & Prasad, P. V. V. (2023). Integrated nutrient management enhances yield, improves soil quality, and conserves energy under the lowland rice–rice cropping system. Agronomy, 13(6), 1557. https://doi.org/10.3390/agronomy13061557

Pramono, J., & Romdon, A. S. (2022). Peningkatan produktivitas melalui perbaikan sistem budidaya padi sawah di tengah ancaman perubahan iklim. KaliAgri Journal, 3(2), 9–19. https://doi.org/10.56869/kaliagri.v3i2.409

Pusat Pelatihan Pertanian. (2024). *Buku saku Brigade Pangan*. Badan Penyuluhan dan Pengembangan SDM Pertanian. https://repository.pertanian.go.id/handle/123456789/24857

Rachman, L. M., Saleh, A., Wetik, J. D., Palahudin, Ardiana, & Chaniago, E. (2023). Land consolidation challenges to improve farm management through the establishment of rice estate community. AIP Conference Proceedings, 2596(1), 100005. https://doi.org/10.1063/5.0119441

Ramija, K. E., Listiawati, Nurzannah, S. E., & Rahmi, M. (2025). Petani milenial, kunci sukses program Brigade Pangan. Buletin Teknologi & Inovasi Pertanian, 4(1), 1–6. https://repository.pertanian.go.id/handle/123456789/28926

Rhofita, E. I. (2022). Optimalisasi sumber daya pertanian Indonesia untuk mendukung program ketahanan pangan dan energi nasional. Jurnal Ketahanan Nasional, 28(1), 82–100. https://doi.org/10.22146/jkn.71642

Rozaki, Z., Indri, Y., Indardi, Wulandari, R., Triyono, Rahmawati, N., & Ardila, R. A. (2024). Key factors influencing rice farmers' decisions: Animal power vs. tractors in Kalibombong Village, Banjarnegara, Indonesia. BIO Web of Conferences, 144, 01006. https://doi.org/10.1051/bioconf/202414401006

Ruan, D., Tang, J., Wang, J., Zhou, J., Zeng, X., & Liu, H. (2025). A new path to aggregate area expansion by agricultural mechanization: The seedling field saving effect of machinery rice transplanting and the case of China. Agriculture, 15(2), 121. https://doi.org/10.3390/agriculture15020121

Ruzzante, S., Labarta, R., & Bilton, A. M. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. World Development, 146, 105599. https://doi.org/10.1016/j.worlddev.2021.105599

Saranya, C., Devi, K. S., Prabakar, C., & Ponnarasi, T. (2024). Drone technology: Unlocking the potential of agricultural input through services market in Pondicherry District. Indian Journal of Agricultural Economics, 79(3), 750–762. https://doi.org/10.63040/25827510.2024.03.029

Sasmita, A., Ali, S. S., & Amrullah, A. (2023). Modernitas petani: Tingkat modernitas serta hambatan struktural dan budaya dalam agribisnis padi. Jurnal Sosial Ekonomi Pertanian, 20(1), 51–64. https://doi.org/10.20956/jsep.v20i1.22620

Siddique, M. N. E. A., Lobry de Bruyn, L. A., Guppy, C. N., & Osanai, Y. (2021). Temporal variations of soil organic carbon and pH at landscape scale and the implications for cropping intensity in rice-based cropping systems. Agronomy, 11(1), 59. https://doi.org/10.3390/agronomy11010059

Sumaryanto, S., Susilowati, S. H., Saptana, S., Sayaka, B., Suryani, E., Agustian, A., Ashari, A., Purba, H. J., Sumedi, S., Dermoredjo, S. K., Purwantini, T. B., Yofa, R. D., & Pasaribu, S. M. (2023). Technical efficiency changes of rice farming in the favorable irrigated areas of Indonesia. Open Agriculture, 8(1), 20220207. https://doi.org/10.1515/opag-2022-0207

Suryana, E. A., Raharjo, A. S. S., Ulpah, A., & Mulyono, J. (2025). Membernaskan kelembagaan Brigade Pangan. Suara Analis Kebijakan, 2(1). https://sajak.lan.go.id/article/view/20

Touch, V., Cross, R., Grünbühel, C., Van Ogtrop, F., Ampt, P., Yorn, T., Martin, R. J., Cook, B. R., & Tan, D. K. Y. (2024). Adaptation constraints and prospects for future research priorities in lowland rice-based farming systems: Learning experiences from Northwest Cambodia. Environment, Development and Sustainability, 26(9), 22555–22586. https://doi.org/10.1007/s10668-023-03566-6

van Aalst, M. A., Koomen, E., Tran, D. D., Hoang, H. M., Nguyen, H. Q., & de Groot, H. L. F. (2023). The economic sustainability of rice farming and its influence on farmer decision-making in the upper Mekong delta, Vietnam. Agricultural Water Management, 276, 108018. https://doi.org/10.1016/j.agwat.2022.108018

Yang, Z., Ji, Y., & Yang, Y. (2026). Peers, collective irrigation, and farm efficiency: Plot-level evidence from Jiangsu, China. Land, 15(3), 427. https://doi.org/10.3390/land15030427

Yulia, E., Isyanto, A. Y., & Nurahman, I. S. (2024). Hubungan kompetensi petani padi dengan tingkat penerapan inovasi teknologi jajar legowo di Desa Karyamukti Kecamatan Pataruman Kota Banjar. Jurnal Ilmiah Mahasiswa Agroinfo Galuh, 11(2), 634–643. https://doi.org/10.25157/jimag.v11i2.10885

Yuliani, F., Hermawan, H., & Suryana, E. A. (2024). Strategi optimalisasi lahan suboptimal dalam mendukung peningkatan produksi dan pencapaian ketahanan pangan. Agrica Ekstensia, 18(2), 57–71. https://doi.org/10.55127/ae.v18i2.204