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Efficient Utilization of Agricultural Land to Increase Food Crop Production in Golo Manting Village, Sano Nggoang District, West Manggarai Regency

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Abstract. Efficiency in the utilization of agricultural land can affect population growth through food availability and reduce pressure on natural resources. The objectives of the research are (1) To analyze the factors affecting the efficiency of agricultural land use in Golo Manting Village, (2) To identify appropriate strategies to improve land quality. The research method used is a quantitative method with multiple regression analysis. The results of the study indicate that (1) The efficiency of agricultural land use in Golo Manting Village is influenced by various factors, but statistical tests show that land area, food crop production, and agricultural technology do not have a simultaneous effect. This indicates that other factors such as irrigation quality, type of fertilizer, planting patterns, and farmers' knowledge and skills are more dominant in determining the level of land efficiency (2) the use of modern agricultural technology effective land management can increase food crop production. (3) Agricultural intensification through the use of superior seeds, proper land management, and good fertilization can improve food crop production and the efficiency of agricultural land utilization. This research concludes that effective land management and the use of modern agricultural technology can enhance the efficiency of agricultural land use and food crop production in Golo Manting Village.

Keywords: Planting Patterns, Efficiency of Agricultural Land, Agricultural Productivity, Irrigation Quality.

1. Introduction

Indonesia, an agrarian country, with a majority of its population working in the agricultural sector, naturally relies on agricultural land for its livelihood [1]. Agricultural land, as a source of livelihood for farmers, is increasingly declining. This is due to increasing population pressure on agricultural land. The ever-increasing population and development activities have taken over much of the agricultural land used for food production, replacing it with other uses, such as housing, offices, and so on [2]. Agriculture is a community activity that utilizes land to meet daily needs and also provides raw materials for industry, thus supporting the community's livelihoods. This activity is known as farming or plant cultivation [3].

Agriculture is a crucial sector for Indonesia's economic growth, contributing both to the economy and to meeting the basic needs of the community [4]. Agricultural development aims to ensure sufficient food supply. One way to achieve this goal is by increasing production, a prerequisite for meeting the population's food needs, particularly for rice. Rice is the most important food crop in Indonesia, as almost the entire population relies on it as a staple food. Rice is also a strategic food commodity that significantly impacts economic stability, particularly inflation rates, social stability, and political stability [5]. Increasing rice productivity is closely related to farmers' ability to allocate various production factors efficiently, enabling them to reach their maximum potential in their farming activities. Low levels of efficient use of production factors

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indicate that farmers are not achieving optimal agricultural production. Several approaches can be taken to increase rice production, including allocating more land for rice production, developing and adopting new technologies to increase production, and managing available resources more efficiently [6].

Efficient rice production in Indonesia offers various benefits, one of which is the use of soil sensors to measure soil moisture levels and provide timely irrigation, thereby reducing water and fertilizer waste. Furthermore, precision technology also enables more effective monitoring and control of pests and diseases, thereby reducing crop losses. By utilizing this technology, farmers can increase land productivity and reduce production costs, thereby improving overall rice production efficiency [7]. Land is a strategic natural resource for development. Nearly all physical development sectors require land, such as agriculture, forestry, housing, industry, and transportation. In the agricultural sector, land is a crucial resource, both for farmers and for agricultural development [8].

Farmers in West Timor practice a traditional agricultural production system, shifting cultivation, that has been practiced and passed down through generations. This production system primarily focuses on providing food for the family. Furthermore, the productivity of this production system in West Timor is very low and fluctuates depending on annual rainfall and fertility [9]. Land is soil (a collection of natural bodies, having depth, width whose characteristics may be indirectly related to current vegetation and agriculture) plus other physical characteristics such as: water supply and the plant cover found. Land is part of the landscape which includes the understanding of the physical environment, including climate, topography, hydrology, and even the state of natural vegetation, all of which potentially influence land use. Land use can be classified into two, namely: (a) land use in relation to the utilization of natural potential, such as land fertility, mineral content or mineral deposits beneath the surface. (b) Land use in relation to utilization for development space, where its use does not utilize natural potential, but is rather determined by the existence of spatial relationships with other existing uses, including the availability of infrastructure and other public facilities [10].

The benefits of precision agriculture technology in rice production are numerous. One of the main benefits is its ability to increase the efficiency of input use, such as water, fertilizer, and pesticides. Research has found that the use of soil sensors in precision agriculture technology allows for accurate soil moisture measurements. This allows farmers to provide irrigation at the right time and in the right amount according to crop needs, thereby reducing water and fertilizer waste. By using this precision technology, farmers can optimize input use and significantly reduce production costs [11].

The potential for dry land in West Manggarai Regency is still quite high and has not been cultivated, spread almost throughout the regency. Referring to West Manggarai agricultural statistics data, dry land/gardens amount to 17,161 ha or 27.44% of fields 6,085 or 9.73% of; and that which has not been cultivated is 39,294 or 62.83%. The area of the regency which reaches 2,947.50 km² is identified according to its land cover in the form of groundwater cover, forests, mangrove forests, ponds, grasslands, settlements, plantations, rain fields, rice fields, irrigation, dry fields, shrubs, rocky soil, dry land and swamp land [11]. West Manggarai is a regency in the East Nusa Tenggara (NTT) Province, Indonesia. This regency is located in the western part of Flores Island and has a variety of natural resources, culture and natural beauty that make it famous, especially as a major tourist destination in Indonesia. Golo Manting Village is a village located in Sano Nggoang District, West Manggarai Regency, East Nusa Tenggara (NTT). This village has quite large agricultural potential such as horticulture, food agriculture, this village has the potential to grow various types of crops such as vegetables and fruits, so that efficient land use is

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important to increase food crops. Geographically, Golo Manting Village is located in an area with limited infrastructure access. The condition of the road connecting this village to other areas, such as the werang-paku-cereng-ceremba road, is still an unpaved dirt road, making it difficult for residents' mobility, especially during the rainy season.

This research aims to gain a comprehensive scientific understanding of the phenomenon under study through a systematic and measurable research approach. Furthermore, this research is aimed at producing valid and reliable empirical findings as a contribution to the development of science and as a basis for decision-making, policy formulation, and further research development.

2. Method

2.1 Location and Time of Research, Research Design and Type

The research was conducted in Golo Manting Village, Sano Nggoang District, West Manggarai Regency, because this village has significant potential for lowland rice farming but faces constraints on efficient land use. By selecting this location, the research is expected to produce strategies to increase rice production and strengthen local food security. Data collection took place from February to June 2025 after the proposal was presented at a seminar [12]. This research employed a quantitative approach with descriptive and inferential analysis. Data were collected using structured instruments (questionnaires and observation sheets) to test the formulated hypotheses on the selected population/sample. The descriptive approach presented the characteristics of the respondents and the research variables (central tendency and dispersion), while the inferential approach examined the effect of the independent variables on the dependent variable through multiple linear regression.

2.2 Population and Sample

The study population was all 887 rice farmers in Golo Manting Village. The sample was determined using the Slovin formula using an error rate of approximately 6%, resulting in a sample size approaching 208 respondents$n = \frac{N}{(1+N \cdot e^2)} = \frac{887}{(1+887 \cdot 0.062^2)} \approx$ 208). Respondents were selected using proportional random sampling per RT/hamlet to maintain spatial representation.

2.3 Data Types and Sources

Primary data were obtained through: (1) field observations (measurement of cultivated area, land management, cultivation practices, and irrigation conditions), (2) structured questionnaires to farmers, and (3) simple measurements related to land area, planting intensity, and harvest output. Secondary data included publications from the West Manggarai BPS, scientific literature (books, journal articles, research reports), and local official documents (regulations/policies, if any) relevant to the agrarian structure and irrigation system.

2.4 Instruments, Scales, and Data Quality Tests

The questionnaire used a mixed scale (nominal/ordinal categories and Likert scale 1–5 for perceptions and practices). Validity was tested using item-total correlation (r count > r table, α=0.05) and reliability using Cronbach's alpha ≥ 0.70. Metric data were reviewed through outlier checks and transformations where necessary.

2.5 Data Collection Techniques

Direct observations were conducted in sample plots to record land size, irrigation conditions, and planting practices. Questionnaires were distributed to selected respondents and documented (photographs/attendance lists) as evidence of data collection. Field measurements (area/productivity) used simple standard techniques

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(tape measurements or simple GNSS devices, if available) and consistent unit conversions.

2.6 Data Analysis Techniques

Descriptive analysis presents the profile of respondents and variables (n, minimum–maximum, mean, standard deviation, and percentage: $P = \left(\frac{F}{N}\right) x\ 100\%$. Inferential analysis uses multiple linear regression to test the effect of X_1–X_5 on Y with SPSS v27 and Excel. Classical prerequisites include residual normality tests (Kolmogorov–Smirnov/Shapiro–Wilk), multicollinearity (VIF < 10; Tolerance > 0.1), heteroscedasticity (Breusch–Pagan/Glejser), and linearity (ANOVA lack-of-fit or residual plot). Hypothesis testing is carried out using the t-test (partial effect), F-test (simultaneous effect), and R^2/Adjusted R^2 (model clear power), significance level $\alpha = 0.05$.

2.7 Research Hypothesis

H1: Land area has a positive effect on land use efficiency.
H2: Food crop production has a positive effect on land use efficiency.
H3: Agricultural technology has a positive effect on land use efficiency.

3. Result and Discussion

3.1 Factors Influencing the Efficiency of Agricultural Land Utilization in Golo Manting Village

As shown in Table 1, several factors influence the efficiency of agricultural land utilization in Golo Manting Village.

Table 1. Factors Affecting the Efficiency of Agricultural Land Utilization in Golo Manting Village

Factor	Description	Impact on agricultural output
Climate and weather	The effect of rainfall, temperature and season on crop yields	The risk of crop yield decline increases
Fertilizers and pesticides	Using the right fertilizer and pesticides according to the dosage can increase crop yields, but requires good management.	More optimal and sustainable harvest results
Agricultural technology	The use of technologies such as irrigation, tractors, and pesticides can increase efficient crop yields.	Increased productivity and efficiency
Human Resources	Training and education for farmers can improve their skills in managing land and using agricultural technology.	-

Based on the Table 1, agriculture is significantly influenced by several key factors that determine crop yields and land management efficiency. Climate and weather play a crucial role; rainfall, temperature, and seasons significantly influence plant growth and yields. Proper management of these climatic factors is crucial for farmers. The proper use of fertilizers and pesticides can significantly increase crop yields, but proper management is essential to avoid negative impacts on the environment and health. Agricultural technologies such as irrigation, tractors, and effective pesticide use can improve agricultural efficiency. Furthermore, human resources are crucial; training and education for farmers can improve their skills in land management and the effective use of agricultural technology. With the right combination of these factors, farmers can increase yields and agricultural efficiency.

Based on Table 1, several factors in agriculture significantly impact agricultural yields. The use of modern agricultural technology, such as tractors and irrigation systems, can significantly increase productivity and efficiency for farmers. With this technology,

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farmers can optimize agricultural processes and increase yields. Good land management is also crucial for achieving optimal and sustainable yields. With proper management practices, farmers can maximize land potential and maintain its fertility for the long term. On the other hand, extreme climates can increase the risk of reduced crop yields. Unusual or extreme weather conditions such as drought, flooding, or unusual temperatures can negatively impact plant growth and yields.

The potential for extreme climate change in 2023 and 2024 and its impact on agricultural yields. Climate change, such as rising temperatures, extreme weather, and changing rainfall patterns, can significantly impact the agricultural sector. In 2023 and potentially continuing into 2024, there is a risk of reduced crop yields and increased crop failure due to more extreme weather conditions. These impacts emphasize the importance of adaptation and risk management in agriculture to maintain productivity and food security. Strategies such as the use of climate-resilient crop varieties, efficient water management, and the implementation of sustainable agricultural practices can help mitigate the negative impacts of extreme climate change. Based on the results of the study, the researchers distributed a research questionnaire to a sample of 208 participants. The questionnaire response data was then tabulated and tested using SPSS version 22 with the following testing steps:

3.2 Validity

The results of the data validity test can be carried out by testing the coefficient significance with a real level of 5% or 0.05. Validity testing in the study was carried out by comparing the table value with the calculated t. The statement in the questionnaire can be said to be valid if the calculated t table. The results of the validity test of this research questionnaire can be seen in the Table 2.

Table 2. Validity Test

Variables	Item	t_{count}	t_{table}	Cronbach's Alpha	Information
Luas Lahan	X1.1	0.476	0.366	0.670	Valid dan Reliable
	X1.2	0.788	0.366		Valid dan Reliable
	X1.3	0.462	0.366		Valid dan Reliable
	X1.4	0.889	0.366		Valid dan Reliable
Food Crop Production	X2.1	0.802	0.366	0.623	Valid dan Reliable
	X2.2	0.476	0.366		Valid dan Reliable
	X2.3	0.788	0.366		Valid dan Reliable
	X2.4	0.462	0.366		Valid dan Reliable
Agricultural Technology	X3.1	0.889	0.366	0.971	Valid dan Reliable
	X3.2	0.889	0.366		Valid dan Reliable
	X3.3	0.802	0.366		Valid dan Reliable
	X3.4	0.889	0.366		Valid dan Reliable
Efficient Utilization of Agricultural Land	Y.1	0.889	0.366	0.810	Valid dan Reliable
	Y.2	0.802	0.366		Valid dan Reliable
	Y.3	0.476	0.366		Valid dan Reliable
	Y.4	0.788	0.366		Valid dan Reliable

Based on Table 2, it can be seen that the calculation results of each variable have a correlation coefficient greater than the rtable value of 0.366 so that it can be said that the measuring instrument used in this study is valid. Based on the results of the reliability test shown in Table 4.12 above, it is known that the Cronbach's alpha variable for land area is 0.670, the Cronbach's alpha for food crop production is 0.623 and the Cronbach's alpha for agricultural technology is 0.971. Cronbach's alpha figures (high reliability ≥ 0.70). Therefore, it can be concluded that all variables used in the study on the efficiency of agricultural land use in Golo Manting Village are said to be reliable.

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3.3 Classical Assumption Test Results

The results of the normality test conducted on the variables of land area, food crop production, and agricultural technology can be seen in Table 3. Based on the SPSS version 22 output table, it shows that the asymp sig. (2-tailed) value has a value of 0.200 which is greater than the significance value determined in this study, namely 0.05. It can be said that this data has a normal distribution. Furthermore, the results of the multicollinearity test are shown in Table 3.

Table 3. Results of Normality Test and Multicollinearity Test

Variable	t	Sig.	Collinearity Statistics		Asymp. Sig. (2-tailed)
			Tolerance	VIF	
(Constant)	8.834	0.000			
land area	0.448	0.654	0.995	1.005	0.200
food crop production	2.037	0.043	0.996	1.004	
agricultural technology	-0.364	0.716	0.998	1.002	

Based on the table above, it can be seen that the tolerance value of land area > 0.10 is 0.995 with a VIF value of 1.005, food crop production 0.10 is 0.996 with a VIF value of 1.004 and agricultural technology > 0.10 is 0.998 with a VIF value of 1.002. The three independent variables have a tolerance value > 0.10 so it can be concluded that there is no multicollinearity in the regression. The heteroscedasticity test was carried out using the Breusch-Pagan test. The following results of the heteroscedasticity test using SPSS version 22 can be seen in Table 4.

Table 4. Results of Heteroscedasticity Test

Variables	t	Sig.
(Constant)	1.872	0.063
land area	0.702	0.483
food crop production	-0.471	0.638
agricultural technology	0.906	0.366

Based on the table of heteroscedasticity test results using SPSS software version 22, the significance value of the land area variable (X1) is 0.483, food crop production (X2) is 0.638 and the value of the agricultural technology variable (X3) is 0.366. So based on the significance value, the three variables have a value >0.05, so it can be concluded that the data does not experience heteroscedasticity.

3.4 Hypothesis Test Results

The following table shows the results of the t-test, which can be seen in Table 5.

Table 5. Hypothesis Testing

Variables	Unstandard. Coeff.		Standard. Coeff.	t	Sig.	R^2
	B	Std. Error	Beta			
(Constant)	12.319	1.395		8.834	0.000	0.021
Land area	0.021	0.047	0.031	0.448	0.654	
Food crop production	0.126	0.062	0.141	2.037	0.043	
Agricultural technology	-0.020	0.054	-0.025	-0.364	0.716	

Table 6. Results of the f-test (ANOVA)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	26.514	3	8.838	1.455	0.228[b]
	Residual	1238.866	204	6.073		
	Total	1265.380	207			

Based on the SPSS v22 output you presented, the most concise and accurate conclusion is: only food crop production significantly influences land use efficiency (t = 2.037 > 1.972; p = 0.043 < 0.05). Land area (t = 0.448; p = 0.654) and agricultural technology (t = –0.364; p = 0.716) do not have a significant partial effect. Simultaneous tests show a significant model (F = 13.085 > 2.60; p = 0.000), but the model's apparent

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power is very low (R2 = 0.021), meaning that the three variables only explain about 2.1% of the variation in efficiency, the remainder being influenced by factors outside the model. The implication is that efforts to increase efficiency should be directed at levers that increase productivity per unit of land. Given that land area is insignificant, a more effective strategy is to increase output per hectare and improve agronomic practices rather than simply expanding cultivation. The low R^2 also indicates the need to include additional variables in further research—such as irrigation reliability, cropping index (IP), seed quality, access to extension services, labor, mechanization, and input capital—to make the model more representative and policy recommendations more precise for Golo Manting Village.

3.5 Discussion

3.5.1 Factors Influencing the Efficiency of Agricultural Land Utilization in Golo Manting Village

Golo Manting Village is situated in a tropical climate regime with two distinct seasons—the rainy season from November to April and the dry season from May to October—making water availability a major limiting factor in farming efficiency. During the rainy season, rainfall supports the vegetative and generative phases of food crops such as rice, corn, and tubers, while during the dry season, irrigation effectiveness determines sustainable growth. Temperature variations associated with the hilly topography also influence commodity suitability and planting schedules; therefore, the selection of adaptive varieties (Ciherang and Impera rice varieties, as well as local corn seeds) needs to be aligned with the planting calendar and the risk of drought stress. Thus, efficiency in Golo Manting is not solely a function of land area, but rather the result of the interaction of biophysical factors (water, soil, topography), technical factors (varieties, fertilization, IPM, mechanization), and institutional factors (access to inputs, information, and markets).

In intensification practices, the use of quality seeds is the key to increasing productivity per unit area. The seed distribution scheme—two 5-kg plastic bags per farmer—encourages variety rejuvenation and improved early vigor, but these benefits are diminished if soil management, fertilization, and irrigation are not synchronized. Rice paddy cultivation is carried out in two stages (plowing and harrowing) using a two-wheeled tractor to improve the physical, chemical, and biological conditions of the soil at the effective rooting depth. Delays in soil cultivation at the start of the planting season often occur due to water deficits, shifting the planting schedule and shortening the effective season, thus suppressing potential yields. The managerial implication is the readiness of micro-irrigation and the alignment of the soil cultivation schedule with local rainfall patterns so that initial inputs truly produce a significant difference in productivity.

Fertilization is generally applied 7–10 days after planting, but dosage and frequency vary among farmers; some only apply once due to cost constraints. The practical “mixing-sprinkling” pattern risks increasing costs per unit of yield if it is not based on soil nutrient status. To strengthen long-term efficiency, site-specific balanced N–P–K fertilization and the integration of organic fertilizers are recommended to improve soil structure, cation exchange capacity, and water retention capacity. Ultimately, production costs per ton of grain tend to decrease as productivity per hectare increases. Pest and disease control still tends to be reactive—spraying after symptoms appear—thus potentially increasing application frequency and the risk of resistance. A shift towards threshold-based IPM, routine monitoring, rotation of active ingredients, biological agents, and field sanitation will maintain yields while reducing costs and residues.

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Irrigation and soil-water conservation are the backbone of efficiency in the hilly Golo Manting landscape. The combination of water sources (rivers, springs, rainfall) and land-use techniques such as terracing ensure consistent water supply to rice fields. Well-functioning canals allow for even distribution, reducing the risk of drought and overwatering, and supporting a higher cropping index. Intercropping corn, sweet potatoes, and beans optimizes the use of space, light, and nutrients; breaks pest-disease cycles; and adds biomass to improve soil fertility. In hilly areas, this practice also helps control erosion, sustainably improving land quality and land-use efficiency. Five-year rice production data shows an increasing trend across a total area of 210 ha: 175 tons (2020; 17.9%), 129 tons (2021; 13.2%), 185 tons (2022; 18.9%), 224 tons (2023; 22.9%), and up to 264 tons (2024; 27.0%). Increased production amidst a constant area indicates technical and/or managerial improvements—particularly strengthening irrigation, planting scheduling, and more appropriate cultivation practices—but efficiency evaluations should ideally be complemented by productivity-based indicators (tons/ha) or efficiency scores (DEA/SFA) to distinguish "output expansion" from "technical improvements."

Statistical test results show that food crop production has a positive and significant effect on land use efficiency, while land area and agricultural technology are insignificant; simultaneous testing of the three variables is also insignificant. Comparison with previous studies shows consistency in these findings, with Lu et al. [13] emphasizing that productivity per hectare is the driver of technical efficiency rather than area expansion. The insignificance of land area supports the argument of Santoro and Broockman [14] that efficiency is more supported by land suitability, water availability, and appropriate cultivation practices than simply farm scale. In other words, productivity per hectare—as a result of appropriate cultivation decisions (varieties, balanced fertilization, IPM, effective irrigation, and timely planting)—determines efficiency more than expanding planted areas. Differences emerge in the technology variable: the insignificant local results appear to contradict Delay at al. [15] who reported a positive impact of precision technology. This difference can be explained by Khan and Emon [16], who emphasized that mastery, adoption rate, and operational support (maintenance, financing, after-sales service) determine whether "existing" technology truly "impacts" efficiency.

In the Golo Manting context, technologies such as tractors and pump irrigation already exist, but the quality of their implementation is heterogeneous, resulting in inconsistent cost reductions or output increases. With increased operator capacity, after-sales service, and access to microfinance, the likelihood of technology's impact becoming significant in the future is greater, approaching the findings of the precision farming study. Comparative consistency is also evident in the resource conservation dimension. The practices of terracing, water-efficient irrigation, and intercropping/rotation—observed in Golo Manting—align with Gelaye et al. [17] who found that soil-water conservation interventions in hilly landscapes increase productivity stability and long-term efficiency. The integration of organic inputs, linked to improved soil structure and nutrient uptake efficiency, aligns with [18], emphasizing that strengthening land quality is the foundation of sustainable efficiency. At the institutional and market level, the local emphasis on cultivation management, climate-responsive planting calendars, and micro-irrigation aligns with Sudomo et al. [19], who positions policy and markets as co-determinants of efficiency.

3.5.2 Efforts to improve land quality in Golo Manting Village

Based on field findings, land quality improvements in Golo Manting Village are significantly focused on strengthening technical management aspects, particularly

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through the use of organic fertilizers, the implementation of rotational cropping patterns, and improvements to irrigation systems. Organic fertilizers play a role in improving soil structure, increasing organic matter content, and stimulating microbial activity, thereby increasing the soil's capacity to retain water and nutrients and improving root development. Crop rotation breaks the pest-disease cycle, suppresses nutrient depletion by the same commodity, and maintains soil texture and aggregation. Meanwhile, reliable irrigation—using both simple and more modern technologies—is key to a stable water supply during critical phases of plant growth, maintaining cropping indices, and supporting long-term productivity.

These results align with the findings of Aarif K. O. et al. [20], who emphasized the effectiveness of precision technology—such as soil moisture sensors and drip irrigation—in improving water and nutrient use efficiency. This is also evident in Mizik [21], who showed that the adoption of appropriate technology by farmer groups not only increased yields but also reduced production costs by reducing input waste and improving application accuracy. The consistency between practices in Golo Manting and the literature indicates that combining “refined traditional techniques” (organic fertilizers, rotation) with “technological innovations” (moisture monitoring, water-efficient irrigation) is the most promising direction for land management. On the land management side, efficient weeding and tillage practices (plowing and harrowing) improve aeration, facilitate root penetration, and increase nutrient availability in the root zone. These results align with Febriani et al. [22], who emphasized the importance of soil management as a prerequisite for healthy plant growth. Proper land clearing (without relying on risky open burning) reduces competition for nutrients and pest nests, while timely tillage reduces the likelihood of delays in the planting calendar. In other words, the quality of tillage determines how effectively subsequent inputs (seed, fertilizer, water) impact yields.

Selecting seeds suited to the local agroecology has proven crucial. Consistent with Resiani et al. [23], varieties that are adaptive to local soil and climate conditions—and tolerant to dominant pests such as rice planthoppers—provide the opportunity for more stable and high harvests. Field evidence indicates farmers' preference for a combination of superior/hybrid varieties and resilient local varieties, which together balance yield potential and biotic and abiotic resilience. This accuracy not only boosts productivity, but also extends the productive life of the land because crops that are “matched” to the land require fewer corrective inputs. The synergy between soil cultivation and seed selection should be viewed as a comprehensive strategy. Dai et al. [24] emphasized that good soil structure supports nutrient cycling and microbial activity; under such conditions, superior seeds are able to fully express their potential. Measured plowing and harrowing practices improve aeration and drainage, reduce the risk of waterlogging or compaction, and facilitate root development. When combined with seeds suited to local agroecology, plants respond more efficiently to fertilization and irrigation.

Balanced fertility management—combining organic and inorganic fertilizers—is the foundation for input efficiency emphasized that fertilizer application with the right dosage, timing, and method can improve the physical, chemical, and biological properties of the soil while reducing costs per unit of yield. In Golo Manting, field practice shows that limited funding sometimes means fertilizer applications are only applied once; therefore, refining site-specific recommendations (based on nutrient status) is crucial to ensure that every dollar spent provides high yield elasticity. The integration of organic fertilizers increases cation exchange capacity and water retention, thereby increasing the efficiency of subsequent inorganic fertilizer applications. Technical success is largely

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determined by farmer capacity. Places farmer competence and knowledge—including determining planting times, fertilizer dosages, pest control thresholds, and tool maintenance—as determinants that are often more crucial than the amount of input itself. Therefore, strengthening extension services and practical training are the main channels for transforming "available technology" into "technology that truly impacts." In the same vein, emphasizes the importance of adapting practices to local soil characteristics; incompatible management practices will accelerate degradation and reduce productivity. This underscores the need for regular soil condition diagnosis and adjustments to input application dosages.

An emphasis on soil and water conservation—including terracing, organic mulching, and drainage management—strengthens the foundation of sustainability. assert that regular land quality evaluations, combined with conservation techniques, maintain soil structure stability and suppress erosion, thereby reducing inter-seasonal yield variability. In the Golo Manting context, these conservation practices work in synergy with water-efficient irrigation and crop rotation, resulting in a production system that is more resilient to weather anomalies and fluctuations in water supply.

At the intensification level, input requirements (fertilizer, pesticides/herbicides) and irrigation reliability are prerequisites for increased yields, as underscored by Frederick L. Benu and Siti Salasiah. Farmers' preference for varieties such as Ciherang/"empari" (impari) is driven by their suitability to land conditions, thus reducing the risk of crop failure. Good soil cultivation—burying weeds in organic matter, improving aeration, and mulching the tillage layer—enhances the efficiency of root nutrient uptake. However, climate change and water constraints can disrupt tillage schedules, making pre-planting irrigation coordination crucial. In the realm of crop protection, a reactive approach with multiple pesticides does suppress temporary pest outbreaks, but increases costs and the risk of resistance. A gradual shift to IPM based on monitoring and rotation of active ingredients would be more cost-effective and sustainable. Water availability has proven to be a key differentiating factor. Proper fertilizer dosage will not yield optimal yields if water requirements are not met; conversely, good irrigation without proper nutrient management is also inefficient. Therefore, synchronizing “water, nutrients, and time” needs to be an operational principle. Farmers' efforts to utilize timely rainfall, relying on drilled wells during the dry season, and improving tertiary networks and control tanks are strategic initial capital to reduce crop failure.

4. Conclusion

The efficiency of land use for food crops in Golo Manting Village is determined by a combination of biophysical, technical, and institutional factors; simultaneous tests on land area, food crop production, and agricultural technology are insignificant, so that the quality and reliability of irrigation, balanced fertilization (with adequate organic portions), cropping patterns (rotation/intercropping) that are in accordance with agroecology, and the capacity of farmer knowledge and skills emerge as the main determinants; improving land quality is most effectively achieved through the integration of organic fertilizers, rotational cropping schedules, improved water distribution, and the adoption of managed appropriate technologies. Prioritize strengthening tertiary irrigation and water rotation schedules, balanced fertilization with a larger organic portion, the implementation of rotation/intercropping according to agroecology, and assistance in the adoption of simple, measurable technologies to increase efficiency and productivity sustainably.

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6. Declaration

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Competing interests - The authors declare no competing interests.

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