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A COMPARATIVE STUDY OF ECONOMIC EFFICIENCY OF SORGHUM IN MONOCULTURE AND INTERCROPPING PATTERNS IN ENDE DISTRICT, INDONESIA

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ABSTRACT

Sorghum is one of the rice substitution commodities, and a source of carbohydrates, protein, vitamins and minerals, however, the percentage of its productivity witnessed a decrease. This research aims to analyze the economic efficiency level of sorghum cultivation through the development of monoculture and intercropping agricultural models. Additionally, the research is aimed at discovering the fundamental factors that influence the efficiency level. This research was conducted in Nggela village, starting from September to November 2023. The population was 170 participants, consisting of 95 people applying monoculture farming and 75 people for the intercropping farming model. The census method was used in this research. The researchers adopted the Cobb-Douglass Stochastic Frontier Analysis (SFA) approach for data analysis. The results of the study showed that the average technical, allocative and economic efficiency of monoculture sorghum farmers was lower than that of intercropping sorghum farmers; this caused farmers to be more interested in intercropping technology than monoculture. Advantages of intercropping; reducing plant pests, increasing soil fertility, and increasing farm income. Factors that affect technical, allocative and economic efficiency are; age, length of farming, farmer

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membership dummy, cropping model dummy, and land ownership status dummy and the one that did not have a significant effect was the credit access dummy, This has an impact on the slow development of sorghum farming businesses. It is recommended that farmers adopt intercropping practices and optimize their use of inputs for greater efficiency.

Keywords: *income, productivity, sorghum farming*

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INTRODUCTION

The Ministry of Agriculture of the Republic of Indonesia estimates that rice production in 2023 will drop drastically to 1.2 million tons (Widi, 2023). Therefore, sorghum can be an alternative food, and an answer to the idea of food diversification. According to Hardono, (2014), food diversification is closely related to the existence of alternative food choices, which can reduce dependence on dominant types of food, such as rice.

East Nusa Tenggara (NTT) Province is one of the regions in Indonesia that always experiences the impacts of climate change; drought, floods, landslides and forest fires. This condition is increasingly worrying because agriculture in NTT Province is dry land agriculture, with the population continuing to increase, economic activity continues to increase and the contribution to economic growth is very dependent on agriculture. Facts on the ground are that meeting people's food needs still relies heavily on rice, but with climate change, several rice centre areas are experiencing planting and harvest failures. The Indonesia Climate Change Sectoral Roadmap (ICCSR) has designed a road map for overcoming climate change through adaptation and mitigation programs (Hannoeriadi A. et al., 2022), including the cultivation of certain food crops that can adapt to long drought conditions, so that it is able to meet the community's food needs in the midst of prolonged hot climate conditions, one of which is sorghum.

Sorghum is an alternative food that has been largely, successfully cultivated around the world including in America. In Indonesia, sorghum has become the major and strategic commodity to be fully developed in the dry-land farming areas. The cultivation of this plant generates advantages in terms of accessibility and mobility to marginalized areas. Additionally, this process does not require a significant amount of water, is resistant and adaptable to summer temperatures, and extreme climate changes, and can maximize productivity. According to Wijayanti et al., (2016), sorghum plants have a waxy coating on their stems and leaves, and relatively small leaf surfaces, which helps to regulate water reduction caused by evaporation.

Sorghum productivity in Indonesia currently averages one ton/ha, in contrast to the United States where it can reach 3.6 tons/ha. In America, the agricultural system has been run with the concept of agribusiness, cultivation technology has been carried out well, and agricultural inputs are used efficiently. Ende Regency needs to develop sorghum with this concept. This low productivity is attributed to improper cultivation techniques, irregular plant spacing, the use of local varieties with inadequate fertilization, and failure to consider plant needs Sutrisna et al., (2013). According to Widowati, (2010) research, some regions in Indonesia have relatively high sorghum productivity, ranging from 2.5 to 6.0 tons per hectare.

The productivity of sorghum farming in Ende Regency is considerably low due to the conventional farming implementation. Suryo, (2022) documented that national productivity reaches 2 to 3 tons/ha, while the Head of Agriculture Office of Ende Regency reported that sorghum productivity in Ende reached a low of 1-1.5 tons/ha. The low productivity of sorghum in Ende can be attributed to several factors, inadequate attention to plant spacing, poor maintenance, conventional cultivation technology, and the scarcity of qualified fertilization. These factors indicate that subsistence agriculture is subject to various constraints. Thus, improving and maximizing technical capabilities for increasing agricultural productivity is essential (Chepng’etich, et al, 2015);(Itam et al., 2015). One solution that can be done is to apply an intercropping pattern. The benefits of this planting pattern are; improving soil structure, improving groundwater management by increasing soil infiltration, increasing soil productivity and minimizing pest and disease attacks.

Increasing production through technical, allocative and economic efficiency is very important because it can multiply the potential output of farmers and reduce farming costs (Kusnadi et al., 2011). Efficiency can improve output without having to add input and the level of efficiency is influenced by socio-economic factors (Ogundari & Brümmer, 2011). This concept has not been implemented well by farmers in several developing countries. Increasing production is done by expanding land, this is due to limited knowledge and access to agricultural inputs. The concept of efficiency is increasing productivity through optimal use of inputs, and getting maximum profit.

Studies on efficiency in monoculture and intercropping patterns are rarely conducted, most farmers in developing countries tend to apply monoculture planting patterns. The results of this study indicate that farmers in intercropping patterns are more economically efficient, for this reason this study is expected to contribute to the broader literature on agricultural efficiency in developing countries.

Sorghum is being considered as a potential substitute for rice in the East Nusa Tenggara province. Therefore, intercropping sorghum with groundnuts is necessary to increase farmers' productivity and income. The intercropping planting pattern has a significant influence on the growth parameters of the main plants and all yield components, when compared with the monoculture planting pattern. Intercropping involves planting two or more crops on the same piece of land at the same or different times. The success of intercropping patterns largely depends on the selection of crop combinations. Legume crops are frequently selected for their ability to enhance soil nutrients and produce affordable vegetable protein (Noviana, 2015 and Tang et al., 2020). Moreover, the previous study reported that intercropping farming model has been demonstrated as an effective method for increasing agricultural productivity (Sasmita et al., 2014 and Chen et al., 2019) and weeds controlling (Amosun, J.O., et al, 2016). In general, farmers with intercropping planting patterns maintain better agricultural soil health, allocation of agricultural inputs and pest and disease control is more optimal.

Limited fertilizers, pesticides and high prices of agricultural inputs cause most of the respondent farmers in Nggela Village to be inefficient in allocating agricultural inputs, which has an impact on the productivity and income of the farm. A farm is said to be technically efficient if the farm is able to achieve maximum production with a certain combination of inputs. Allocative efficiency is achieved if the farm is able to generate maximum profit. While economic efficiency is obtained if both efficiencies are achieved. For this reason. this study aims to analyzed the technical, allocative, and economic efficiency of sorghum farming in monoculture and intercropping patterns and the factors that influence this efficiency.

RESEARCH METHOD

The study was conducted between September and November 2023 at Nggela Village, Wolojita District, Ende Regency. The region was selected because of its strategic location for developing sorghum crops and the persistence of customary sorghum framing ceremonies. 170 Nggela Village inhabitants participated in the study; 95 engaged in monoculture farming, while 75 interplanted sorghum and groundnuts. The census approach includes all farmers as participants. The fact that there are just 170 sorghum farmers is a factor considered when choosing the census method. To avoid potential bias in this study, data was collected consistently, objectively and using representative samples.

The Cobb-Douglas stochastic frontier production function analysis was used in the study, with the considerations, 1) having parameters that can be estimated using the OLS method, 2) the calculation is easy and can be made into

a linear form 3) the amount of elasticity of each production factor that is estimated as the return to scale. In general, parametric and non-parametric methods (Stochastic Frontier Analysis, or SFA) can be used to examine efficiency issues. The parametric method is less flexible since it makes rigid assumptions about particular functional forms. The efficiency of using agricultural inputs for a variety of commodities has been the subject of numerous research, including those by (Gebregziabher, 2014); (Latruffe and Nauges, 2014), and (Galluzzo, 2017).
Variations in data, methodology, variables, and location are the leading causes of the disparities in the study

The estimate process used the Maximum Likelihood estimate (MLE) method after the Ordinary Least Squares (OLS) method. Coeli's Frontier Program version 4.1c was the program utilized. The production function is presented below:

$$L_nY = \beta_0 + \beta_1\, l_n\, x_1 + \beta_2\, l_n\, x_2 + \beta_3\, l_n\, x_3 + \beta_4\, l_n\, x_4 + \beta_5\, l_n\, x_5 + E_jD_j(v_i - u_i)$$

Description:

X	=	Production
X_1	=	Land is (ha)
X_2	=	Sorghum Seedlings (kg)
X_3	=	Fertilizer (kg)
X_4	=	Workers (Working days)
X_5	=	Pesticides (kg)
E_j	=	Dummy variable coefficient
D_j	=	Dummy variable of cropping pattern (D = 1 Intercropping method, D = 0 Monoculture method).
β_i	=	Regression coefficient (i = 0,1,2, ... 5).

Technical efficiency of sorghum farming for the i-th farmer can be measured using the following formula

$$TE_i = \frac{Y_i}{Y_{i^*}} = \frac{e^{x_i}\beta + v_i - u_i}{e^{x_i}\,\beta + v_i} = e^{-u_i}$$

Yi represents the observation of actual production, while Yi* represents the estimated frontier production obtained from the stochastic frontier production function. The analysis of allocative economic efficiency is conducted using the stochastic frontier cost functional approach. The empirical model is formulated as follows:

$$L_nC_i = \alpha_0 + \alpha_1 L_nPx_{1i} + \alpha_2 L_nPx_{2i} + \alpha_3 L_nPx_{3i} + \alpha_4 L_nY_i + E_jD_j + (v_i + u_i)$$

Description:

C	=	Production cost (Rp)
X_1	=	Price of sorghum seed 9 (Rp)
X_2	=	Fertilizer price (Rp)
X_3	=	Workers cost (Rp/HKSP)
Y_i	=	Total output (Kg)
E_j	=	Dummy variable coefficient
D_j	=	Dummy variable of cropping pattern (D = 1 Intercropping method, D = 0 Monoculture method).
$V_i + U_i$	=	Error term component
V_i	=	Random variable that is assumed to be iid N(0, α_v^2).
U_i	=	Non negative adjunct variable and assumed cost of inefficiency in production which is often assumed to be iid N(0, α_v^2).
α	=	Estimated parameter

Cost inefficiency is the ratio between the actual total cost (C) and the estimated minimum total cost (C^*). The value of CE_i ranges from 1 to infinity, and its inverse represents the level of cost efficiency, which ranges from 0 to 1

$$CE_i = \frac{C}{C^*} = \frac{\mathrm{e}(\mathrm{cI}u_{i,}Y_i P_i)}{\mathrm{e}\ (c_i \mathrm{I}\ 0, Y_i, P_i)} = e^{-ui}$$

Economic efficiency is obtained from the multiplication between technical and allocative efficiency, in which mathematically, economic efficiency can be formulated as follows: $EE_i = ET_i . EA_i$. Technical efficiency shows the relationship between input and output; allocative efficiency shows the relationship between cost and output. Economic efficiency is achieved if technical and allocative efficiency are achieved.

Using the OLS method with multiple linear regression analysis, the study estimated factors that affect technical, allocative, and economic efficiency. The factors considered were age average, length of farming, farmer group membership, credit access, and land ownership status. The study formulated a multiple regression model as follows:

$$U_i = \delta_0 + \delta_0 Z_1 + \delta_0 Z_2 + \delta_0 Z_3 + \delta_0 \delta_4 + \delta_0\ Z_5$$

Description:

U_i	=	Technical, allocative and economic efficiency
Z_1	=	Farmers age (year)
Z_2	=	Length of farming (Year)

Z_3	=	Dummy farmer group membership (1 = if yes, 0 = if no).
Z_4	=	Credit access dummy (1 = if yes, 0 = if no).
Z_5	=	Dummy cropping pattern (1 = Intercropping, 0 = Monoculture)
Z_6	=	Dummy land tenure status (1 = own land, 0 = rented land)

RESULT AND DISCUSSION

Respondent Characteristics

This study was conducted in Nggela Traditional Village, 75 km from the capital of Ende Regency. Agriculture in Nggela Village is dry land agriculture. Sorghum is the main food of the community, besides dry rice and corn. Sorghum plants are cultivated to this day and are one of the commodities that are always used in traditional rituals. 90% of the village community work as farmers.

There are 170 respondent farmers, with 70% being male and the rest being female. Formal education 10% graduated from high school, the rest graduated from junior high school. 100% of respondent farmers have their own land, with an average land area of 0.5 ha. The low level of formal education of farmers has an impact on the average efficiency level of less than 90%. The number of male workers, which reaches 70%, helps in dry land processing and other cultivation activities.

Impact of Monoculture and Intercropping Farming on Technical Efficiency Stochastic Frontier Production Function

Table 1. presents the estimation results of the sorghum frontier production function using the Maximum Likelihood Estimation (MLE) method. The presence of inefficiency factors is indicated by a value of sigma squared > 0. The efficiency level of each farmer varies, as shown by a real gamma coefficient of 96.7%. This is because each farmer has limited knowledge about cultivation and limited access to agricultural inputs. The research recommends that sorghum farmers in the location can achieve maximum production by improving their farm management. The MLE method's likelihood ratio test value of 35.18 is higher than the OLS method's value of 23.17, indicating that the MLE method production function is superior to the OLS method. The estimated parameter value based on MLE results in the observation sample being included in the observation more often. The LR test value of 9.61, which is greater than X^2 3.21, indicates that there is an effect of technical inefficiency on sorghum farming. This finding is consistent with the research conducted by (Nurdiani & Prasetyo, 2023). Field findings show that the technical inefficiency of sorghum farming is influenced by factors such as age, length of farming, membership of farmer groups, access to credit, planting patterns and land ownership.

Table 1. The Estimation of Production Function on Sorghum Farming in Monoculture and Intercropping Patterns with Maximum Likelihood Estimation (MLE) method

Variables	Coefficient	Standard-error	t-stat
Intercept	6.234	0.498	10.762
X_1 (Land)	0.017	0.012	3.957
X_2 (Seeds)	0.213	0.001	2.821
X_3 (Fertilizer)	0.412	0.030	2.532
X_4 (pesticides)	0.111	0.101	2.902
X_5 (Workers)	-0.012	0.021	-1.210
D_1 (Planting patterns)	0.032	0.041	2.651
Sigma-squared	0.034		
Gamma	0.967		
Loq likelihood Function	35.18		
LR test	9.61		
X^2	3.21		

The production factors that generate the significant and positive effect on sorghum production at the 95 percent significance level are land, seeds, fertilizers, and pesticides. A 10% increase in these variables leads to a 0.17% increase in sorghum production per hectare for land, a 4.12% increase for seed, and a 1.11% increase for fertilizers and combined pesticides. This has an impact on farmer behavior, for example; storing the harvest for seeds in the next planting period, utilizing idle land for sorghum cultivation, and utilizing agricultural waste for organic fertilizer. Sorghum production is influenced by various factors such as land, seeds, fertilizers, pesticides, and cropping patterns (intercropping or monoculture). The labor variable has no real effect. This study is consistent with the findings of (Asmara & Hanani, 2017). Findings at the research location show that, the workforce is over 47 years old, with a small number in 1 village. The younger generation is less interested in working in the agricultural sector

The sorghum seeds used are local varieties that farmers cultivate themselves from previous harvests. Sorghum is readily available every year for the Nggela community, both for seeds and to fulfill household food needs. Additionally, sorghum holds significant cultural value for the Nggela community, as evidenced by the annual Nggua Lolo ritual. Therefore, sorghum is planted consistently by the community, using intercropping technology with peanuts and including the use of efficient agricultural inputs to maintain sorghum plant productivity.

The Distribution of Technical Efficiency Level

Table 2. displays the technical efficiency levels of Sorghum farmers with monoculture cropping patterns. The average level is 75%, with a maximum of 87% and a minimum of 57%. This suggests that sorghum farmers can achieve at least 75% of their potential production in monoculture cropping by utilizing production inputs effectively. Sorghum farmers in monoculture systems can potentially increase their sorghum production by 25%. With professional management based on standardized systems, production could increase by 908 kilograms. For this reason, the role of field extension officers must be optimized, as well as making it easier for farmers to buy agricultural inputs at affordable prices, or produce compost fertilizer, by utilizing existing agricultural waste. The average production is estimated to be 2.725 kilograms per hectare, calculated as (100:75) x 2.725 = 3.633. The standard deviation value for sorghum farmers using a monoculture planting approach is significantly lower compared to the intercropping planting pattern. This recommends that the actual production variation with monoculture planting is smaller compared to the intercropping system.

Table 2. Distribution of Technical Efficiency Levels of Sorghum Farmers in Monoculture and Intercropping Farming Patterns

Technical Efficiency Level	Planting Pattern			
	Monoculture		Intercropping	
	Total	Percentage	Total	Percentage
Up to – 0,50	-	-	-	
0,51 – 0,60	2	2	1	2
0,61 – 0,70	35	37	6	8
0,71 – 0,80	45	47	53	71
0,81 – 0,90	13	14	10	13
0,90 – 1,00	-	-	5	6
Total	95	100	75	100
Average Efficiency Level	0.75		0.82	
Minimum	57		59	
Maximum	87		90	
Deviation Standard	0.05		0.11	

The technical efficiency of sorghum and groundnut intercropping patterns averaged 82%, with a maximum of 90% and a minimum of 59%. This suggests that sorghum farmers who implement intercropping patterns can achieve at least 82% of their potential production through combining the production inputs. This presents an opportunity to increase production percentage by 18%, with an actual average of 3.657 Kg. The potential production per hectare is calculated by multiplying the current production by the ratio of 100 to 82, resulting in 4.459.

Thus, the implementation of effective and efficient management and the incorporation of standardized and qualified innovative technology must be applied in sorghum farming intercropping pattern in order to significantly increase the production average to 802 Kilograms.

Factors Affecting Technical Efficiency of Sorghum Farming in Monoculture and Intercropping Patterns

Table 3. displays the F-statistical value of 57.213, where the F-count value is greater than the F-table value (61.432 > 2.91). This indicates that all variables have a simultaneous effect on technical efficiency. The variable has a significant negative effect. Furthermore, an increase in the age of sorghum farmers can lead to a decrease in technical efficiency levels, which is generally associated with farmers' physical capability. This finding is consistent with the research results of (Ismail et al., 2017), (Sahara et al., 2019), (Lanamana & Supardi, 2020), (Lanamana & Fatima, 2022), and (Lestari et al., 2023). The age of farmers has been found to negatively impact their ability in applying agricultural science and modern technology in an innovative and efficient manner (Okoye et al., 2016 & Mango et al., 2015). Interventions that can be carried out on older farmers to increase technical efficiency are by optimizing the role of field extension officers in providing continuous assistance.

Table 3. Factors Affecting Technical Efficiency of Sorghum Farming in Monoculture and Intercropping Patterns.

Variables	Coefficient	Standard Error	t-ratio
Constant $(Z)_0$	0.673***)	0.030	12.324
Age $(Z)_1$	0.023***)	0.043	-3.321
Length of farming $(Z)_2$	0.112**)	0.120	2.287
Farmer group membership $(Z)_3$	0.024***)	0.034	2.871
Credit access dummy $(Z)_4$	0.065	0.121	1.012
Cropping pattern $(Z)_5$	0.123**)	0.113	2.314
land ownership status $(Z)_6$	0.012***)	0.011	3.114
R^2,	0.798		
F- Statistic	57.213		

Description:

Ftable (α = 0.01 df 1 = 6. df 2 = 163) = 2.91 ***) Significant at α 1 %

Ttable α 0.01 = (0.01.df 163) = 2.60 **) Significant at α 5 %

Ttable α 0.05 =(0.05.df 163) = 1.97 *) Significant at α 10 %

Ttable α 0.10 =(0.10.df 163) = 1.65

The length of time spent in farming has a significant and positive effect on farmers' knowledge, skills, and technology, including the efficient use of agricultural inputs. On average, farmers in this study have been engaged in sorghum farming for 15 years. This finding is consistent with the previous research by (Burhansyah, 2016), (Yoko et al., 2017), (Murniati et al., 2017), and (Lestari et al., 2023). The technical efficiency and agricultural productivity of farmers are determined by the length of time they have been farming, as stated by (Itam et al, 2015).

The dummy variable for farmer group membership is both significant and positive. Farmer groups serve as forums for discussing and sharing knowledge, experiences, and scientific advancements. By joining a farmer group, the use of agricultural inputs can become more efficient. The study found that 80% of farmers are members of farmer groups. Fadwiwati et al., (2014) and Widyantari et al., (2023) findings suggest that farmers who receive counseling in farmer groups experience a significant increase in the percentage of farming productivity. This study differs from, Minarsih, et al., (2019) and Sarini et al., (2022) in the variable of farmer group membership does not have a significant effect on technical inefficiency. This suggests that becoming a member of a farmer group does not necessarily increase technical inefficiency. The studies conducted by Tri Santiasih, (2022) and Utari et al., (2022), indicate that farmer-group variables do not have a significant effect. Although many farmers are registered in farmer groups, they do not actively participate in group activities and only seek for the assistance from the government. Efforts that can be made to increase the active participation of farmer group members are by providing continuous counseling and training, as well as mentoring of cultivation activities by field extension officers.

The dummy variable for access to credit did not have a significant effect. This fact is caused because farmers are not accustomed to accessing credit from credit institutions, either in villages or in cities. This is in line with the findings Putri et al., (2019). The research findings indicate that farmers face difficulties in obtaining credit for sorghum farming. Additionally, research conducted by Anggraini et al., (2017) suggests that access to credit may reduce technical efficiency, as farmers may use the credit for non-farming activities. On the other hand, the cropping pattern dummy variable showed a significant and positive sign. Intercropping patterns can impact the efficiency of agricultural input use and the productivity of agricultural products. According to Abebe, (2014) findings, the application of intercropping patterns affects the technical efficiency of farming. The variable of land ownership status has a significant and positive effect. The field findings indicate that 80% of sorghum farmers own their land, while the remaining 20% are tenants. This phenomenon shows that individual land owners have higher technical efficiency compared to tenant farmers. This finding is relevant to the studies conducted by Rivanda et al., (2015) and Lanamana, (2019), but differs from the results of Ahdiningtyas et al. (2023).

Distribution of Allocative Efficiency Levels

Table 4. shows that sorghum farmers with monoculture cropping patterns generate an average allocative efficiency of 73%, which is lower than that of sorghum farmers with intercropping cropping patterns. This means that, on average, sorghum farmers with monoculture cropping patterns achieve a minimum cost level of around 73% of the frontier cost. If farmers can achieve optimal cost efficiency, they can increase their profits by 17.98% (1-(0.73/0.89). For the least efficient farmers, the potential profit increase is 42.7% (1-(0.51/0.89). Low efficiency in monoculture planting patterns affects low productivity and farm income. Plants that are planted repeatedly in monoculture planting patterns will affect soil fertility, reduce the availability of nutrients, the soil becomes harder and is easily attacked by pests and diseases.

Table 4. Distribution of Allocative Efficiency Levels Among Sorghum Farmers in Monoculture and Intercropping Farming Patterns

Technical Efficiency Level	Planting Pattern			
	Monoculture		Intercropping	
	Total	Percentage	Total	Percentage
Up to – 0,50	-	-	-	
0,51 – 0,60	5	5	-	-
0,61 – 0,70	57	60	5	7
0,71 – 0,80	25	26	60	80
0,81 – 0,90	8	9	4	5
0,90 – 1,00	-	-	6	8
Total	95	100	75	100
Average Efficiency Level	0.75		0.82	
Minimum	51		62	
Maximum	89		93	
Deviation Standard	0.07		0.12	

The average allocative efficiency of sorghum farmers with intercropping patterns is 85% which means that the minimum average cost level achieved by farmers is 85% of the cost frontier. If farmers achieve the most efficient level of cost efficiency, they can obtain additional profit of 8.61 (1-(0.85/0.93). The possibility of additional profits for the least efficient farmer is 33.34% (1-(0.62/0.93), assuming that farmer can combine agricultural inputs and outputs at the most efficient price. Onubuogu & Esiobu, (2019) researched on food crops in Nigeria obtained an allocative efficiency value of 0.86, which is similar to the research conducted in Nggela Village. The average allocative efficiency differs between monoculture and intercropping sorghum farmers. This difference is influenced by the fact that intercropping sorghum farmers are mostly actively participating in farmer groups and have good access to the market prices.

The allocative efficiency of sorghum farmers in monoculture and intercropping patterns is generally satisfactory, although some farmers have values as low as 51 and 62. This indicates that sorghum farming is relatively efficient in input allocation at certain input price levels. Additionally, farmers are able to access market information on agricultural input and output prices.

Factors Affecting Allocative Efficiency of Sorghum Farming in Monoculture and Intercropping Patterns

Table 5. shows all variables affect allocative efficiency, as indicated by the F-statistic value of 61.432 (where F-count > F-table, 61.432 > 2.91). The age variable has a significant negative effect, resulting in relatively lower work productivity and allocative efficiency for older farmers. Older farmers often do not attend farmer group meetings and tend to maintain conventional work patterns that have been passed down from previous generations, making it difficult for them to adapt to new information. This study presents a contrasting perspective to Haile, (2015) and Girei et al., (2016) findings, which suggest a positive correlation between experience and age. However, it is crucial to observe that farming business efficiency conceivably improve with the farmer's age.

Table 5. Factors Affecting Allocative Efficiency of Sorghum Farming in Monoculture and Intercropping Patterns

Variables	Coefficient	Standard Error	t-ratio
Constant $(Z)_0$	0.521***)	0.101	9.712
Age $(Z)_1$	0.122***)	0.021	-3.213
Length of farming $(Z)_2$	0.013***)	0.010	3.021
Farmer group membership $(Z)_3$	0.054**)	0.023	2.351
Credit access $(Z)_4$	0.031	0.014	1.131
Cropping patternZ$)_5$	0.041***)	0.022	2.810
land ownership status $(Z)_6$	0.102**)	0.104	2.323
R^2 = 0.798			
F- Statistic = 57.213			

Description:

Ftable (α = 0.01 df 1 = 6. df 2 = 163) = 2.91 ***) Significant at α 1 %
Ttable α 0.01 = (0.01.df 163) = 2.60 **) Significant at α 5 %
Ttable α 0.05 =(0.05.df 163) = 1.97 *) Significant at α 10 %
Ttable α 0.10 =(0.10.df 163) = 1.65

The length of time spent for farming generate a significant and positive effect. Farmers gain experience through interactions with fellow farmers in group discussions. This experience is gained as they continue to engage in sorghum farming activities. Moreover, the research found that being part of a farmer group had a substantial and favorable effect on farmers' capacity to obtain information on the costs of agricultural inputs and outputs from field extension officers. This study contrasts with the results of Dogba et al., (2020), that allocative efficiency decreased when farmers participated in farmer groups with poor management and inactive development.

The results indicate that the dummy variable for credit access does not have a significant effect, because farmers have never utilized credit facilities from banks or cooperatives for sorghum farming activities. The dummy variable for cropping patterns is significant and positive for farmers who apply intercropping patterns. These farmers are often more efficient in allocating resources and can obtain lower prices for agricultural inputs and higher prices for their outputs. This is influenced by the farmers' level of education and their involvement in farmer groups. The land ownership status dummy variable shows a significant and positive effect. Based on the available evidence, sorghum farmers who own their land are more efficient in allocating resources than tenant farmers. The factors that influence this efficiency are the farmers' education level, participation in farmer groups, and income levels.

The Distribution of Economic Efficiency Levels

The technical and allocative efficiency are economic efficiency measurements which is a combination of both. Table 6 shows that sorghum farmers in monoculture cropping patterns have an average economic efficiency of 70%, which is lower than the 81% in intercropping patterns. The intercropping of sorghum and peanuts has a positive effect on sorghum plants, maintaining soil fertility and reducing pest attacks. Moreover, intercropping provides sorghum farmers with an affordable access to the market for agricultural inputs and outputs, resulting more controlled prices.

Table 6. shows that 53 monoculture farmers and 5 intercropping farmers had an economic efficiency below 0.70. The evidence suggests that sorghum farming is not economically efficient yet, which is consistent with the findings of Sasana & Santoso, (2018). A value of economic efficiency below 70 indicates inefficiency in farming. Therefore, it is necessary to improve management of production input costs, as noted by (Rosdiantini, 2020).

If sorghum farmers with a monoculture planting pattern achieves the highest economic efficiency level, they can save costs by 80.45% (1- (0.70/0.87). Even the least efficient farmer can save costs by 42.53% (1-(0.50/0.87)). Thus, it is essential to strive for the highest level of economic efficiency. Farmers who incorporate intercropping patterns can save up to 8.99% on costs if they achieve the highest level of economic efficiency. Even the least efficient sorghum farmers can save up to 32.59% on costs (1-(0.60/0.89).

Table 6. Distribution of Economic Efficiency Levels among Sorghum Farmers in Monoculture and Intercropping Farming Patterns

Economic Efficiency level	Planting Pattern			
	Monoculture		Intercropping	
	Total	Percentage	Total	Percentage
Up to 0,50	-	-	-	-
0,51 – 0,60	3	3	-	-
0,61 – 0,70	50	53	5	7
0,71 – 0,80	27	28	55	73
0,81 – 0,90	15	16	9	12
0,90 – 1,00	-	-	6	8
Total	95	100	75	100
Average Efficiency Level	0.70		0.81	
Minimum	50		60	
Maximum	87		89	
Deviation Standard	0.05		0.10	

Factors Affecting Economic Efficiency of Sorghum Farming in Monoculture and Intercropping Patterns

Table 7. shows that the F-statistic value is 52.763, significant at 1% α. F-count value > Ftable value (52.763 > 2.91). This analysis shows that all variables in the model have a joint effect on economic efficiency. The age variable has a significant negative effect on economic efficiency. As farmers age, they tend to become less innovative and update their knowledge and technology less frequently, relying instead on knowledge passed down from previous generations. These findings are consistent with the research of (Ayodele et al., 2012).

The length of time a farmer has been in business has a significant and positive effect on economic efficiency. The phenomenon is observed as a result of increasing farmers' experience, knowledge and the understanding of applying sorghum cultivation technology. These findings are consistent with the research conducted by Ogunleye et al., (2014) and Kareem & Şahinli., (2018). Additionally, the membership status in a farmer group has a significant and positive effect on economic efficiency. Farmer groups provide knowledge about sorghum cultivation technology and price information on the agricultural inputs and outputs to assist farmers become more efficient in obtaining agricultural inputs. This leads to the agricultural products sale at more competitive prices in the market. These findings align with Mutoko et al., (2015) research, but contrast with Lanamana, (2019) findings.

Table 7 Factors Affecting Economic Efficiency of Sorghum Farming in Monoculture and Intercropping Patterns.

Variables	Coefficient	Standard Error	T-ratio
Constant $(Z)_0$	0.322***)	0.101	9.712
Age $(Z)_1$	0.011***)	0.021	-3.213
Length of farming $(Z)_2$	0.024***)	0.010	3.021
Farmer group membership $(Z)_3$	0.061**)	0.023	2.351
Credit access $(Z)_4$	0.041	0.014	1.131
Cropping pattern $(Z)_5$	0.052***)	0.022	2.810
Land ownership status $(Z)_6$	0.110**)	0.104	2.323
R^2	0.741.		
F- Statistic	52.763		

Description:
Ftable (α = 0.01 df 1 = 6. df 2 = 163) = 2.91 ***) Significant at α 1 %
Ttable α 0.01 = (0.01.df 163) = 2.60 **) Significant at α 5 %
Ttable α 0.05 =(0.05.df 163) = 1.97 *) Significant at α 10 %
Ttable α 0.10 =(0.10.df 163) = 1.65.

The dummy variable for credit access had no significant effect and was positive. Field findings showed that none of the farmers had ever accessed credit from financial institutions, including banks or cooperatives, for sorghum farming activities. The dummy variable for cropping patterns had a significant and positive effect. The application of intercropping patterns can increase economic efficiency. Intercropping sorghum and peanuts increase soil fertility, agricultural productivity, and farm income from both crops. This aligns with Nyi, et al, (2014) findings. The dummy variable for land ownership status is significant and positive, indicating that sorghum farmers who own their land are more economically efficient than those who rent. On average, owner farmers who are active in farmer groups possess better knowledge and skills than tenant farmers in efficiently combining agricultural inputs to optimize production while minimizing expenses. Based on field findings, it has been observed that landowner farmers tend to achieve higher levels of production and income from sorghum farming compared to tenant farmers.

CONCLUSION AND SUGGESTION

Conclusion

The study conducted in Nggela Village found that sorghum farmers who use monoculture planting patterns exhibit lower technical, allocative, and economic efficiency compared to those who use intercropping planting patterns.

The study also identified significant factors affecting efficiency, including age, length of farming, farmer group membership, cropping pattern, and land ownership status. However, credit access was not found to be a significant factor

Suggestion

The role of field extension workers from the Ende District Agriculture Service needs to be improved, by increasing the number of field extension workers, improving training and skills for field extension workers and the frequency of presence of field extension officers in the village. The availability of sorghum seeds, fertilizers, and pest control drugs in the village needs to be increased.

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