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ADOPTION LEVEL OF RICE FARMING TECHNOLOGY ON SWAMP LAND IN INDONESIA

Abstract:

Improved agricultural technology adoption has the potential to increase the productivity of rice and maximize profit farming. However, the farmers who cultivate swamp land have many limitations to adopting all of the rice technology. The aims of this study were (1) to analyze, and its impact on productivity and (2) to analyze the influence of socio-economic characteristics on the level of technology adoption of rice farming in swampy land. The sampling method used was the simple random sampling method, and data was collected through direct interviews with 90 rice farmers. The collection of data used includes primary and secondary data. Processing data using simple linear regression and multiple regression. The results showed that farmers had adopted technology in the form of tractors, organic fertilizers, inorganic fertilizers, pesticides, combined harvesters, superior varieties of seeds, and rice threshing machines. The level of technology adoption is in the high category. There is Pattern A (tractor, organic fertilizer, chemical fertilizer, insecticide, HYV, combine harvester) which has a proportion of farmers of 62.2% and a productivity of 3,187 kg/ha. The variables age, education level, land area, experience, income, interaction with extension workers, availability of facilities and infrastructure, and institutional roles all affect the adoption rate. Farmers should own or raise livestock such as goats or cows. To be able to adopt organic fertilizer technology that can increase productivity by Pattern C (tractor, organic fertilizer, chemical fertilizer, insecticide) with low variable costs.

Keywords:

rice farming, productivity, swamp land, technology, adoption.

JEL Classification: A10, A14, A19

Introduction

Sustainable Development Goals has a series of global targets set by the United Nations (UN) to achieve sustainable development seen from three aspects, namely economic, social and environmental (Eang et al., 2023; Ghufran et al., 2024; Sadiq et al., 2023; Scrucca et al., 2023). Due to Zero Hunger is one aspect of sustainable development (SDGs) that is targeted to be realized by 2030, so there are many policies carried out by each country to achieve these goals (Fernandes & Rodrigues, 2023; Ghosh & Sahu, 2023; Mohamad Taghvaee et al., 2023; Vogliano et al., 2021). One of the policies in question is the implementation of sustainable agriculture through increasing agricultural productivity, strengthening food security and protecting the environment (Allahyari & Poursaeed, 2020; Arora & Mishra, 2022; Khanal et al., 2021; McConnell et al., 2023). Zero hunger aims to address the global hunger problem, as well as ensure that everyone has equal and equal access to quality and nutritious food (Ashfaq et al., 2023; Chen et al., 2023; Hameed et al., 2023; Singh & Chattopadhyay, 2023). The global hunger index in 2018 also states that the problem of hunger in Indonesia is ranked 73rd in the world with an index value of 21.9 or at a fairly serious level and begins decline until 2023 in medium level (The Global Hunger Index, 2023). From this data, it is important for Indonesia to be able to optimize food security and reduce or even eliminate hunger cases in Indonesia.

Optimizing rice productivity as a staple food is currently one of the steps to ended up the hunger and achieve food security in Indonesia (Azyan et al., 2023; Herdiansyah et al., 2023a; Liu et al., 2023). Marginal land management such as lebak swampland management is an important things to support food security in Indonesia (Berliana & Fitri, 2022; Khairullah, 2022; Mulyani et al., 2023; Swastiwi et al., 2023). In practice, the success of swamp land management influenced by several factors, such as climate change. An extreme climate change can affected the success of farming activities in Indonesia. (Aldyan, 2023; Azyan et al., 2023) The climate change can cause an increase or decrease in extreme rain patterns that can cause swamplands to experience an extreme flood or drought conditions (Omotoso et al., 2023; Weathers et al., 2023; Zaitchik et al., 2023; Zhou et al., 2023).

In addition, climate change can also cause more crop demage and yield loss due to pathogens and pests attack (Kaur et al., 2023; Singh & Chattopadhyay, 2023; Subedi et al., 2023). If left continuously without special treatment of agricultural crops, it will be indirectly have an impact on decreasing agricultural productivity (M. Ahmed et al., 2023; Dong & Wang, 2023; Timpong-Jones et al., 2023). Climate as one of natural factor in agricultural productivity that cannot be avoided but can be prevented or controlled with the existence of appropriate technology (Bendig et al., 2023; Chien et al., 2023). Therefore, it is necessary to develop technology introduced and adopted by farmers in swampland as one of the efforts to optimize agricultural activities (Ibrahim & Truby, 2023a; Li et al., 2024a; Nyagango et al., 2023).

Technology development in lebak swampland has great potential to be able to increase agricultural productivity, environmental conservation and the welfare of local communities. Some technological initiatives that can be implemented include the following: (1) Land processing, modern machines such as tractors and other soil processing equipment can increase efficiency and productivity in processing swampland. In addition, it can reduce the workload of farmers (Thomas et al., 2023) ; (2) irrigation and drainage, can help regulate water supply efficiently, reduce the risk of water and excess water and can increase crop yields (Bastaubayeva et al., 2023; Khudayorov et al., 2023; Yan et al., 2023); (3) efficient use of fertilizers and pesticides, precision agricultural technology and pesticides in the right right can reduce the risk of waste and the risk of negative impact on the environment (Li et al., 2024b); (4) postharvest equipment, existing technology can make it easier for farmers to carry out post-harvest activities, in addition to increasing efficiency in time, it can also increase efficiency economically because it saves labor costs (Akter, 2024); (5) Economic opportunities, with the development of technology can enable farmers to carry out economic activities from existing technology by selling or leasing products / services offered to consumers (Bethi & Deshmukh, 2023; Mariyono, 2020)

However, currently there are still limited data related to the extent to which technology in the agricultural sector is adopted by swampland, or how much swampland in Indonesia has adopted agricultural technology (Ibrahim & Truby, 2023b; Ilham et al., 2023). Therefore, this study was conducted comprehensively to fill the GAP of existing problems.

Method

The sampling method carried in simple random sampling, conducted in lebak swamp area, South Sumatra. The method is carried out to obtain the data representatively and data accurately. The number of examples used for this study was as many as 90 respondents of lebak swampland rice farming. Calculated based on the slovin formula of a total population of 140 people.

The data collection carried out by primary data and secondary data. Primary data is data obtained from the results of interviews directly with sample farmers through several questions in the questionnaire that has been prepared. The data obtained from the interview results are systematically processed in the form of tabulations and explained descriptively. To see the type of technology used by rice farmers, the data processing with descriptive analysis. It is presented in the form of diagrams and described. Then, the analysis of technology adoption is carried out objectively by looking at the highest value (number of respondents) of the adopted pattern. To analyze the effect of rice farming technology adoption using simple regression analysis with the help of IBM SPSS 26.

Multiple regression analysis was used to see the influence between socioeconomic characteristics in decision making on the adoption of rice farming technology in lebak swampland. The analysis was performed with IBM SPSS 26 program tools. The analytical approach used with the equation of the function is mathematically as follows:

$$Y = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + \beta 8X8 + \beta 9X9 + e$$

Information:

Y = Adoption rate of rice farming technology in lebak swampland (%)

α = Constant

β = Regression coefficient

X1 = Farmer's age (Years)
X2 = Last education (Year)
X3 = Land area (ha)
X4 = Farm experience (Years)
X5 = Revenue (Rp/ha)
X6 = Number of family dependents (People)
X7 = Interaction with extension workers (%)
X8 = Availability of facilities and infrastructure (%)
X9 = Institutional role (%)

Result and Discussion

A. Socio economic characteristics sample

Table 1. Socio Economic Characteristics Sample, 2023

No	Variable	Categories	Percentage (%)	Standard Dev. (±)
1.	Gender	Male	17.8	-
		Female	82.2	
2.	Age (Year)	26 – 35 (Early Adult)	5.56	9.92 (30±75)
		36 – 45 (Late Adult)	16.67	
		46 – 45 (Early Elderly)	27.78	
		56 – 65 (Late Elderly)	41.11	
		>65	8.89	
3.	Experience (Year)	≤ 10	13.3	12.71 (3±50)
		11 – 20	25.6	
		≥21	61.1	
4.	Land Use (Hectare)	< 0.5	10.0	0.92 (0.25±4)
		0.5 – 1	37.8	
		> 1	52.2	
5.	Family Mamber (Person)	0 – 3	64.4	1.27 (0±6)
		4 – 6	35.6	
6.	Extension Intensity (times in year)	0	6.67	0.27 (0±2)
		1 – 4	93.3	
		4 – 6	0.00	
		9 – 12	0.00	

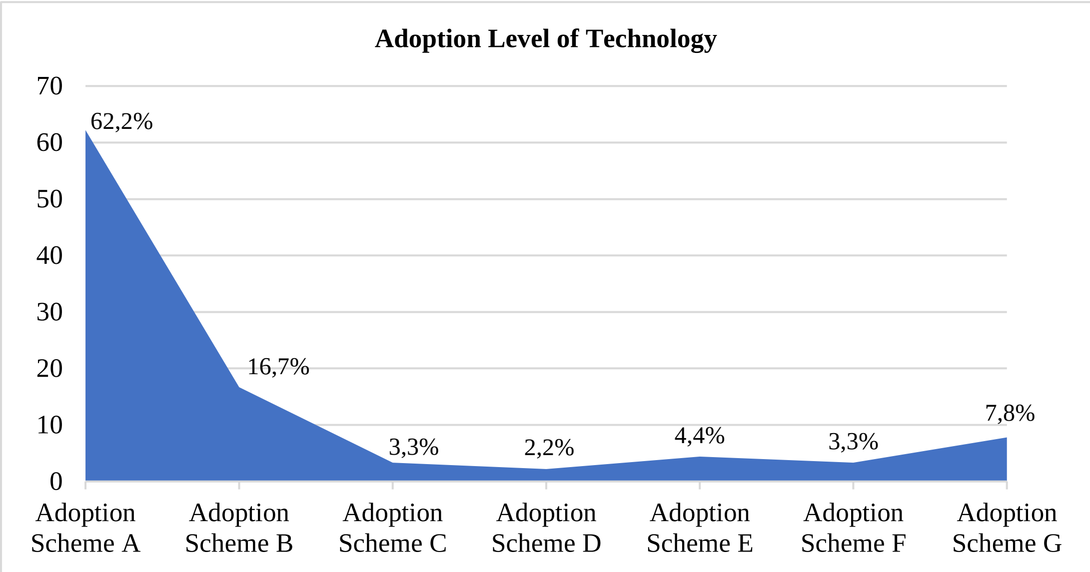
The results showed that most respondents were women, with old age in the age range of 46-65 years or included in the early and late elderly categories, which included in the productive age of human resources in working until the age of 60 years. In line with that, research respondents have more than 20 years of farming experience. It shows that farming activities have become the main occupation. The results of the study shows that the more experienced a person is in doing farming activities, the more skilled she/he will be. However, although farming activities are unfortunately not so extensive land ownership, which is a maximum of only about 4 hectares, even so with existing farming activities, farmers have family members as many as 0-3 people in each household. The size of the number of family members who are dependents of farmers will affect household expenses. The greater the number of family members covered, the greater the expenditure that will be incurred. Therefore, farmers need to have sufficient income through increasing farm productivity so that they can meet the needs of farmer households. The farming activities carried out are certainly inseparable from the role of extension workers. Most farmers get a maximum of 2 times a year. Extension activities are very important for farmers to get, because they can increase farmers' knowledge, insight and skills in carrying out agricultural activities. But unfortunately, not all the farmers consider with this extension activity, although in a small part, at least there are around 6.67% of farmers who did not participate in extension activities. Even extension activities indeed insightfull and might be improve the farmers' skills.

B. Adoption Patterns Based on the Number of Technologies Implemented by Respondents

The application of technology adoption adopted by farmers, consists of 7 technology categories. The seven categories were then formed into 7 patterns of farm adoption based on the amount of technology applied by farmers. The seven categories are categories A, B, C, D, E, F, G. Analysis of the level of technology adoption seen from the percentage number in classifying technology. Objectively, the application of technology by respondents falls into the high category. This is because more than 50 percent of samples adopt pattern A or it can be said that more than 50 percent of farmers have adopted 7 technologies in their farming activities. The use of *a combine harvester as* the main machine in harvesting activities is clear evidence that technology has been adopted. According to respondents, the use of these tools helps in the harvesting process. This is in line with the results of research which explains that the harvesting process using *combine harvaster* more quickly, more cheaply and more efficient than manually (Athaillah, 2023) . The same thing is also seen in the process of post-harvest land management using a tractor. Both of tractors and combine harverster are quite expensive equipment, so for small and medium farmers cannot afford it (Gusev et al., 2023; Mani, 2023). Both of these technologies are brought by extension institutions that bring innovation through the support of tools. Generally, in Indonesia small and medium farmers rent the machinery (Especially for an expensive equipment, such us tractor and combine harvester) for farming activity. But the rental system is less than optimal for improving farmer welfare, only to support increased farming productivity. Individual and group rentals also have differences greater profits are obtained if farmers rent individually (Herdiansyah et al., 2023b; Widyanto & Subanu, 2023). Based on existing local wisdom, the rental payment system does not always have to be paid with money, but can be exchanged for harvested dry grain. For 1 ha of using tractor and *combine harvester* will usually be exchanged for a fee of around IDR 1,200,000 (69.67 EUR) or dry grain harvested as much as 2.5 quintal. In addition, another factor of tractor and combine harvester technology adoption is because of respondents consider that the use of these two machines is not so difficult. This is in line with the opinions expressed by (Al-Emran & Griffy-Brown, 2023) states that the willingness of farmers in the use of tractor machines and combine harvesters is high.

In contrast to tractors and cobine harvesters, water management systems is still in a low rate of technology adoptiion. Farmers have not yet water channels that can be benefical to agricultural activities due to the risk of flooding when the rainy season arrives. In addition to water management technology, the technology of using high-yielding varieties has been applied by respondents. However, due to limited capital, some of them mixed seeds of high-yielding varieties with the harvest of the previous growing season. Some types of rice varieties that are widely used today are types of paddy seeds, such as Inpari 32, Inpara 2, Mekongga, and Ciherang (Waluyo et al., 2023). In some developing countries such as Indonesia, Pakistan, Nigeria and Indian lack of financial capital are still the main obstacle for the smallholder farmers (Datta & Behera, 2022; Raza et al., 2023). Agricultural credit accessibility is one of financial solution of it (Rayhan et al., 2023; Raza et al., 2023).

For several technologies such as organic fertilizers, inorganic fertilizers, superior varieties, rice threshing machines, and pesticides began to be introduced since 2013. Until now, it has taken almost 11 years for



respondents to actually adopt the technology. However, technology adoption is not a immediet process, it takes a long time for a farmers actually adopt a new technology since it realised (Al-Emran & Griffy-Brown, 2023) On the other hand, there are still a small number of farmers who have not been able to adopt the technology due to the impossible accessibility. Cost of Innovation, Lack of access to credit facilities, lack of farmers participation in agricultural innovation programme development, inadequate extension service, lack of training on adoption, unavailability of the agricultural innovation in local market are some of agricultural technologies adoption in farmers (Achukwu et al., 2023; Amoussohoui et al., 2023; Saito et al., 2023). For more details looking at the percentage of technology adoption patterns can be seen in Table 2. The following:

Information:

1. Adoption Pattern A (7 Technologies): Tractors, organic fertilizers, inorganic fertilizers, pesticides, high-yielding varieties, harvesting machines, and rice threshers.
2. Adoption Pattern B (6 Technology): Tractors, organic fertilizers, inorganic fertilizers, pesticides, high-yielding varieties, and harvesting machine.
3. Adoption Pattern C (5 Technology): Tractors, organic fertilizers, inorganic fertilizers, pesticides, and high-yielding varieties.
4. Adoption Pattern D (4 Technology): Tractors, organic fertilizers, inorganic fertilizers, pesticides, and high-yielding varieties.
5. Adoption Pattern E (3 Technology): inorganic fertilizers, pesticides, and harvesting machines.
6. Adoption Pattern F (2 Technology) : Inorganic fertilizer and harvesting machine.
7. Adoption Pattern G (1 Technology) : Harvesting machine.

Diagram 1. Technology Adoption Rate, 2023

C. Rice Farm Productivity Based on Adopted Production Patterns

The data in Diagram 2. Shows that the more types of technology applied by respondents, the higher the productivity of rice farming they have. One of the reasons why respondents do not want to adopt technology is because the amount of land area is not so large, which is only about 0.5 ha. More details on the adoption pattern of patterns D and E are not in line with existing trends due to lower variable risks and costs in pattern D. The quantity of fertilizer used in pattern D tends to be lower than pattern E. this` is what causes productivity in pattern E to be higher than pattern D. in line with some research results that the more technology adoption, the more farming productivity increased (Gabriel & Gandorfer, 2023a; Passarelli et al., 2023) The use of appropriate redtechnology and the right amount really plays an important role in increasing farming productivity (Redclift, 2023). Indeed, to adopt the technology, farmers generally have a lack of capital problem (Alabi et al., 2023), so they depend on natural resources to meet their farming nutritional needs. In addition, Lebak swamp area current irrigation system is not optimal, with the climate change extrem factors, the land can be extreme floods and droughts anytime.

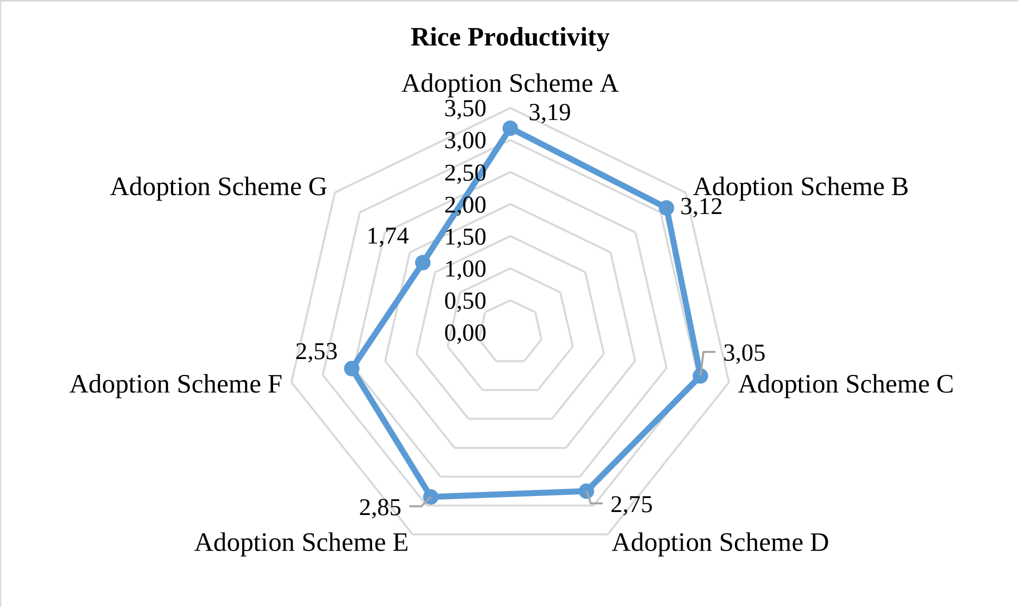


Diagram 2. Rice Farm Productivity

D. The Effect of Technology Adoption Rate on Productivity

Technology adoption has the potential to improve farming productivity and profitability in agriculture (Miah et al., 2023). Rice farming productivity in a wet lands might be increase through the integrated crop management technology (Ali et al., 2023; Haka et al., 2023). It also can be applied in lebak swampland area with new higher varieties, agriculture, site-specific loss management, water management, and integrated pest and disease management (Hatta et al., 2023; Raharjo et al., 2023).

Table 3. Effect between Adoption Rate and Productivity

Type	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.284a	1	.070	1.019946

Table 3. above explains that the influence of adoption on productivity is very high, which is 8.1%. Proven by the adoption patterns and productivity levels in Table 2. Which almost has the same trend, the more technology adopted by farmers, the higher the level of productivity resulting from agricultural activities. (Raharjo et al., 2023) In his research also stated that the level of technology adoption is very influential on farm productivity. This is also supported by the t-Test results in Table 4. The magnitude of the effect of technology adoption can increase productivity by 0.156 for every 1 percent increase in technology adoption variables. For more details, the data can be seen on Tabe 4. The following:

Table 4. Calculated Value Test t

Type	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.145	.350		6.124	.000

Adoption	**.156**	.057	.284	2.763	.007

E. Socio-economic characteristics on the level of technology adoption

Table 5. Test Results t Social Economic Characteristics

Type	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-2.168	7.203		-.301	.764
Age	.023	.048	.056	.471	.639
Education	.378	.200	.201	1.888	.063
Land Use	-.039	.038	-.106	-1.024	.309
Farming Experience	.095	.042	.306	2.257	.027
Income	1.197E-10	.000	.103	.972	.334
Extension	-.030	.048	-.066	-.616	.540
Means	.137	.066	.217	2.067	.042
Institutional	-.035	.022	-.167	-1.609	.111

In Table 5. Age has a positive influence on the rate of technology adoption. This is according to research (Haruna et al., 2023; Sukayat et al., 2023) Which states that age has a positive effect on agricultural production factors especially in technology adoption. Age can be influence the technology adoption due to differences in habits, preferences, skills, and comfort using new (Garai-Fodor et al., 2023). Younger generations tend to be quicker to adopt new technology because they are more accustomed to change and more skilled at using digital devices (Chan & Lee, 2023). Meanwhile, older generations may need more time to overcome technological obstacles and accept new innovations.

The increasing of age also has an impact on a person's gaps of technology (Sadrul Huda et al., 2023), therefore it takes a long time for older generation to be able to adopt the technology.

Education has a positive influence on technology adoption rates. This is according to research (Rustandi et al., 2020) which states that the level of Education has a positive effect on the adoption rate. Education provides individuals with skills, knowledge, and understanding of technology (Carroll et al., 2023). People who have higher education tend to be more familiar with technology and have the ability to overcome obstacles in using new technology (Yin et al., 2023). In addition, education also allows people to be more open to innovation and have the motivation to continue learning and developing new technological skills (Alfaro-Ponce et al., 2023).

The variable of farming experience has a positive influence on the level of technology adoption. This is in line with the research shows that the majority of farmers have farming experience more than 21 years. It forms a practical knowledge and understanding of various aspects of farming (Griffin et al., 2023). Farmers who have extensive experience in agriculture may be more likely to be open to the adoption of new technology because they have experienced the direct benefits of using technology in increasing productivity and efficiency (Gabriel & Gandorfer, 2023b). Apart from that, experience also helps farmers to identify the problems and challenges they face in their agricultural business, and technology can be a solution to overcome these problems (Mizik, 2023).

Income has a positive influence on technology adoption rate. Higher incomes enable individuals to purchase the devices and equipment necessary to use the technology (Papadopoulos & Cleveland, 2023). For example, farmers with higher incomes may be better able to afford modern agricultural machinery or automated irrigation systems (H. Ahmed & Ahmed, 2023). The use of technology often requires additional operational costs (Lee et al., 2023; Malik et al., 2023), such as electricity costs or maintenance costs. People with lower incomes may not be able to afford these additional costs. Higher incomes are also often associated with better access to technology-enabled infrastructure, such as a stable internet network or reliable electricity grid (Sadrul Huda et al., 2023). Individuals with higher incomes tend to have greater confidence and self-confidence in adopting new technologies. They may be more ready to take risks and try new things. Indeed, People with higher incomes may have different spending priorities, which may include investing in technology that can increase their comfort or efficiency (Ren et al., 2023).

Facilities and infrastructure also being the last variable which has a positive influence on the level of technology adoption rate. Good infrastructure, such as reliable telecommunications and electricity networks (Sadrul Huda et al., 2023). ensures that technology is accessible to the wider community (Wanof, 2023). Without adequate infrastructure, it is difficult for individuals or communities to adopt new technologies. In an agricultural context, good storage facilities and efficient distribution systems allow the use of technologies such as more complex monitoring or inventory management systems (Ahmad & Sharma, 2023; Tushar et al., 2023). According to field conditions, there are some agriculture facilities existing such as drying locations, storage warehouses for agricultural products, and milling. All the facilities builds owned by individuals.

Conclusion

The results of research that have been conducted show that the pattern of technology adoption is very influential on the productivity of farmers produced by respondents. The more technology adopted by farmers, the higher the productivity produced. It's just that to achieve it all cannot be done instantly, it even takes up to 11 years until many respondents not only accept but also want to adopt technology. Technology adaptation has a major influence on the level of agricultural productivity, especially if agricultural activities are carried out on lebak swampland and are influenced by climate that allows the land to experience extreme floods and droughts. So that with the adoption of technology, it can be used as a special treatment for agricultural activities in Rawa Lebak lahahan.

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