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TECHNICAL EFFICIENCY OF LEISA SYSTEM SHALLOT FARMING IN BANTUL REGENCY

Retno Lantarsih[1*], Putri Perdana[1], Irene Kartika Eka Wijayanti[2], and Erni Ummi Hasanah[3]
[1]Department of Agribusiness, Janabadra University, Yogyakarta, Special Region of Yogyakarta, Indonesia
[2]Department of Agribusiness, Jenderal Soedirman University, Banyumas, Central Java, Indonesia
[3]Department of Development Economics, Janabadra University, Yogyakarta, Special Region of Yogyakarta, Indonesia

*Correspondence Email: retno@janabadra.ac.id

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ABSTRACT

Implementing the Low External Input Sustainable Agriculture (LEISA) concept is expected to optimize the use of local inputs, reduce negative environmental impacts, and produce safe products. In Bantul Regency, a group of shallot farmers have cultivated using the LEISA system, but their production has decreased. This research aims to determine factors that influence production, the influence of technical inefficiency on production variability, sources of inefficiency, and the level of technical efficiency of LEISA system shallot farming. This research is quantitative descriptive. Determining the research location used the purposive method and selecting the sample using random sampling techniques. Technical efficiency analysis uses the Cobb Douglas Stochastic Frontier production function. The research results show that land area positively affects shallot production in the LEISA system with a regression coefficient of 0.718. Technical inefficiency problems that farmers can control contribute 1% to production variability, and technical inefficiency originates from farmer age. LEISA system shallot farming in Bantul Regency is not technically efficient. This research implies that farmers can increase LEISA system shallot production by increasing the land area, and to increase technical efficiency, this can be done by increasing farmer experience and increasing the motivation of young farmers in LEISA system shallot farming. Farmers with experience and who are young have better physical and decision-making abilities. Apart from that, further research must be conducted to evaluate the sustainability of the LEISA system shallot farming.

Keywords: *Bantul, frontier, shallot, technical efficiency*

BACKGROUND

In modern agriculture, technology can support efforts to increase food production and save agriculture from environmental pressure. Climate-smart agriculture and the revolution in genetic engineering techniques are ways to reduce the negative impacts of climate change (Raza et al., 2019). Organic fertilizer has also been proven to activate microorganisms, which play a role in improving soil structure. In several regions in Indonesia, agricultural development shows the direction towards environmentally friendly and sustainable agriculture (Mahanty et al., 2017) with the implementation of Low External Input and Sustainable Agriculture (LEISA) (Djuwendah et al., 2018; Sarkar et al., 2020).

Implementing sustainable agriculture through the LEISA concept is a form of concern for the environment. This effort is essential in optimizing the use of locally based productive resources such as land, air, microclimate, vegetation, appropriate technology, environment, human resources, and social capital. The LEISA system can reduce dependence on external resources (Djuwendah et al., 2018), mitigate adverse impacts on the environment (Sarkar et al., 2020), improve the physical and biological properties of soil, reduce soil erosion, avoid ecological risks from external inputs, and increasing the use of internal inputs in agroecosystems (Raza et al., 2019), increasing porosity and air holding capacity, increasing organic matter, macronutrients, micronutrients, cation exchange, and populations of soil microbes in the root zone. Implementing the LEISA farming system in the long term can reduce the need for synthetic fertilizers while increasing soil organic carbon (Setiyo et al., 2023). LEISA's performance also has a positive impact in producing safe agricultural products (Lestari & Astuti, 2023; Sarkar et al., 2020), ensuring food security while preserving natural resources that are important for human welfare (Ashari et al., 2020; Djuwendah et al., 2018), as well as an increase in the number of millennial farmers in vegetable cultivation (Lestari & Astuti, 2023).

Several groups consider organic farming systems to offer the best way of food production, sustainable and environmentally friendly use of resources (Ashari et al., 2020), and limited use of pesticides (Mie et al., 2017). The implementation of LEISA in Bantul Regency is still limited to rice commodities centred in Kebonagung Village and shallots in Nawungan Village through organic agricultural land management. The Bantul Regency Government supported this program by providing guidance counselling and organic fertilizer. Consuming environmentally friendly products has become a lifestyle popular among various levels of society (Lantarsih et al., 2021). The main challenges of organic farming include concerns about decreasing crop yields during the conversion period, low technical knowledge and government support, chemical contamination from conventional farming, and high conversion costs. Organic farming has yet to be widely adopted by farmers (Ashari et al., 2020).

Increasing the efficiency of agricultural production relative to resource utilization is the basis of many concepts that aim to achieve the dual challenges associated with increasing agricultural production while reducing its impact on the environment (Bennett et al., 2014). Sustainability has become increasingly prominent in sustaining agricultural policy in recent decades. It has caused more and more stakeholders to pay attention to monitoring and evaluating agricultural practices and appropriate indicators to assess aspects of poverty, including the three pillars of desire, namely environmental, economic, and social (Latruffe, Ryan, et al., 2016). Meanwhile, the characteristics of farmers are very diverse and complex. Most large farmers are small farmers and fall into the marginal category. The low income and standard of living of farmers, especially the younger generation, has encouraged the younger generation's interest in pursuing the non-agricultural sector. The participation of young farmers in rural areas continues to decline. Most large farmers do not have other employment options (Narain et al., 2015). The level of farmer activity regarding the environment depends on the farmer's willingness and ability to implement environmental management practices and directions for improving environmental management. Farmers' willingness to engage in ecological activities depends on beliefs, individual values, and societal norms (Mills et al., 2017) and the desire to sustainably conserve natural resources. The priority motivation of farmers in cultivating organic vegetables is related to self-actualization (Lantarsih et al., 2022).

As a national strategic commodity in Indonesia, shallots have competitive and comparative advantages in their cultivation. Increasing domestic shallot production is more profitable for

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Indonesia than importing. Utilization of advanced technology, increasing agricultural infrastructure and farmer resource capacity, as well as government incentive policies to increase productivity and sustainable competitiveness, can increase the competitiveness of shallot commodities (Susanawati et al., 2018). Of the total harvested area of seasonal vegetable crops in Indonesia, most of the land is devoted to shallot production (Pane et al., 2019). Even though shallot production has reached large quantities, there is still a significant difference between shallot production and consumption due to high demand (Pane & Supriana, 2020). The increase in demand for shallots continues to occur, while domestic shallot production has yet to meet the high demand for shallots. This causes the shallot market condition to become unbalanced and drives up prices (Pane et al., 2019) Shallots have high economic value, and most farmers cultivate them intensively. However, shallot cultivation also has high risks, such as plant pest attacks and climate change, which can cause crop failure (Astuti et al., 2020). The evaluation of the benefits obtained by farmers by implementing environmentally friendly shallot cultivation technology shows that the level of technology adopted by farmers is high, and the characteristics of farmers are supportive especially age and education. The application of technology can increase shallot production, reduce chemical input costs, and increase farmer profits. Thus, the technology introduced provides economic and environmental benefits for farmers (Mahfudz et al., 2019).

Bantul Regency has significant potential for developing shallot commodities, especially in the sandy lands of the southern coast of Java, such as the Kretek and Sanden Districts. Shallot production in the two districts in 2022 reached 6,957 tons and 3,272 tons, respectively (BPS Bantul Regency, 2023). In this area, farmers intensify shallot cultivation using chemical fertilizers. One area in Bantul Regency is Selopamioro Village, Imogiri District, where farmers implement the LEISA system in shallot cultivation. Implementing the LEISA system in shallot cultivation is intended to reduce dependence on external inputs, increase its desire and produce healthier and safer food for consumption. Farmers in cultivating shallots use the Bima variety from Brebes Regency, implement crop rotation, use organic mulch to maintain soil moisture, control plant pests and diseases using biological agents, utilize ground air for irrigation, and prioritize the use of organic fertilizers in the form of compost, manure, and molasses as the main source of nutrients for plants. However, in implementing the LEISA system, shallot farmers still face several challenges, including dependence on the season, the availability of local inputs such as organic fertilizers, and pest and disease attacks that impact decreasing production.

Research on the technical efficiency of farming has been widely conducted on food crops and horticulture. Applying adaptation strategies to climate change (Akpa et al., 2023) and using new superior varieties can increase technical efficiency in corn plants. Technical efficiency in horticultural farming is higher than in mixed farming (Lampach et al., 2021; Galluzzo, 2022). Meanwhile, research on the technical efficiency of shallot farming with the LEISA system has not been widely conducted. This research is important because, in addition to providing an overview of environmentally friendly farming, it can also provide an overview of the technical efficiency of shallot farming cultivated with the LEISA system. Farmers must allocate inputs efficiently to increase productivity when running a large cultivation business. From this background, this study aims to analyze the factors that influence production, determine whether technical inefficiency affects production variability, identify sources of inefficiency, and determine the level of technical efficiency of shallot farming with the LEISA system in Bantul Regency. The novelty of this research is identifying the LEISA system in shallot

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cultivation related to technical efficiency, sources of technical inefficiency, and levels of technical efficiency.

RESEARCH METHODS

Research Design

This research uses descriptive methods. In this descriptive research, it is necessary to dig up information related to existing symptoms, formulate goals, plan the approach used, and collect various data as material for compiling reports. In this research, the author wants to find an overview of technical efficiency and sources of inefficiency in LEISA system shallot farming. The approach used in this research is quantitative, starting from collecting and interpreting data and presenting research results using numbers. This approach is also related to research variables that focus on current problems and phenomena occurring at the moment with the form of research results in the form of meaningful.

Determination of Location, Population, and Sample

Determining the research location uses a purposive method, namely selecting a research area that considers known reasons. This research centers on Nawungan Hamlet, Selopamioro Village, Imogiri Subdistrict, Bantul Regency where farmers cultivate shallots in the LEISA farming system. Meanwhile, other areas producing shallots in Bantul Regency still implement agricultural intensification using chemical fertilizers. The population in this study were all members of the farmer group "Taruna Tani Manunggal," which had 54 farmers as members. The sample was determined using random sampling techniques and interviewed 30 farmers as samples.

Data Type

This research uses primary data and secondary data. Preliminary data is data obtained from interviews using a structured questionnaire. This primary data includes data on farmer characteristics (age, education, farming experience), while farming business data (amount of use and price of inputs; quantity and cost of production; and number of workers and wages) during one planting season. The secondary data collected is a review from various sources and related agencies.

Method of Collecting Data

Data collection methods used in this research include observation, interview, and questionnaire. Observation is data collection carried out directly regarding LEISA system shallot farming in the research area. An interview is a collection of data obtained by conducting direct questions and answers with respondent farmers regarding the respondent's identity data, as well as data related to the use of inputs, production quantities, and prices, as well as the implementation of LEISA system shallot farming that farmers have carried out. The questionnaire is data collection carried out through several written questions related to implementing the LEISA system shallot farming that farmers have carried out.

Analysis of Factors Influencing Production and Analysis of Technical Efficiency

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The dependent variable used in this study is the input used by shallot farmers in Selopamioro, which supports implementing the LEISA system in shallot cultivation. The land area has gone through a conversion period as organic land is used for shallot cultivation; onion seeds use local varieties, namely the Bima variety; and manure is organic fertilizer derived from livestock manure. The fulfilment of manure and labour comes from the surrounding area. Meanwhile, farmers still use chemicals like dolomite and NPK fertilizer. The use of dolomite is intended to neutralize soil pH. Dolomite can be substituted for firewood ash, but the availability of firewood ash is still very limited. Farmers still use NPK fertilizer in basic fertilization, intended to meet nutrient needs at the beginning of plant growth.

Data analysis uses the Stochastic Frontier production function model. This analysis model considers the uncertainty of the results caused by the error term. The error can come from noise (v_i). Farmers cannot control these errors and other random factors (such as weather and natural disasters). Meanwhile, errors originating from inefficiency effects (u_i) indicate technical (Galluzzo, 2022). Calculating the technical efficiency of shallot farming, the LEISA system uses the Cobb Douglas Stochastic Frontier Analysis (SFA) production function using the Frontier 4.1 software program. This research uses the Maximum Likelihood Estimation (MLE) method because this method has the best performance at the level of use of existing technology (Jumiati et al., 2021). The production function equation is as follows.

$$LnY=\beta_0+\beta_1 LnX_1+\beta_2 LnX_2+\beta_3 LnX_3+\beta_4 LnX_4+\beta_5 LnX_5+\beta_6 LnX_6+(v_i-u_i)$$

Information:
Y : Shallot production (qu)
X_1 : Land area (ha)
X_2 : Number of seeds (kg)
X_3 : Amount of manure (kg)
X_4 : Amount of dolomite (kg)
X_5 : Amount of NPK fertilizer (kg)
X_6 : Number of workers (working days)
β_0 : Constant
β_j : Parameter coefficient value, j= 1,2,3,4,5 and 6, $\beta j > 0$
v_i : Nuisance variables, which are external factors (noise effects) such as climate, pests/diseases and others
u_i : Technical inefficiency effect variable, an internal factor of shallot farmers.

The parameter test uses Cobb-Douglas stochastic frontier production function analysis. Estimation of the parameter value β_j using the OLS method. A positive coefficient value ($\beta_j > 0$) indicates that increasing input will increase shallot production in the LEISA system and vice versa. The Cobb-Douglas production function coefficient value also explains the elasticity value for each variable.

Analysis of Factors that Influence the Technical Inefficiency of LEISA System Shallot Farming

The variable for the effect of technical inefficiency is the internal factors of shallot farmers. Age, education, and farmer experience are suspected of influencing the technical inefficiency of

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shallot cultivation using the LEISA system. These variables were adopted from several previous studies related to technical inefficiency (Astuti et al., 2020; Fadzil et al., 2023; Febriyanto & Pujiati, 2021), which showed that they influence the technical inefficiency of shallots. In the author's opinion, these variables are still relevant to the real conditions of shallot cultivation using the LEISA system. The parameter value (u_i) shows the impact of technical inefficiency in LEISA system shallot farming, which is determined using the following equation:

$$U_i=\delta_0+\delta_1 Z_1+\delta_2 Z_2+\delta_3 Z_3+\omega_1$$

Information:
u_i : Technical inefficiency effect
Z_1 : Age (years)
Z_2 : Education (years)
Z_3 : Experience (years)

Expected coefficient values: $\delta_0 > 0$, $\delta_1>0$, $\delta_2>0$, $\delta_3<0$, meaning that if $\delta_i > 0$, it means the coefficient value has a positive effect on inefficiency or a negative impact on efficiency. Inefficiency analysis processing using the Frontier 4.1 Program in the stochastic frontier model requires two testing stages. The test in the first stage uses ordinary least squares (OLS), which aims to test classical assumptions. If the first testing stage passes, the second test continues using the maximum likelihood estimation (MLE) method at $\alpha = 5\%$. If the log-likelihood MLE value > OLS, the production function is good and follows field conditions.

Technical Efficiency Analysis

The technical efficiency analysis calculation uses the following equation:

$$TE = \frac{E(Y/U_i, X_1, X_2, X_3, X_4, X_5, X_6)}{E(Y^*/U_i = 0, X_1, X_2, X_3, X_4, X_5, X_6)}\pi r^2$$

Information:
TE : Technical efficiency level
$E(Y/U_i, X_1, X_2, X_3, X_4, X_5, X_6)$: Observation output level
$E(Y^*/U_i = 0, X_1, X_2, X_3, X_4, X_5, X_6)$: Frontier output level

The level of technical efficiency of farming has a value of $0 \leq TE \leq 1$. The one-sample T-test is useful to determine whether the LEISA system of shallot farming in Bantul Regency is technically efficient.

RESULT AND DISCUSSION

Overview of Farmers Group Taruna Tani Manunggal

The Taruna Tani Manunggal Farmer Group is a community organization of young farmers in Nawungan Hamlet, Selopamioro Village, Imogiri Sub-district, Bantul Regency. This organization was established in 2021 and carries out various cultivation activities to market agricultural products.

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The Taruna Tani Manunggal Farmer Group has 56 farmer members with shallots as its superior product. Each group member has the opportunity to receive subsidies for organic fertilizers and organic pesticides as well as various programs from the Bantul Regency Food Security and Agriculture Service related to the implementation of environmentally friendly agriculture, such as training and counselling. The Taruna Tani Manunggal Farmer Group routinely holds meetings once a month with the aim of increasing cooperation. In this routine meeting, the latest information related to environmentally friendly cultivation practices is also discussed. One of the activities carried out by the “Taruna Tani Manunggal” Farmer Group is the manufacture of botanical pesticides (biosaka) using plant-based materials. The Taruna Tani Manunggal Farmer Group is under the auspices of the Bantul Regency Food Crop Protection Center.

The Taruna Tani Manunggal Farmer Group is a group of farmers producing shallots using the LEISA system. The success of farmers in realizing environmentally friendly shallot cultivation and reducing dependence on external inputs cannot be separated from the active role of farmer groups, the Bantul Regency Government, Bank Indonesia, and universities. To implement this LEISA system, the “Taruna Tani Manunggal” farmer group has been converting land for 2 years so that the land can meet organic farming standards. The most important step in this conversion is that the land must be free of chemical fertilizer residues or synthetic pesticides, so farmers are not allowed to cultivate conventionally. The Taruna Tani Manunggal Farmer Group has succeeded in obtaining organic certification from the Organic Certification Institute. Farmers in Nawungan Hamlet cultivate shallots using large amounts of organic fertilizer, which is intended not only to meet the nutritional needs of plants but also to maintain and improve soil quality. Farmers apply crop rotation and use organic mulch to maintain soil moisture and they do not use synthetic chemical pesticides. The shallots produced are not only more environmentally friendly but also safer and healthier for consumption. The implementation of the LEISA shallot cultivation system is very different from the implementation of conventional cultivation carried out by most shallot farmers in Bantul Regency who still use synthetic chemical fertilizers and pesticides in their cultivation, and the land used in cultivation is also not certified organic.

Respondent Characteristics

This research involved 30 farmer respondents. The following section explains the characteristics of shallot farmers using the LEISA system in Nawungan Hamlet, including age, education level, and farming experience. By knowing the features of the LEISA system shallot farmers in Nawungan Hamlet, we can see the farmers' situation, especially from the social aspect. Farmers' identification is related to their behavior when they make farming decisions.

Age

Table 1 presents the age distribution of shallot farmers. Most LEISA system shallot farmers are in the 30-39 year age group, with the youngest farmer being 24 years old and the oldest being 47 years old. There is a relationship between age and income in the agricultural sector. Businesses managed by young farmers achieve the best net-added value (Hlouskova & Prasilova, 2020). A farmer's productivity level is closely related to age and experience, influencing production and income (Gebre et al., 2021). The average age of adults working in the agricultural sector is relatively constant, and the trend is even slightly decreasing because the rate of productivity growth in farming is relatively slow compared to other sectors. Agriculture needs to establish strategies to achieve faster

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economic transformation by strengthening effective youth employment (Yeboah & Jayne, 2018). Those who are weak or dependent are young and old, an economically inactive population, so their survival depends on the productive part of the population. Referring to Table 1, all farmers are in the influential age group. More people in the practical age group indicate that more people can be employed, which means less dependency on life. The age factor implicitly influences the level of one's work productivity. The productive age group is the stage grouping of 15-64 years, the non-productive age group is the age group between 0-14 years and the age group is over or equal to 65 years (Waluyo, 2022). The results of this study indicate that shallot cultivation with the LEISA system supports young farmers with higher energy and stamina, better adaptability to technological advances, and a willingness to take risks. If traced further, young farmers aged 30-39 can produce 1,500 kg of shallots per farming business. This amount is greater than the shallots produced by farmers aged 40-49, which are 1,263 kg.

Table 1. Distribution of LEISA system shallot farmers in Bantul Regency by Age Group.

No	Age (Year)	Number of Respondents (People)	Percentage (%)
1	20-29	5	16.7
2	30-39	17	56.7
3	40-49	8	26.6

Source: Primary Data Analysis (2023)

Education

Farmers' ability to manage their farming business influences their success in farming. The level of education, experience, or guidance and extension usually contributes to a farmer's abilities. The story of education affects farmers' knowledge and frame of mind, impacting their farming activities. With an adequate level of education, farmers will find it easier to find information and solve problems that arise in their farming business. Table 2 shows that the educational level of shallot farmers in the LEISA system is primarily high school education. The study's results showed that the higher the education, the higher the ability of farmers to produce shallots. The average onion production produced by farmers with elementary, junior high, high school, and bachelor's degrees was 550 kg, 1,067 kg, 1,283 kg, and 2000 kg per farm. Human resources with higher education have better knowledge in farm management, better decision-making skills, adaptability, and risk management. Education provides a strong foundation for farmers to improve the quality and quantity of shallot production.

Table 2. Distribution of LEISA System Shallot Farmers in Bantul Regency Based on Education

No	Education	Number of Respondents (People)	Percentage (%)
1	Elementary School	2	7
2	Junior High School	3	10
3	Senior High School	24	80
4	College	1	3

Source: Primary Data Analysis (2023)

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Experience

Soft-skill competency has a significant effect on farmer productivity. Therefore, it is essential to carry out systematic planning and improve farmers' skills and experience to increase agricultural productivity (Tamsan & Yusriadi, 2022). Farming experience contributes to farmers' understanding of the risks involved in farming, such as the dangers of pesticides to human health and their impact on the environment (Suminartika et al., 2022). Table 3 shows that the majority of farmers have experience in shallot farming for 1 to 5 years, namely 60%, while 6.7% of farmers have experience of more than 10 years. Farming experience can help farmers make decisions about managing their farming business, both in the use of inputs and in controlling pests and diseases. They are also better able to adapt. In this study, the production of farmers with farming experience of up to 10 years was 1,177 kg per farm, while farmers with more than ten years of experience can reach 2,650 kilograms per farm. This figure shows that farmers' experience in farming contributes to increasing red onion production in the research area.

Table 3. Distribution of LEISA system shallot farmers in Nawungan Hamlet Based on Farming Experience

No.	Experience (year)	Amount Respondent (people)	Percentage (%)
1	1- 5	18	60
2	6-10	10	33.3
3	11-15	2	6.7

Source: Primary Data Analysis (2023)

Production Factors

Production factors used in shallot farming using the LEISA system in Bantul Regency include land area, seeds, manure, dolomite, NPK fertilizer, and labour. Table 4 presents a description of the amount of production and use of the LEISA system shallot production factors per farming business in Bantul Regency. LEISA system shallot production produced by farmers ranges from 200 kg to 3,000 kg per farm with an average production of 1,270 kg or the equivalent of 10,583 kg/Ha. The area of cultivated land for LEISA system shallot farming is very diverse, ranging from 0.01 to 0.35 hectares, with an average land area of 0.09 hectares. All LEISA system shallot farmers in Bantul Regency run farming businesses in the small-scale category with an average cultivated land area of 0.12 hectares. Farmers' capital capabilities influence the area of arable land they cultivate. The amount of funds required will increase along with the area of land cultivated. Most commercial agriculture is a function of land area. Commercially oriented farmers are primarily driven by their ability to access markets to maintain and increase profits (Stringer et al., 2020).

Shallot farmers use the Brebes accession Bima seeds, a lowland shallot variety. When planted in medium to high altitudes, the Brebes accession Bima provides a relatively slower growth response (Tandi et al., 2021). The average use of seeds is 90.43 kg per farming business. Farmers make seeds by cutting off ¼ of the tip of the shallot bulb. Farmer groups play an essential role in procuring shallot seeds. Experience in the field shows that the Bima Brebes shallot variety has better disease resistance than other varieties. The existence of Bima Brebes is very popular as a parental line and is an advantage, so people can more easily use this variety. Farmers in Indonesia like the Bima Brebes variety because it has good quality, can adapt well to wet and dry land (Saadah et al., 2023; Fiana &

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Hidayanto, 2023).Bima shallots are round and relatively light compared to Talaja shallots (Kurniawan et al., 2020).

To meet the nutritional needs of shallot plants, fertilizer contributes to the growth of shallot plants so that the plants are able to grow and produce. The fertilizer that is widely used for LEISA system shallot plants is manure. The average amount of manure reached 661 kg per farming business, or 5,508 kg/ha. There are two ways to apply manure, namely by sprinkling or placing it around the planting hole. The second method saves more on fertilizer use but requires more work time. The addition of biological organic matter can increase the overall population of soil bacteria because the amount of organic matter shows the amount of energy that soil organisms have. Therefore, the addition of organic matter to the soil can be a source of soil carbon that soil microorganisms can use to help their metabolism. Using organic fertilizer can increase the relative number of beneficial bacteria and significantly improve soil structure. Long-term use of organic fertilizers contributes to increasing agricultural production (Liu et al., 2021). The use of manure is very important in the initial growth of shallot plants and is more environmentally friendly.

The average amount of dolomite applied was 235 kg per farming operation. Dolomite fertilization can increase enzyme activity, reduce acidity, and increase Mg levels in the soil. This enzymatic activity reacts to changes in the soil environment (Lasota et al., 2021). Providing dolomite combined with liquid organic fertilizer can increase the yield and quality of shallots as identified through the parameters of the weight of the shallot bulbs in each cluster, the weight of the bulbs after storage, and the percentage of weight loss (Jayanti & Tanari, 2021). Apart from manure and dolomite, shallot farmers using the LEISA system also apply NPK fertilizer. Farmers need 15.47 kg of NPK fertilizer per farming business during one planting season. Fertilizers are important in increasing soil fertility and plant production through appropriate fertilizer management according to plant nutritional needs. NPK 16-16-16 on shallot plants at a dose of 700-900 kg/ha can encourage relatively high plant growth and produce 14.5-16.3 t/ha production. This result is higher than using a single dose with a production of 12.8 t/ha (Suddin et al., 2021). However, using N fertilizer also has high negative impacts, such as increasing greenhouse gases, nitrous oxide emissions, high ammonia evaporation, air pollution, and effects on human health (Dimkpa et al., 2020).

Agriculture is the main source of income for most people in the research area. The LEISA system of shallot farming requires a lot of labour to carry out activities ranging from preparing seeds, tilling the land, planting, fertilizing, maintaining, and harvesting activities. The majority of workers come from within the family, while many workers from outside the family play a role in land processing and harvesting activities. Based on the age and education of respondents, the majority of farmer respondents (73.33%) were between 20 and 39 years old, 33.67% were 41 to 46 years old, and the majority (80%) of them had a high school education. For one planting season, the LEISA system shallot farming business requires an average of 36.97 working days per farming business.

In this LEISA system, shallot farmers in the research area use inputs prioritized from local and environmentally friendly materials. They use organic fertilizers derived from fermented livestock manure. The amount of organic fertilizer used by shallot farmers in the LEISA system is more than the traditional system to improve soil structure and fertility and support the creation of environmental sustainability by reducing pollution and soil degradation, which is often associated with the use of synthetic chemical fertilizers in large quantities. In controlling pests and plant diseases, shallot farmers in Nawungan are getting training in making biosaka to naturally control pests and plant

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diseases that are more environmentally friendly. Biosaka means active ingredients derived from plants that are useful for saving nature naturally.

It took quite a long time for shallot farmers in Nawungan Hamlet to switch from the traditional system to the LEISA system to implement more sustainable agricultural practices. In the early stages, assistance provides farmers with an understanding of the importance of using environmentally friendly inputs. This activity is in the form of training and counseling on ecologically friendly cultivation techniques. It then takes about two years to convert the land from the traditional system to the LEISA system through the land certification process by the Organic Certification Institute so that the land can be genuinely declared ready for the implementation of the LEISA system. The implementation of this LEISA system requires the participation of farmer group members, support from the Bantul Regency Food Security and Agriculture Service, banks that help access capital, and universities to provide assistance starting from making organic fertilizers, testing soil quality, environmentally friendly pest and disease management, capital, to marketing. Thanks to this long struggle, Nawungan Hamlet has become a center for organic shallot production in Bantul Regency.

Table 4. Description of Production Amount and Use of Shallot Production Factors per Farming Business with the LEISA System in Bantul Regency

No	Variable	Mean	Standard Deviation	Minimum	Maximum
1	Production (kg)	1270	879.71	200	3,000
2	Land (Ha)	0.12	0.08	0.01	0.25
3	Seeds (kg)	90.43	77.22	15	300
4	Manure (kg)	661.66	431.45	200	1,850
5	Dolomite (kg)	235.67	235.67	80	1,000
6	NPK Fertilizer (kg)	15.47	7.14	0	30
7	Labor (working days)	36.97	7.26	23	48

Source: Primary Data Analysis (2023)

Factors Affecting Shallot Production

Based on normality and multicollinearity tests, the results show that the OLS model used meets classical assumptions so that the OLS model meets the requirements for analyzing factors that influence the production of shallots cultivated using the LEISA system. The results of the normality test show that the data is normally distributed, and the multicollinearity test shows that the Variance Inflation Factor (VIF) value is in the range of 0.0231 and 5.3241, which indicates a number below 10. This test shows that there is no multicollinearity in the model. The LEISA system shallot farming production factors in this research include land area, number of seeds, amount of manure, amount of dolomite, amount of NPK fertilizer, and number of workers. Table 5 shows the results of estimating the shallot production function for the LEISA system using the Cobb-Douglas production function approach. The Adjusted R Square value of 0.968 means that the production factors of land area, number of seeds used, amount of manure, amount of dolomite, amount of NPK fertilizer, and amount of labour used are able to explain the variation in changes in shallot production by 96.8%, while the remaining (other factors outside this research model such as climate/weather conditions, planting systems, etc.) are able to explain variations in changes in production of 3.2%. Based on the F test, it shows that the probability value of F (0.000) is less than 0.05, which means that all production factors that are variables in this research together have a significant effect on shallot production.

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Based on the t-test analysis in Table 5, it shows that the production factor of land area has a calculated t value of 6.059 with a probability of 0.000 (less than α 0.05), which means that land area has a real effect on the LEISA system shallot production. The regression coefficient is positive, namely 0.718, which means that every 1% increase in land area will increase the amount of shallot production by 0.718%, assuming other variables are constant. The variables seed, amount of manure, amount of dolomite, amount of NPK fertilizer, and number of workers have no effect on shallot production using the LEISA system.

Shallot production will increase along with increasing land area. The average land area used for shallot farming is 0.12 ha. The land used by farmers to cultivate shallots using the LEISA system has gone through a conversion period. Land requires a minimum of two consecutive years to meet organic cultivation requirements. Shallots produced from this land during this conversion period were not considered organic. The research results show that land area positively affects shallot production in the LEISA system. Previous research focused more on the intensification of shallot production systems and showed that land area affected production (Istiyanti & Maylani, 2022; Suminartika et al., 2022). Meanwhile, other research provides different results to this research, namely that land area has no effect on the output of shallot land, which is included in the narrow category, and the land is still in the conversion process (Malta et al., 2018).

Based on the facts in the field, the Bantul Regency Food Security and Agriculture Service has conducted training and counseling on environmentally friendly shallot cultivation techniques, providing recommendations for using inputs in shallot cultivation to achieve high production levels. However, not all farmers have the capital and understanding of shallot cultivation techniques, especially in controlling and handling plant pests and diseases. This condition is the cause of input variables such as the number of seeds, the amount of manure, the amount of dolomite, the amount of NPK, and labor not affecting the production of shallots using the LEISA system. However, a more comprehensive land area provides a more significant opportunity for farmers to obtain higher output through more efficient modern agricultural technology, such as land processing using tractors and irrigation systems. The use of this technology will save on the use of labor.

Table 5. Estimation Results of the LEISA System Shallot Production Function

No	Variable	Symbol	Coefficient	t -Statistical	Significance
1	Constant	C	7.119	5.326	0.000
2	Land area (Ha)	X_1	0.718	6.059	0.000
3	Number of seeds (kg)	X_2	0.127	0.812	0.425
4	Amount of manure (kg)	X_3	0.059	0.516	0.611
5	Amount of dolomite (kg)	X_4	-0.048	-0.453	0.655
6	Amount of NPK fertilizer (kg)	X_5	0.020	1.134	0.268
7	Number of workers (working days)	X_6	0.247	1.085	0.289

Source: Primary Data Analysis (2023)

Stochastic Frontier Production Function Estimation

Table 6 shows the results of estimating the LEISA system shallot production function using the stochastic frontier approach, which includes the sigma squared (σ2), gamma (ɣ), and LR test parameter values. In the LEISA system shallot farming business, the sigma squared (σ^2) parameter value is 0 .0388 and is significant at the $\alpha = 0.01$ level. This value shows the distribution of the

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technical inefficiency (u_i) error term or, in other words, truly variable production. The results of this research are in line with previous research, which shows that there are technical inefficiencies that affect shallot production (Sri et al., 2023).

There is no evidence that all LEISA system shallot farming carried out by farmers is one hundred per cent efficient. The gamma parameter value (ɣ) for the shallot business in the LEISA system is 0.0145. This value means that technical inefficiency problems that farmers can control contribute 1 per cent of the residual variation in the model. Stochastic effects (v_i), such as pest attacks, weather influences, and modelling errors, account for 99 per cent of the residual variation. It shows that technical inefficiency does not really affect output variability.

Implementing the LEISA system in shallot cultivation shows that although farmers can control some aspects of technical inefficiency through technology and better cultivation management, factors beyond farmers' control have a more significant influence on shallot production. Because stochastic factors are more dominant, increasing technical efficiency will not substantially affect the variability of shallot production. Therefore, production increases policies at handling stochastic factors such as better handling of pests and plant diseases through the development of "biosaka," the discovery of shallot varieties that are more resistant to weather changes, and considering other variables in the model.

Table 6. Estimation Results of the Stochastic Frontier Production Function using the Maximum Likelihood Estimation (MLE) Method

No	Variable	Coefficient	t -Statistical	Significance
1	Constant	7.7158	10.6426	****
2	Land area (Ha)	0.7067	7.9556	****
3	Number of seeds (kg)	0.1268	0.8121	
4	Amount Manure (kg)	0.1743	0.0400	
5	Amount of dolomite (kg)	-0.0619	-0.7050	
6	Amount of NPK fertilizer (kg)	0.0155	1.0306	
	Number of workers (working days)	0.1514	0.7689	
	Sigma- squared	0.0388	3.4765	****
	Gamma	0.0145	0.0655	
	Log likelihood function MLE	5.8190		
	LR test of the one-sided error	3.3110		

Information:
1. ****) = significant at the α = 1% level (t-table = 2.80734)
2. ***) = significant at the α = 5% level (t-table = 2.06866)
3. **) = significant at the α = 10% level (t-table = 1.71387)
4. *) = significant at the α = 20% level (t-table = 1.31946)

Source: Primary Data Analysis (2023)

Sources of Technical Inefficiency

Table 7 describes the results of estimating factors that influence technical inefficiency in LEISA system shallot farming. Table 7 shows that the age and experience of farmers in the LEISA system of shallot farming are two factors that have a significant influence on the technical inefficiency of shallot farming. In contrast, the education factor has no significant influence on technical inefficiency. The coefficient of the farmer age variable is 0.4734 and has a significant effect on the technical inefficiency of the LEISA system shallot farming business. The positive sign of the age

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variable indicates that the higher the farmer's age, the higher the technical inefficiency or the lower the level of technical efficiency of the farming business. In other words, the younger the farmer, the higher the level of farming efficiency.

The coefficient value of the farming experience variable has a negative sign and is significant for business inefficiency. It means that as farmers gain more experience in farming, they will be able to make rational decisions regarding the farming business they undertake. Experience is one of the fundamental attributes for individual farmers to develop their potential, apart from other attributes such as a combination of emotions with agriculture, feelings towards agriculture, knowledge and skills, awareness of the difficulties and importance of farming, and farming abilities (Bertolozzi-Caredio et al., 2020). Experienced farmers are farmers who have a lot of experience in shallot farming (Fadzil et al., 2023). Soft-skill competency and experience influences farmer productivity (Tamsan & Yusriadi, 2022). The results of this research are in line with previous research. The farming experience variable has a significantly negative effect on technical inefficiency. The more experience farmers have in managing farming, the lower the technical inefficiency or the higher the technical efficiency achieved. Farmers with long experience in agriculture become more adept at managing their businesses. Farmers' experience helps them make logical decisions about their farming. Habits reflect experience and knowledge and the individual's process of conducting evaluations. Experience, new knowledge, and practices generated through participation reshape habits, including conducting evaluations (Alonso et al., 2020).

The older the farmer, the less efficient they are in producing shallots. Several arguments can explain this phenomenon. As the farmer ages, their physical ability to manage shallot cultivation decreases, which has an impact on reducing work efficiency. The older they are, the less able they are to adapt to new technologies, and they are used to old patterns. This condition will hinder the increase in technical efficiency. Therefore, a different approach is needed in providing training, mentoring, and counseling for groups of older farmers. The results of this study also show that the longer the farmer's experience in farming, the more technically efficient they are. With more knowledge of farmers in growing shallots, farmers can have good experience and understanding of local ecology, which will make it easier for them to make more appropriate decisions, such as when they will plant and harvest shallots that can provide the greatest benefits for farmers. The longer the farmer's experience, the more skilled the farmer is in managing his farming business, such as the use of inputs, handling pests and diseases, and harvest planning. The longer the farmer's experience, in general, the better networks and access to resources.

Table 7. Estimation Results of Factors Affecting Technical Inefficiency of LEISA System Shallot Farming in Bantul Regency

No	Variable	Symbol	Coefficient	t -Statistical	Significance
1	Constant	C	-1.2054	-4.6584	****
2	Age	Z_1	0.4734	1.6226	*
3	Education	Z_2	1.6281	-0.6503	
4	Farming experience	Z_3	-0.1003	-4.5507	****

Information:
1. ****) = significant at the α = 1% level (t-table = 2.80734)
2. ***) = significant at the α = 5% level (t-table = 2.06866)
3. **) = significant at the α = 10% level (t-table = 1.71387)
4. *) = significant at the α = 20% level (t-table = 1.31946)

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Source: Primary Data Analysis (2023)

Technical Efficiency Value of LEISA System Shallot Farming Business

Efficiency is a measuring tool that can be used as an indicator to see the success of farming. This research uses a production input approach to understand the concept of technical efficiency. A shallot farming business is technically efficient if it is able to produce a certain amount of output using less input or is able to produce a maximum output from using a certain amount of input for technical efficiency analysis using the stochastic frontier production function. In essence, a technical efficiency index value that is close to one means that farmers are very efficient in using their inputs. However, if the index value reaches 0, it means that farmers are not technically efficient. The results of technical efficiency calculations in Table 8 show that the entire shallot farming business using the LEISA system is in the efficient category. The average technical efficiency value of respondent farmers is 0.95, which means that the average respondent farmer has achieved technical efficiency in the LEISA system shallot production in Bantul Regency. This research uses a stochastic frontier production model, which is analyzed simultaneously to determine the technical efficiency value. The technical efficiency of the LEISA system shallot farming business has a value ranging from 0 to 1. Table 8. summarizes the distribution of technical efficiency levels of LEISA system shallot farming in Bantul Regency.

The technical efficiency value of the LEISA system shallot farming in Bantul Regency, based on Table 8, is in the range between 0.85 and 0.99, with an average value of 0.95. A technical efficiency level of 95% illustrates that the average farmer can achieve production of up to 95 per cent of the production factors that have been sacrificed. Overall, the average success rate of LEISA system shallot farming in achieving maximum production is in the range of 95 per cent of the frontier. This result is higher when compared to the technical efficiency of shallot farming in several regions in Indonesia, such as in Brebes, where the technical efficiency reaches 89.72% and in Serdang it reached 51.9 (Astuti et al., 2020; Lubis et al., 2023).

The maximum production level that can be achieved by combining various resources available under the best LEISA system shallot cultivation conditions. In this condition, the average farmer still has the opportunity to increase shallot production using the LEISA system by 5 per cent, which can be achieved through technological improvements and increased managerial capabilities. Increasing production will increase farmer income. The research results show that 83 per cent of LEISA system shallot farmers in Bantul Regency are operating at a technical efficiency level of above 90 per cent, and the remaining 17 per cent of farmers have technical efficiency below 90 per cent. In the short term, the average shallot farmer in Bantul Regency has the opportunity to increase production by 14 per cent (1- (0.85/0.99)). Farmers can seize these opportunities by improving their skills and abilities in adopting the most efficient cultivation technology innovations, as well as improving farming business management. Technological innovations that need to be developed to increase the chances of achieving maximum production in the LEISA system of shallots are technologies related to effective and environmentally friendly integrated pest management, irrigation technology that can save energy, seed technology that can produce superior varieties that are adaptive to local conditions (soil, weather, climate change). In addition to technological innovation, it is also necessary to improve management capabilities and farmer access to inputs. There is a need to increase farmer knowledge, skills, and awareness of the importance of more efficient resource management (input) through the

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use of inputs in the right amount, at the right time, and in the right way to produce products that meet high-quality standards.

Table 8. Distribution of Technical Efficiency Values for LEISA System Shallot Farming in Bantul Regency

Index	Number (Person)	Percentage (%)
0.80 – 0.89	5	17
0.90 – 1.00	25	83
Average Efficiency	0.95	
Minimum efficiency	0.85	
Maximum efficiency	0.99	

Source: Primary Data Analysis (2023)

Table 9 shows the results of one sample t–test analysis for average technical efficiency. Decision criteria: if t count < -t table or t count > t table or P value < 0.05, then Ho is rejected and Ha is accepted. Based on Table 10, the t-value (-6.136) < - t-table (-2.0452) with a significance level of P value (0.000) < 0.05. This condition shows that the average technical efficiency of LEISA system shallot farming in Bantul Regency is 0.95, which is significantly different from the value of 1 (one); in other words, LEISA system shallot farming in Bantul Regency is technically not yet efficient. To improve the technical efficiency of shallot cultivation using the LEISA system in Bantul Regency, better input management supported by technological innovation can be carried out.

Table 9. Results of t-test Average Technical Efficiency of Red Onion Farming with LEISA

One-Sample Test						
Test Value = 1						
ET	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference t	
					Lower	Upper
	-6.136	29	.000	-.05200	-.0693	-.0347

Source: Primary Data Analysis (2023)

CONCLUSION AND SUGGESTION

The results of the Cobb Douglass production function analysis show that land area has a positive effect on LEISA System shallot production with a regression coefficient of 0.718, while the variables number of seeds, amount of manure, amount of dolomite, amount of NPK fertilizer, and number of workers have no effect on shallot production using the LEISA system. Technical inefficiency problems that farmers can control account for 1 per cent of the residual variation in the model. Stochastic effects (vi), such as pest attacks, weather influences, and modelling errors, account for 99 per cent of the residual variation. It shows that technical inefficiency does not affect output variability. The age variable has a positive effect, and the farming experience variable has a negative effect; in contrast, the education variable does not affect the technical inefficiency of the LEISA

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system shallot farming. The average technical efficiency of the LEISA system shallot farming business in Bantul Regency is 0.95, which is significantly different from the value of 1 (one), which means that the LEISA system shallot farming business in Bantul Regency is technically not yet efficient.

Implementing the LEISA system in shallot farming can provide high technical efficiency. Farmers utilize local resources, especially manure, widely available to support the ecosystem. Farmers can increase shallot production with the LEISA system by increasing the land area, and farmers can increase their farming experience to increase agricultural technical efficiency. Further research is needed related to farmers' interests, motivation to develop the LEISA system in shallot farming, as well as the sustainability of this system. It is important to develop agriculture through the utilization of the potential of shallots using the LEISA system in Nawungan Hamlet. In addition, a more comprehensive study is also needed regarding the validity of the LEISA system of shallot cultivation so that it can be used as a consideration for related parties in the development program.

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