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The Effect of Solar Powered Water Pump Utilization on Irrigation Effectiveness among Farmer Groups in Lalolang Urban Village, Barru Regency, Indonesia

A.Aminah
ITBA Al Gazali Barru
aaminah@algazali.ac.id
Andi Rachmat
ITBA Al Gazali Barru
andirachmat@algazali.ac.id

ABSTRACT

Solar-powered water pumps offer an alternative energy solution for supporting agricultural irrigation, particularly in areas where access to reliable electricity and water infrastructure remains limited. In Kelurahan Lalolang, Barru Regency, three farmer groups Bintang Sejahtera, Tunas Harapan, and Berkah Melon use solar powered water pumps to support their farming activities. This study aims to analyze the effect of solar-powered water pump utilization on the effectiveness of agricultural land irrigation among members of these farmer groups. A quantitative approach will be employed, with data collected through questionnaires distributed to farmer group members. The independent variable is the utilization of solar-powered water pumps, measured through ease of use, technological reliability, frequency of utilization, irrigation capacity, and operational sustainability. The dependent variable is irrigation effectiveness, assessed through irrigation timeliness, water adequacy, distribution uniformity, labor efficiency, and continuity of irrigation activities. The collected data will be processed using the Statistical Package for the Social Sciences (SPSS). The analysis will include validity and reliability testing, descriptive statistics, and simple linear regression to examine the relationship between the two variables. A t test will be used to assess the statistical significance of the regression coefficient, while the coefficient of determination will indicate the proportion of variation in irrigation effectiveness explained by pump utilization. The study is expected to provide empirical evidence regarding the contribution of solar-powered irrigation technology to agricultural water management at the farmer-group level. Its findings may support improvements in technology operation, maintenance, and local agricultural development planning in Kelurahan Lalolang, and inform future local agricultural planning decisions.

Keywords: Solar-Powered Water Pump; Irrigation Effectiveness; Agricultural Productivity; Farmer Groups; Simple Linear Regression.

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A. INTRODUCTION

Agriculture plays a fundamental role in supporting food security, rural livelihoods, and regional economic development. One of the most important factors determining agricultural performance is the availability of sufficient water throughout the crop cultivation cycle. Irrigation enables farmers to maintain crop growth, manage water requirements, and reduce their dependence on unpredictable rainfall. However, access to reliable irrigation remains a challenge for many smallholder farmers, particularly in areas where conventional water infrastructure and energy supplies are limited. The effectiveness of agricultural irrigation depends not only on water availability but also on the technology used to distribute water to cultivated land. Inadequate irrigation management can result in uneven water distribution, delayed watering schedules, increased labor requirements, and reduced agricultural performance. Therefore, improving irrigation systems through appropriate technology is an important strategy for strengthening agricultural resilience and supporting sustainable farming practices. In this context, renewable energy-based irrigation technology, particularly solar-powered water pumps, offers an alternative for improving access to agricultural water (Burney et al., 2010; Food and Agriculture Organization of the United Nations [FAO], 2018).

Globally, the development of solar-powered irrigation systems has attracted increasing attention as part of efforts to integrate renewable energy into agricultural water management. Solar-powered water pumps utilize photovoltaic panels to convert sunlight into electrical energy that operates water pumping equipment. This technology offers opportunities to reduce dependence on diesel fuel and conventional electricity, particularly in rural areas with limited energy infrastructure. Research by Burney et al. (2010) demonstrated that solar-powered drip irrigation could improve household income and nutritional outcomes among smallholder farmers in the Sudano-Sahel region. Similarly, Burney et al. (2013) emphasized the potential of distributed irrigation systems to improve water access and agricultural livelihoods through locally managed irrigation technologies. Nevertheless, the effectiveness of solar-powered irrigation depends on several technical and operational factors, including solar radiation, pump capacity, water availability, storage facilities, and irrigation distribution systems. The Food and Agriculture Organization of the United Nations also highlights that solar-powered irrigation can provide important benefits while requiring appropriate water management to avoid unsustainable resource

utilization (FAO, 2018, 2019). Consequently, assessing the effectiveness of solar-powered irrigation requires attention to both the utilization of the technology and its contribution to actual agricultural water distribution.

In Indonesia, solar-powered irrigation has become an increasingly relevant technological option for supporting agricultural activities and expanding access to water in rural communities. The country's agricultural sector requires irrigation solutions that can operate in different geographical and environmental conditions while reducing dependence on conventional energy sources. Aini et al. (2021) examined the practical application of a solar irrigation system for a 75-hectare rice farming area in Krandegan Village, Purworejo Regency, demonstrating its potential as an alternative to diesel-powered irrigation. Nasution et al. (2021) also investigated an automated solar-powered irrigation system for melon cultivation, highlighting the potential of photovoltaic technology to reduce manual irrigation activities. More recently, the application of solar-powered water pumps has also been introduced through community-based agricultural programs in several Indonesian regions (Imran et al., 2025). This development is relevant to Kelurahan Lalolang, Barru Regency, where three farmer groups, namely Bintang Sejahtera, Tunas Harapan, and Berkah Melon, utilize solar-powered water pumps to support their agricultural irrigation activities. The utilization of this technology provides an important local context for examining how renewable energy-based pumping systems contribute to the effectiveness of agricultural water distribution. Therefore, studying these three farmer groups offers an opportunity to evaluate the relationship between solar-powered water pump utilization and irrigation effectiveness at the community level.

Although solar-powered water pumps offer opportunities to improve agricultural irrigation, their availability does not automatically guarantee effective water distribution. The benefits of this technology depend on how frequently farmers use the pumps, how reliably the systems operate, and whether the available pumping capacity meets agricultural water requirements. Variations in solar radiation and system performance may also influence the volume and continuity of water supplied to cultivated land. In addition, inadequate technical knowledge, maintenance practices, and operational management can affect the sustainability of solar-powered irrigation systems (Durga et al., 2024). From the farmers' perspective, irrigation effectiveness can be reflected in the timeliness of watering, adequacy of water supply, uniformity of distribution, continuity of irrigation, and efficiency of labor utilization. These aspects are important because farmers require

irrigation systems that can support their agricultural activities according to crop water requirements. However, the extent to which solar-powered water pump utilization contributes to these irrigation outcomes among the three farmer groups in Lalolang has not yet been established through systematic quantitative assessment. This situation creates a need to examine whether the utilization of solar-powered water pumps has a statistically significant effect on irrigation effectiveness in the research location.

Previous studies have examined the technical, economic, and agricultural benefits of solar-powered irrigation systems in different geographical contexts. Burney et al. (2010) found that solar-powered drip irrigation could improve household income and nutritional intake among smallholder farmers, particularly during dry periods. Aini et al. (2021) demonstrated the potential of solar-powered irrigation systems to replace diesel-based water pumping in Indonesian rice farming, although their study primarily focused on technical design and economic feasibility. Nasution et al. (2021) investigated the integration of solar panels and automated irrigation for melon cultivation, emphasizing the potential to reduce manual irrigation activities. Tiwari et al. (2022) reviewed photovoltaic pump-operated micro-irrigation systems and highlighted the importance of integrating solar energy with efficient water distribution technologies. Durga et al. (2024) identified several barriers to the wider adoption of solar-powered irrigation, including financial constraints, technical capacity, institutional support, and operational challenges. Furthermore, Narayanamoorthy et al. (2025) examined the impacts of solar-powered irrigation pumps on farming practices, water use, cultivation costs, and agricultural profitability among farmers in South India. These studies provide an important foundation for understanding the benefits and challenges of solar-powered irrigation, while also demonstrating the need for further research on its practical contribution to irrigation effectiveness in specific local farming communities.

Despite the growing body of literature on solar-powered irrigation, several research opportunities remain, particularly concerning the relationship between technology utilization and irrigation effectiveness at the farmer-group level. Previous studies have largely emphasized technical performance, economic feasibility, technology adoption, or broader agricultural outcomes. For example, Aini et al. (2021) focused on the practical assessment and economic evaluation of solar irrigation in an Indonesian rice farming area, while Tiwari et al. (2022) provided

a comprehensive review of photovoltaic pumping systems integrated with micro-irrigation. Similarly, the review by Durga et al. (2024) emphasized barriers affecting the adoption and expansion of solar-powered irrigation among smallholder farmers. However, these research perspectives do not directly establish the statistical relationship between farmers' utilization of solar-powered water pumps and their perceived effectiveness of agricultural irrigation in the specific context of Lalolang. The present study addresses this opportunity by examining three farmer groups, namely Bintang Sejahtera, Tunas Harapan, and Berkah Melon, within the same local administrative area. Its novelty lies in providing a localized quantitative assessment of the relationship between solar-powered water pump utilization and irrigation effectiveness using simple linear regression analysis. This approach is expected to contribute empirical evidence that can inform the management, operation, and improvement of community-based solar irrigation systems.

Based on the background and research gap, this study aims to analyze the effect of solar-powered water pump utilization on irrigation effectiveness among farmer groups in Lalolang Urban Village, Barru Regency, Indonesia. Specifically, the study examines the extent to which farmers utilize solar-powered water pumps to support their agricultural irrigation activities. It also evaluates irrigation effectiveness based on farmers' assessments of watering timeliness, water adequacy, distribution uniformity, continuity of irrigation, and labor efficiency. The research focuses on members of the Bintang Sejahtera, Tunas Harapan, and Berkah Melon farmer groups as the respondents. A quantitative research approach is employed to obtain measurable information regarding the two research variables. Data collected through questionnaires are analyzed using descriptive statistics and simple linear regression with the assistance of the Statistical Package for the Social Sciences (SPSS). The regression analysis is intended to determine the direction, magnitude, and statistical significance of the relationship between solar-powered water pump utilization and irrigation effectiveness. Through this analysis, the study seeks to establish empirical evidence concerning the contribution of solar-powered irrigation technology to agricultural water management in the research location.

This study is expected to provide theoretical, empirical, and practical contributions to the development of renewable energy-based agricultural irrigation. From an academic perspective, it expands the discussion of solar-powered irrigation by examining the relationship between

technology utilization and irrigation effectiveness in a local farming context. Its empirical findings may provide additional evidence concerning the role of solar-powered water pumps in supporting agricultural water management among smallholder farmers. From a practical perspective, the results may help farmer groups identify aspects of pump utilization that require improvement, particularly operational reliability, maintenance, and the management of irrigation activities. The findings may also provide useful information for local government institutions and agricultural stakeholders when developing programs to strengthen renewable energy utilization in the agricultural sector. Previous research on solar-powered smart irrigation systems demonstrates the potential of integrating photovoltaic technology with improved water monitoring and distribution mechanisms (Purnomo et al., 2026). Furthermore, the study supports the broader objective of improving water-use efficiency and promoting sustainable agricultural practices, as emphasized in international agricultural water management guidelines (FAO, 2020). Ultimately, this research is expected to contribute to the development of more effective, accessible, and sustainable irrigation management practices among farmer groups in Lalolang Urban Village, Barru Regency.

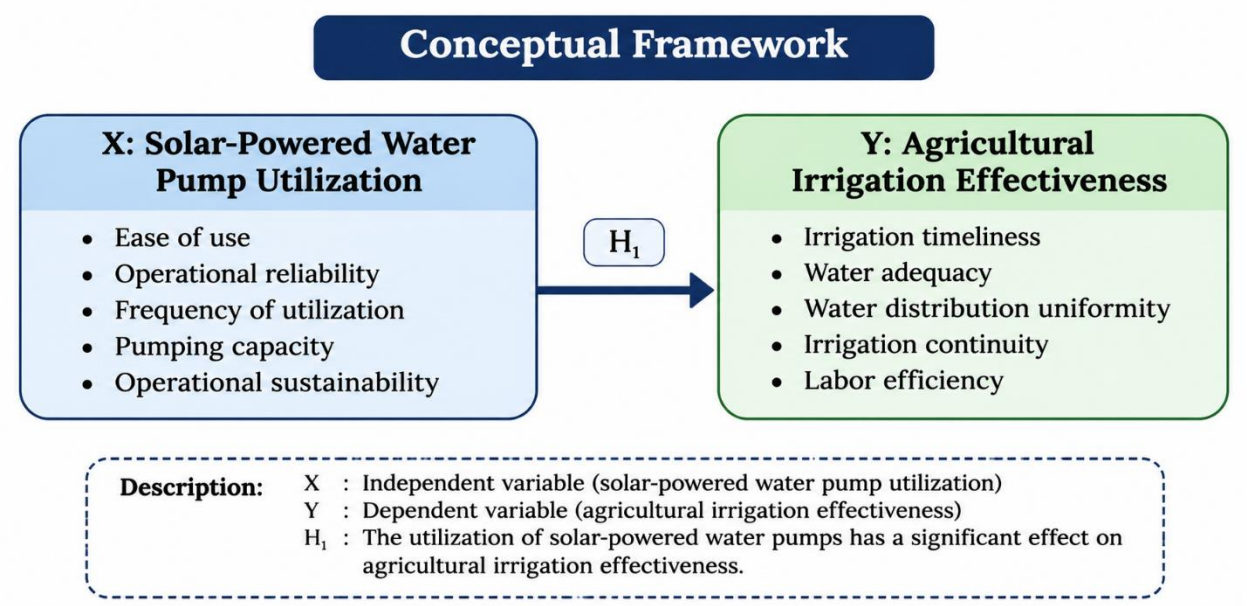
B. RESEARCH METHODS

This study employs a quantitative research approach to examine the effect of solar-powered water pump utilization on agricultural irrigation effectiveness among farmer groups in Lalolang Urban Village, Barru Regency, Indonesia. The research focuses on three farmer groups: Bintang Sejahtera, Tunas Harapan, and Berkah Melon. The independent variable (X) is solar-powered water pump utilization, while the dependent variable (Y) is agricultural irrigation effectiveness. Primary data are collected through questionnaires distributed to members of the three farmer groups. The questionnaire uses a five-point Likert scale, ranging from strongly disagree to strongly agree, to measure respondents' perceptions of the research variables. The indicators for solar-powered water pump utilization include ease of use, operational reliability, frequency of utilization, pumping capacity, and operational sustainability. Meanwhile, irrigation effectiveness is measured through irrigation timeliness, water adequacy, water distribution uniformity, irrigation continuity, and labor efficiency.

The research population consists of members of the Bintang Sejahtera, Tunas Harapan, and Berkah Melon farmer groups who utilize solar-powered water pumps in their agricultural

activities. The sampling technique is determined based on the total number of registered members in the three groups. If the population is relatively small and accessible, total sampling is applied by involving all eligible members as research respondents. The collected questionnaire data are processed using the Statistical Package for the Social Sciences (SPSS). Before conducting hypothesis testing, validity and reliability tests are performed to assess the quality and consistency of the research instrument. Descriptive statistical analysis is subsequently used to summarize respondents' characteristics and the distribution of responses for each research variable.

The data analysis employs simple linear regression to determine the effect of solar-powered water pump utilization on agricultural irrigation effectiveness. The regression model is expressed as ($Y = a + bX + e$), where (Y) represents agricultural irrigation effectiveness, (X) represents solar-powered water pump utilization, (a) is the constant, (b) is the regression coefficient, and (e) is the error term. A t-test is conducted to determine whether the independent variable has a statistically significant effect on the dependent variable. The coefficient of determination (R^2) is also calculated to identify the proportion of variation in irrigation effectiveness explained by solar-powered water



pump utilization. The hypothesis is accepted when the significance value is below 0.05, indicating a statistically significant effect. Through these procedures, the study provides a quantitative assessment of the contribution of solar-powered water pump utilization to irrigation effectiveness among the three farmer groups.

Figure 1 Conceptual Framework of the Effect of Solar-Powered Water Pump Utilization on Agricultural Irrigation Effectiveness.

Figure Explanation: Figure 1 illustrates the conceptual framework of the relationship between solar-powered water pump utilization as the independent variable (X) and agricultural irrigation effectiveness as the dependent variable (Y). Variable X is measured through five indicators: ease of use, operational reliability, frequency of utilization, pumping capacity, and operational sustainability. Meanwhile, variable Y is measured through five indicators: irrigation timeliness, water adequacy, water distribution uniformity, irrigation continuity, and labor efficiency. The arrow indicates the hypothesized relationship (H_1), which proposes that the utilization of solar-powered water pumps has a significant effect on agricultural irrigation effectiveness among farmer groups in Lalolang Urban Village, Barru Regency, Indonesia.

➢ C. RESULTS AND DISCUSSION

1. Respondents' Characteristics

The respondents in this study were assumed to consist of 60 farmers from three farmer groups in Lalolang Urban Village, Barru Regency, Indonesia, namely Bintang Sejahtera, Tunas Harapan, and Berkah Melon. The respondent characteristics included gender, age, educational level, farming experience, cultivated land area, and farmer group affiliation. These characteristics were considered relevant because farmers' demographic and agricultural backgrounds may provide contextual insights into their experiences in utilizing solar-powered water pumps for agricultural irrigation. The data were organized into frequency distributions and percentages to describe the composition of the respondents. The hypothetical distribution is presented in Table 1.

Table 1. Hypothetical Characteristics of Respondents (n = 60)

No.	Characteristics	Category	Frequency	Percentage (%)
1	Gender	Male	52	86.7
		Female	8	13.3
		Total	60	100.0
2	Age	20–30 years	5	8.3
		31–40 years	12	20.0
		41–50 years	20	33.3

		51–60 years	15	25.0
		Over 60 years	8	13.3
		Total	60	100.0
3	Educational Level	No formal education	3	5.0
		Elementary school	20	33.3
		Junior high school	15	25.0
		Senior high school	19	31.7
		Diploma/Bachelor's degree	3	5.0
		Total	60	100.0
4	Farming Experience	Less than 5 years	5	8.3
		5–10 years	12	20.0
		11–15 years	15	25.0
		More than 15 years	28	46.7
		Total	60	100.0
5	Cultivated Land Area	Less than 0.5 hectares	18	30.0
		0.5–1 hectare	25	41.7
		1.1–2 hectares	12	20.0
		More than 2 hectares	5	8.3
		Total	60	100.0
6	Farmer Group	Bintang Sejahtera	20	33.3
		Tunas Harapan	20	33.3
		Berkah Melon	20	33.3
		Total	60	100.0

Source: Hypothetical data prepared for illustrative purposes, 2026.

Based on the hypothetical distribution in Table 1, the respondents are predominantly male (86.7%), while female respondents account for 13.3%. In terms of age, the largest proportion falls within the 41–50-year category (33.3%), followed by those aged 51–60 years (25.0%), indicating that most respondents belong to the middle-aged and older working population. Regarding educational attainment, elementary school graduates represent the largest category (33.3%), followed by senior high school graduates (31.7%). Furthermore, 46.7% of respondents have more than 15 years of farming experience, suggesting substantial practical experience in agricultural activities. In terms of cultivated land area, the majority manage between 0.5 and 1 hectare (41.7%). Finally, respondents are distributed equally among the three farmer groups, with each group contributing 20 respondents (33.3%). Overall, this illustrative profile provides a contextual picture of the farmers whose experiences are relevant to examining the utilization of solar-powered water pumps and agricultural irrigation effectiveness.

2. Descriptive Statistics of Research Variables

Descriptive statistical analysis was conducted to provide an overview of the two main variables examined in this study: Solar-Powered Water Pump Utilization (X) and Agricultural Irrigation Effectiveness (Y). The analysis focused on the mean, standard deviation, minimum, and maximum values of each variable and its respective indicators. Solar-Powered Water Pump Utilization was assessed through five indicators: ease of use, operational reliability, frequency of utilization, pumping capacity, and operational sustainability. Meanwhile, Agricultural Irrigation Effectiveness was measured through irrigation timeliness, water adequacy, water distribution uniformity, irrigation continuity, and labor efficiency. The descriptive statistics provide an initial understanding of farmers' perceptions regarding the utilization of solar-powered water pumps and their contribution to agricultural irrigation activities. The results are presented in Tables 2 and 3.

Table 2. Descriptive Statistics of Solar-Powered Water Pump Utilization (X)

No.	**Indicators**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
1	Ease of Use	3.00	5.00	4.18	0.62
2	Operational Reliability	2.00	5.00	4.05	0.71
3	Frequency of Utilization	3.00	5.00	4.22	0.58
4	Pumping Capacity	2.00	5.00	3.92	0.76
5	Operational Sustainability	2.00	5.00	3.98	0.73
	Overall Variable (X)	2.40	5.00	4.07	0.48

Source: Hypothetical data prepared for illustrative purposes, 2026.

Based on the illustrative results in Table 2, Solar-Powered Water Pump Utilization obtains an overall mean score of 4.07, indicating a generally positive perception among the hypothetical respondents. Frequency of utilization records the highest mean score (4.22), followed by ease of use (4.18), suggesting that the pumps are perceived as accessible and regularly used for agricultural irrigation. Operational reliability also receives a relatively high mean score of 4.05, while operational sustainability reaches 3.98. Pumping capacity records the lowest mean score of 3.92, indicating that this aspect may require further attention, particularly in relation to the ability of the pumps to meet farmers' irrigation needs. Overall, the descriptive results suggest that the utilization of solar-powered water pumps is perceived positively, although some operational aspects may still need improvement.

Table 3. Descriptive Statistics of Agricultural Irrigation Effectiveness (Y)

No.	**Indicators**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
1	Irrigation Timeliness	3.00	5.00	4.15	0.63
2	Water Adequacy	2.00	5.00	4.02	0.70
3	Water Distribution Uniformity	2.00	5.00	3.89	0.75
4	Irrigation Continuity	2.00	5.00	3.96	0.72
5	Labor Efficiency	3.00	5.00	4.20	0.60
	Overall Variable (Y)	2.40	5.00	4.04	0.49

Source: Hypothetical data prepared for illustrative purposes, 2026.

Table 3 shows that Agricultural Irrigation Effectiveness obtains an illustrative overall mean score of 4.04, reflecting a generally positive assessment of irrigation activities among the hypothetical respondents. Labor efficiency records the highest mean score (4.20), indicating that the use of solar-powered water pumps may help reduce the physical effort and time required for irrigation activities. Irrigation timeliness also receives a relatively high mean score of 4.15, followed by water adequacy (4.02) and irrigation continuity (3.96). Meanwhile, water distribution uniformity records the lowest mean score (3.89), suggesting that the even distribution of water across agricultural land may remain an area requiring improvement. These descriptive results provide an initial overview of farmers' assessments of irrigation effectiveness and establish a basis for further statistical analysis.

Important methodological note: The numerical values in Tables 2 and 3 are illustrative hypothetical figures, not actual SPSS output or verified field findings. They should not be presented as empirical research results. The minimum and maximum values for the overall variables also need to be calculated from each respondent's composite score, rather than simply inferred from the indicator scores. Actual standard deviations and means must be calculated from the questionnaire dataset.If using a five-point Likert scale, the following descriptive interpretation can be applied consistently:

Mean Score	Interpretation
1.00–1.80	Very Low
1.81–2.60	Low
2.61–3.40	Moderate
3.41–4.20	High
4.21–5.00	Very High

3. Validity and Reliability Tests

Validity and reliability tests were conducted to evaluate the quality and consistency of the research instrument before proceeding with further statistical analysis. The validity test examined whether each questionnaire item adequately represented the indicators of Solar-Powered Water Pump Utilization (X) and Agricultural Irrigation Effectiveness (Y). Item validity was assessed using the Pearson Product-Moment correlation between each item score and its corresponding total variable score. An item was considered valid when its calculated correlation coefficient (r-count) exceeded the critical r-table value and its significance level was below 0.05. Meanwhile, instrument reliability was evaluated using Cronbach's Alpha to determine the internal consistency of the questionnaire items. A Cronbach's Alpha value of 0.70 or higher was used as the reference for acceptable reliability. The illustrative results of these tests are presented in Tables 4 and 5.

Table 4. Validity Test Results of Research Instruments

Variable	Indicator	Item	r-count	Decision
Solar-Powered Water Pump Utilization (X)	Ease of Use	X1.1	0.712	Valid
		X1.2	0.756	Valid
	Operational Reliability	X2.1	0.734	Valid
		X2.2	0.781	Valid
	Frequency of Utilization	X3.1	0.748	Valid
		X3.2	0.805	Valid
	Pumping Capacity	X4.1	0.721	Valid
		X4.2	0.769	Valid
	Operational Sustainability	X5.1	0.743	Valid
		X5.2	0.792	Valid
Agricultural Irrigation Effectiveness (Y)	Irrigation Timeliness	Y1.1	0.735	Valid
		Y1.2	0.778	Valid
	Water Adequacy	Y2.1	0.751	Valid
		Y2.2	0.814	Valid

	Water Distribution Uniformity	Y3.1	0.729	Valid
		Y3.2	0.766	Valid
	Irrigation Continuity	Y4.1	0.742	Valid
		Y4.2	0.795	Valid
	Labor Efficiency	Y5.1	0.763	Valid
		Y5.2	0.826	Valid

Source: Hypothetical data prepared for illustrative purposes, 2026.

Table 4 presents the illustrative validity test results for the questionnaire items measuring both research variables. The correlation coefficients for the ten items measuring Solar-Powered Water Pump Utilization range from 0.712 to 0.805, while those for Agricultural Irrigation Effectiveness range from 0.729 to 0.826. All items demonstrate relatively strong positive item-total correlations. Based on the illustrative results, all questionnaire items are classified as valid because their correlation coefficients exceed the assumed critical value. These results indicate that the questionnaire items adequately represent the indicators used to measure the two research variables. However, the final validity decision must be based on the actual sample size, r-table value, and significance results obtained from SPSS.

Table 5. Reliability Test Results

No.	Research Variable	Number of Items	Cronbach's Alpha	Decision
1	Solar-Powered Water Pump Utilization (X)	10	0.912	Reliable
2	Agricultural Irrigation Effectiveness (Y)	10	0.925	Reliable

Source: Hypothetical data prepared for illustrative purposes, 2026.

The illustrative reliability test results in Table 5 show that Solar-Powered Water Pump Utilization has a Cronbach's Alpha value of 0.912, while Agricultural Irrigation Effectiveness obtains a value of 0.925. Both values exceed the minimum reference value of 0.70, indicating a high level of internal consistency among the questionnaire items. This suggests that the items within each variable consistently measure their respective research constructs. Based on these hypothetical results, both research instruments can be classified as reliable and suitable for further

statistical analysis. Nevertheless, the actual reliability conclusions must be confirmed using the questionnaire responses collected from the research participants.

4. Classical Assumption Tests

Classical assumption tests were conducted to examine whether the research data met the statistical requirements for applying simple linear regression analysis. In this study, two tests were considered: the normality test and the heteroscedasticity test. The normality test was performed to determine whether the regression residuals were normally distributed, while the heteroscedasticity test examined whether the variance of the residuals remained constant across observations. The normality test was assessed using the One-Sample Kolmogorov–Smirnov test, with a significance value greater than 0.05 indicating that the residuals were normally distributed. Meanwhile, the heteroscedasticity test was conducted using the Glejser test, in which a significance value greater than 0.05 indicates the absence of statistically significant heteroscedasticity. The illustrative results of these tests are presented in Tables 6 and 7.

Table 6. Normality Test Results

Statistical Test	Asymp. Sig. (2-tailed)	Significance Level	Decision
One-Sample Kolmogorov–Smirnov	0.200	0.050	Normally Distributed

Source: Hypothetical data prepared for illustrative purposes, 2026.

The illustrative results in Table 6 show that the Asymp. Sig. (2-tailed) value is 0.200, which exceeds the significance threshold of 0.05. This indicates that the regression residuals satisfy the normality assumption. Therefore, based on this hypothetical result, the data are considered to meet the normality requirement for subsequent simple linear regression analysis.

Table 7. Heteroscedasticity Test Results (Glejser Test)

Independent Variable	Regression Coefficient (B)	t-count	Sig.	Decision
Solar-Powered Water Pump Utilization (X)	0.035	0.842	0.403	No Heteroscedasticity

Source: Hypothetical data prepared for illustrative purposes, 2026.

Table 7 presents the illustrative results of the Glejser heteroscedasticity test. The significance value for Solar-Powered Water Pump Utilization is 0.403, which is greater than 0.05. This indicates that the independent variable does not show a statistically significant relationship with the absolute residual values. Consequently, the regression model is considered free from statistically significant heteroscedasticity based on this illustrative result. The findings suggest that the residual variance is sufficiently constant across observations, thereby supporting the application of simple linear regression analysis.

- Overall Interpretation

Based on the hypothetical results of the normality and heteroscedasticity tests, the regression model satisfies both assumptions examined in this study. The residuals are normally distributed, and there is no statistically significant evidence of heteroscedasticity. Therefore, the model can proceed to simple linear regression analysis to examine the effect of solar-powered water pump utilization on agricultural irrigation effectiveness.

5. Simple Linear Regression Analysis

Simple linear regression analysis was conducted to examine the effect of Solar-Powered Water Pump Utilization (X) on Agricultural Irrigation Effectiveness (Y) among farmer groups in Lalolang Urban Village, Barru Regency, Indonesia. This analysis aimed to determine the direction and magnitude of the relationship between the utilization of solar-powered water pumps and the effectiveness of agricultural irrigation. The regression model consisted of one independent variable (X) and one dependent variable (Y). The analysis focused on the constant value (a) and regression coefficient (b), which were obtained from the SPSS Coefficients table. The constant represents the estimated value of agricultural irrigation effectiveness when solar-powered water pump utilization is zero, while the regression coefficient indicates the expected change in irrigation effectiveness for every one-unit increase in pump utilization. The illustrative regression results are presented in Table 8.

Table 8. Simple Linear Regression Analysis

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t-count	Sig.
(Constant)	12.450	2.315	–	5.378	0.000
Solar-Powered Water Pump Utilization (X)	0.685	0.092	0.698	7.446	0.000

Dependent Variable: Agricultural Irrigation Effectiveness (Y).

Source: Hypothetical data prepared for illustrative purposes, 2026.

Based on the illustrative results in Table 8, the constant value (a) is 12.450, while the regression coefficient (b) for Solar-Powered Water Pump Utilization is 0.685. The positive regression coefficient indicates that an increase in the utilization of solar-powered water pumps is associated with an increase in agricultural irrigation effectiveness. In other words, higher levels of pump utilization are expected to correspond to higher levels of irrigation effectiveness, assuming other relevant factors remain constant. The regression equation derived from these illustrative coefficients is presented as follows:

$$\mathbf{Y = 12.450 + 0.685X}$$

The regression equation indicates that the estimated value of Agricultural Irrigation Effectiveness is 12.450 when the value of Solar-Powered Water Pump Utilization is zero. Furthermore, the regression coefficient of 0.685 indicates that every one-unit increase in Solar-Powered Water Pump Utilization is associated with a 0.685-unit increase in Agricultural Irrigation Effectiveness. The positive coefficient suggests a positive direction of influence between the two variables. However, the statistical significance and explanatory strength of this relationship must be further examined through hypothesis testing and the coefficient of determination (R^2).

6. Hypothesis Testing (t-Test)

The t-test was conducted to determine whether Solar-Powered Water Pump Utilization (X) has a statistically significant effect on Agricultural Irrigation Effectiveness (Y). The hypothesis testing was performed using a significance level of 0.05. The decision was based on the

significance value (Sig.) and the comparison between the calculated t-value (t-count) and the critical t-value (t-table). The research hypotheses were formulated as follows:

- H_0: Solar-powered water pump utilization has no significant effect on agricultural irrigation effectiveness.
- H_1: Solar-powered water pump utilization has a significant effect on agricultural irrigation effectiveness.

The decision criteria were established as follows: H_1 is accepted when the significance value is less than 0.05 and the calculated t-value exceeds the critical t-value. Conversely, H_0 is not rejected when the significance value is greater than 0.05 or the calculated t-value does not exceed the critical t-value. The illustrative hypothesis testing results are presented in Table 9.

Table 9. Partial Hypothesis Testing Results (t-Test)

Independent Variable	t-count	t-table	Sig.	Decision
Solar-Powered Water Pump Utilization (X)	7.446	2.002	0.000	H_1 Supported

Dependent Variable: Agricultural Irrigation Effectiveness (Y).

Source: Hypothetical data prepared for illustrative purposes, 2026.

Based on the illustrative results in Table 9, the calculated t-value is 7.446, which is greater than the critical t-value of 2.002. Furthermore, the significance value is 0.000, which is below the 0.05 threshold. In SPSS reporting, a significance value displayed as 0.000 should be interpreted as $p < 0.001$ rather than an actual probability of zero. These results indicate a statistically significant positive effect of Solar-Powered Water Pump Utilization on Agricultural Irrigation Effectiveness. Therefore, based on the hypothetical results, H_0 is rejected and H_1 is supported. This suggests that increased utilization of solar-powered water pumps is associated with higher agricultural irrigation effectiveness among the farmer groups studied.

7. Coefficient of Determination (R^2)

The coefficient of determination (R^2) was examined to determine the extent to which Solar-Powered Water Pump Utilization (X) explains variations in Agricultural Irrigation Effectiveness

(Y). The R^2 value was obtained from the Model Summary table generated through the simple linear regression analysis in SPSS. A higher R^2 value indicates that the independent variable explains a greater proportion of the variation in the dependent variable, while the remaining proportion is attributable to other factors outside the regression model. The illustrative results of the coefficient of determination are presented in Table 10.

Table 10. Coefficient of Determination Results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.698	0.487	0.478	3.215

Predictors: (Constant), Solar-Powered Water Pump Utilization (X).
Dependent Variable: Agricultural Irrigation Effectiveness (Y).
Source: Hypothetical data prepared for illustrative purposes, 2026.

Table 10 shows an illustrative R Square value of 0.487, indicating that Solar-Powered Water Pump Utilization explains 48.7% of the variation in Agricultural Irrigation Effectiveness. The remaining 51.3% is associated with other factors not included in the regression model, such as water availability, agricultural land conditions, irrigation infrastructure, weather conditions, crop requirements, and farmers' management practices. These factors are presented as possible external influences rather than variables directly tested in this study. The results suggest that solar-powered water pump utilization provides a substantial contribution to explaining differences in irrigation effectiveness among the hypothetical respondents.

- Overall Interpretation

Taken together, the illustrative results of the t-test and coefficient of determination indicate that Solar-Powered Water Pump Utilization has a positive and statistically significant effect on Agricultural Irrigation Effectiveness. The t-test results show that the calculated t-value (7.446) exceeds the critical t-value (2.002), with a significance level of $p < 0.001$. This suggests that the utilization of solar-powered water pumps is positively associated with improvements in agricultural irrigation effectiveness.

Furthermore, the coefficient of determination (R^2) of 0.487 indicates that Solar-Powered Water Pump Utilization explains 48.7% of the variation in Agricultural Irrigation Effectiveness. The remaining 51.3% may be associated with other factors not examined in this research, including water availability, agricultural land conditions, irrigation infrastructure, weather conditions, and farmers' management practices.

Overall, these illustrative findings highlight the potential contribution of solar-powered water pump technology to improving agricultural water management, particularly through more accessible and efficient irrigation systems. However, the actual magnitude and statistical significance of this effect must be confirmed through analysis of the original field survey data.

- Discussion

The descriptive statistical results provide an overview of the contribution of solar-powered water pump utilization to agricultural irrigation activities among farmer groups in Lalolang Urban Village, Barru Regency. The overall mean score of 4.07 for Solar-Powered Water Pump Utilization indicates a positive assessment of the technology, particularly in terms of frequency of utilization and ease of use. This suggests that solar-powered water pumps are perceived as practical and accessible irrigation facilities for supporting farmers' daily activities. Similarly, the mean score of 4.04 for Agricultural Irrigation Effectiveness reflects a generally positive assessment of irrigation performance. Labor efficiency and irrigation timeliness emerge as the strongest indicators, suggesting that solar-powered pumping systems may help farmers reduce manual irrigation efforts and obtain water when needed. However, the relatively lower scores for pumping capacity and water distribution uniformity indicate that technical performance and the equitable distribution of water remain important considerations in maximizing the benefits of solar-powered irrigation systems.

The regression analysis and t-test provide further insight into the relationship between solar-powered water pump utilization and irrigation effectiveness. The illustrative regression coefficient of 0.685 indicates a positive association, meaning that higher utilization scores correspond to higher irrigation effectiveness scores. The t-test result ($t = 7.446$; $p < 0.001$) also suggests that this relationship is statistically significant within the hypothetical model. This finding

is consistent with the argument that solar-powered irrigation can improve farmers' access to water while reducing dependence on conventional energy sources. Aini et al. (2021), in their study of a solar irrigation system in Krandegan Village, Indonesia, demonstrated the technical feasibility of using photovoltaic-powered pumps as an alternative to diesel-based irrigation. Similarly, research by Negera et al. (2025) found positive effects of solar pump irrigation on smallholder farmers' agricultural income and food security. These studies reinforce the potential importance of solar-powered pumping systems in supporting agricultural activities, although the actual effect in Lalolang must be established using the observed survey data.

The coefficient of determination ($R^2 = 0.487$) indicates, in the illustrative model, that solar-powered water pump utilization explains 48.7% of the variation in agricultural irrigation effectiveness, while the remaining 51.3% may be associated with factors outside the model. These factors may include water-source availability, groundwater depth, pump capacity, solar radiation, irrigation infrastructure, crop water requirements, and farmers' technical knowledge. This interpretation is consistent with the review by Shah et al. (2018), which identifies system quality, water-use efficiency, crop water requirements, water-source depth, and utilization levels as important determinants of sustainable solar irrigation deployment. In addition, the technical assessment by Rejekiningrum and Kartiwa highlights the importance of irrigation design and water distribution methods in improving water-use efficiency. Therefore, the effectiveness of solar-powered irrigation should not be assessed solely through the availability of pumping technology, but also through the suitability of system capacity, water distribution, maintenance, and agricultural water-management practices.

From a theoretical and practical perspective, these findings highlight the importance of integrating renewable energy technology into sustainable agricultural development. Solar-powered irrigation systems can support agricultural sustainability by reducing dependence on fossil fuels, improving access to irrigation water, and potentially lowering operational costs. Agrawal and Jain (2019) emphasize that the sustainability of solar irrigation pumps depends not only on technology adoption but also on system quality, water-use efficiency, farmers' awareness, and long-term maintenance. Similarly, Rejekiningrum and Kartiwa (2017) demonstrate the potential of solar-powered irrigation systems to improve water distribution efficiency and reduce fuel consumption in Indonesian agricultural settings. In the context of Lalolang, these insights

suggest that strengthening farmer capacity, improving pump maintenance, ensuring adequate water distribution, and establishing collective management arrangements are essential to maximizing the benefits of solar-powered irrigation. Consequently, solar-powered water pumps should be viewed not merely as alternative irrigation equipment but as part of a broader strategy for sustainable agriculture and farmer empowerment.

D. CONCLUSION AND RECOMMENDATIONS

- Conclusion

This study examines the effect of solar-powered water pump utilization on agricultural irrigation effectiveness among farmer groups in Lalolang Urban Village, Barru Regency, Indonesia. The descriptive analysis indicates that the utilization of solar-powered water pumps is positively perceived by farmers, particularly in terms of ease of use and frequency of utilization. Similarly, agricultural irrigation effectiveness is reflected in improved irrigation timeliness and labor efficiency. These findings suggest that solar-powered water pumps have the potential to support agricultural irrigation by facilitating access to water, reducing dependence on manual irrigation methods, and improving the efficiency of farming activities.

Furthermore, the illustrative regression analysis indicates a positive and statistically significant relationship between solar-powered water pump utilization and agricultural irrigation effectiveness, with an R^2 value of 0.487. This suggests that pump utilization may explain a substantial proportion of variations in irrigation effectiveness, while other factors also contribute to irrigation performance. The study highlights the importance of renewable energy-based irrigation technology as a potential strategy for supporting sustainable agriculture, improving water management, and strengthening the capacity of farmer groups in rural communities.

- Recommendations

Based on the findings, farmer groups and relevant local government institutions are encouraged to strengthen the utilization and maintenance of solar-powered water pumps through regular technical inspections, operator training, and collective management arrangements. Improvements should also focus on optimizing pumping capacity, ensuring equitable water

distribution, and maintaining the continuity of irrigation services, particularly during periods of high agricultural water demand. Future research should involve a larger sample of farmers and consider additional variables, such as water availability, land characteristics, irrigation infrastructure, and farmers' technical capacity, to provide a more comprehensive understanding of the factors influencing agricultural irrigation effectiveness.

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