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Relationship between farmer characteristics, farmer behavior, and the role of agricultural extension workers on the adoption of the recommended shallot cultivation practices in Monta District, Bima Regency, West Nusa Tenggara

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Abstract---Shallot productivity in Monta District, Bima Regency, has experienced fluctuations, which are presumed to be associated with the low adoption of the recommended shallot cultivation package. This study aimed to analyze the effects of farmer characteristics, farmer behavior, and the role of agricultural extension workers on the adoption of the recommended shallot cultivation package in Monta District, Bima Regency, West Nusa Tenggara, Indonesia. The research was purposively conducted in four villages, namely Baralau, Sakuru, Monta, and Tangga. A total of 92 farmers were selected as respondents using the proportional random sampling method. This study employed a quantitative approach with a survey method, and the data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS). The results revealed that farmer characteristics had a positive and significant effect on the adoption of the recommended shallot cultivation package (coefficient = 0.286; p-value = 0.021). Farmer behavior also exerted a positive and significant

effect (coefficient = 0.237; p-value = 0.040). Furthermore, the role of agricultural extension workers showed the strongest positive and significant influence (coefficient = 0.407; p-value = 0.000), indicating that it was the most dominant factor in promoting the adoption of the recommended shallot cultivation package. The findings suggest that strengthening the capacity of agricultural extension workers, improving farmer characteristics and behavior, and implementing more intensive, participatory, and farmer-oriented extension programs are essential strategies for enhancing the adoption of the recommended shallot cultivation package, thereby supporting higher productivity and the sustainability of shallot farming in Monta District.

Keywords---farmer characteristics, farmer behavior, agricultural extension workers, adoption of the recommended shallot cultivation package, SEM-PLS.

Introduction

Agriculture is one of the main pillars of Indonesia's economy, playing a crucial role in ensuring food security, generating employment, and improving rural livelihoods. Among horticultural commodities, shallot (*Allium ascalonicum* L.) is considered a strategic crop because of its high economic value and continuous market demand. Consequently, increasing shallot productivity has become a major priority in agricultural development through the adoption of effective and sustainable cultivation technologies.

Bima Regency, West Nusa Tenggara Province, is one of Indonesia's major shallot-producing regions, with Monta District serving as one of its primary production centers. Despite its strategic role, shallot productivity and production in Monta District have fluctuated considerably over recent years. According to the Bima Regency Agriculture and Plantation Office, production peaked at 18,195 tons in 2022 but declined to 11,113 tons in 2025, accompanied by a productivity level of 112.3 tons ha⁻¹. These fluctuations indicate that production growth has not been sustainable and highlight the need to improve the adoption of recommended cultivation practices to enhance productivity and farming sustainability.

Variations in shallot productivity are influenced by both technical and non-technical factors. Technical constraints include climate variability, pest and disease incidence, seed quality, fertilizer management, and inappropriate cultivation practices. Non-technical factors encompass farmer characteristics, farmers' behavioral responses toward technological innovation, and the effectiveness of agricultural extension services. Therefore, the successful adoption of the recommended shallot cultivation package depends not only on the availability of improved technologies but also on farmers' willingness and ability to adopt innovations, supported by extension workers as agents of change.

Agricultural extension services play a strategic role in facilitating technology dissemination by functioning as educators, facilitators, motivators, and advisors.

However, preliminary field observations revealed several challenges faced by extension workers in Monta District, including the low educational background of farmers, difficulties in changing established farming practices, limited institutional resources, and low farmer participation in extension activities. These constraints reduce the effectiveness of technology transfer, resulting in varying levels of adoption of the recommended shallot cultivation package among farmers. Previous studies on the adoption of shallot cultivation technologies have primarily been conducted in Indonesia's major production centers, such as Brebes, Nganjuk, and Tegal. Most of these studies examined the influence of farmer characteristics or socioeconomic factors independently and were carried out under irrigated agroecosystems that differ substantially from the dryland conditions of Bima Regency. Consequently, their findings cannot be directly generalized to Monta District, which is characterized by limited water availability, dependence on local seed sources, volatile market prices, and distinct institutional conditions. Furthermore, few studies have simultaneously examined the combined effects of farmer characteristics, farmer behavior, and the role of agricultural extension workers on the adoption of the recommended shallot cultivation package.

According to Rogers' Diffusion of Innovations Theory, innovation adoption results from interactions among adopters' characteristics, behavioral attributes, and the effectiveness of change agents. In the context of shallot cultivation, agricultural extension workers no longer serve merely as technology disseminators but also as facilitators, motivators, and institutional linkages that encourage farmers to adopt agricultural innovations. Integrating these three dimensions into a single analytical framework is therefore expected to provide a more comprehensive understanding of the determinants of technology adoption.

This study addresses the existing research gap by simultaneously examining the effects of farmer characteristics, farmer behavior, and the role of agricultural extension workers on the adoption of the recommended shallot cultivation package in Monta District, Bima Regency, using Structural Equation Modeling–Partial Least Squares (SEM-PLS). Unlike previous studies that investigated these factors separately, this study develops an integrated model to explain technology adoption under the specific agroecological conditions of a dryland shallot production area. The findings are expected to contribute both theoretically to the literature on agricultural innovation adoption and practically to the development of more effective extension strategies for improving technology adoption, productivity, and the sustainability of shallot farming in Bima Regency.

Materials and Methods

This study employed a mixed methods approach by integrating quantitative and qualitative methods to obtain a more comprehensive understanding of the factors influencing the adoption of the recommended shallot cultivation practices. This approach was selected because the adoption of agricultural technology is a complex phenomenon influenced by individual, social, institutional, and environmental factors that cannot be adequately explained using a single research approach. The quantitative approach was applied to examine the causal relationships among farmer characteristics, farmer behavior, the role of

agricultural extension workers, and the adoption of the recommended shallot cultivation practices. Meanwhile, the qualitative approach was used to gain a deeper understanding of the underlying reasons for farmers' decisions to adopt or not adopt the recommended cultivation practices.

The research site was purposively selected in Monta District, Bima Regency, West Nusa Tenggara Province, Indonesia, because the district is one of the major shallot production centers in the regency. Monta District consists of fourteen villages: Baralau, Sakuru, Monta, Tangga, Sie, Simpasai, Pela, Waro, Wila Maci, Sondo, Tangga Baru, Nonto Tera, Tolo Uwi, and Tolo Tangga. Among these, four villages—Baralau, Sakuru, Monta, and Tangga—were purposively selected as the study sites because they represent the primary shallot-producing areas and have substantial potential for shallot farming development.

This study utilized both quantitative and qualitative data. Quantitative data consisted of questionnaire responses and statistical analysis results, whereas qualitative data included information on farmer characteristics, farmer behavior, the role of agricultural extension workers, and field observations. Primary data were collected through structured interviews, questionnaires, direct observations, and documentation. Secondary data were obtained from scientific journals, government reports, statistical publications, and other documents relevant to the study.

The study population comprised 1,130 shallot farmers in Monta District. The sample size was determined using the Slovin formula, resulting in 92 respondents selected as the research sample. The study investigated four latent variables: farmer characteristics, farmer behavior, the role of agricultural extension workers, and the adoption of the recommended shallot cultivation practices. Farmer characteristics were measured using four indicators: age, education level, farming experience, and family size. Farmer behavior was measured through knowledge, attitudes, skills, and farming practices. The role of agricultural extension workers was assessed based on their functions as educators, mediators, motivators, facilitators, and evaluators. The adoption of the recommended shallot cultivation practices was measured using four indicators: the level of adoption of the recommended cultivation package, improvements in crop yield, perceived complexity of implementation, and improvements in shallot quality.

The primary instrument for data collection was a structured questionnaire using a five-point Likert scale. The questionnaire was designed to measure respondents' perceptions and attitudes toward all research variables. In addition, field observations and in-depth interviews were conducted to obtain complementary information, thereby strengthening data interpretation and providing a more comprehensive understanding of field conditions.

Data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS software. SEM-PLS was selected because it is appropriate for analyzing complex relationships among latent variables and does not require strict assumptions regarding data normality or large sample sizes. The analytical procedures included outer model evaluation, inner model evaluation, and hypothesis testing.

The outer model evaluation was conducted to assess the validity and reliability of the measurement model using convergent validity, discriminant validity, Average Variance Extracted (AVE), composite reliability, and Cronbach's alpha. Indicators with loading factors greater than 0.70 were considered valid, while composite reliability and Cronbach's alpha values exceeding 0.70 indicated satisfactory construct reliability.

The inner model evaluation examined the structural relationships among latent variables using the coefficient of determination (R^2) and path coefficients. The R^2 value indicates the explanatory power of the exogenous variables on the endogenous variable, whereas the path coefficients describe the direction and magnitude of the relationships among variables. Hypothesis testing was performed using the bootstrapping procedure with a significance level of 5% and a critical t-value of 1.96.

This methodological approach enabled a comprehensive analysis of the direct relationships among farmer characteristics, farmer behavior, the role of agricultural extension workers, and the adoption of the recommended shallot cultivation practices. By integrating quantitative and qualitative evidence, the study provides a more comprehensive explanation of the determinants influencing farmers' adoption of recommended shallot cultivation practices in Monta District, Bima Regency.

Results And Discussion

1. Farmer Characteristics (X_1)

Overall, the descriptive analysis indicates that respondents perceived farmer characteristics as important determinants of the adoption of the recommended shallot cultivation practices. All four indicators—farmers' age, education level, farming experience, and number of family dependents—were predominantly rated 4 (agree), with the highest proportions reaching 43.5%, 42.4%, 48.9%, and 45.7%, respectively. These findings suggest that most respondents recognized individual farmer characteristics as key factors influencing the successful adoption of the recommended cultivation practices. Among the four indicators, farming experience received the highest level of agreement (48.9%), indicating that practical experience plays the most influential role in supporting the adoption of recommended cultivation practices. Farmers with extensive farming experience are more capable of making informed production decisions, addressing technical challenges, and adapting recommended technologies to local farming conditions. Meanwhile, farmers' age and education level were also perceived as important factors because they contribute to farmers' physical readiness, knowledge acquisition, and capacity to understand and implement agricultural innovations. Furthermore, the number of family dependents was considered a motivating factor that encourages farmers to adopt improved cultivation practices in order to increase farm productivity and household income.

2. Farmer Behavior (X_2)

Overall, the descriptive analysis indicates that farmer behavior was generally at a favorable level in supporting the adoption of the recommended shallot cultivation practices. This is reflected in the predominance of respondents in the

high/supportive/skilled categories across all behavioral indicators, namely knowledge (42.0%), attitude (43.0%), skills (46.74%), and practices (41.3%). Among these indicators, farmers' skills recorded the highest proportion, suggesting that most respondents possess adequate technical capability to implement the recommended shallot cultivation practices. Nevertheless, a proportion of farmers remained in the low categories across the four indicators, indicating the need for continuous improvement in farmers' knowledge, attitudes, skills, and farming practices through agricultural extension services, technical training, and field assistance. These findings suggest that farmer behavior constitutes an important internal factor influencing the successful adoption of the recommended shallot cultivation practices in Monta District.

3. Role of Agricultural Extension Workers (X_3)

The descriptive analysis indicates that the role of agricultural extension workers was generally perceived as favorable in supporting the adoption of the recommended shallot cultivation practices. This is reflected by the predominance of respondents selecting the agree (score 4) category across all indicators, including educator (39.1%), mediator (43.5%), motivator (45.7%), facilitator (42.4%), and evaluator (44.6%). These findings suggest that most farmers perceived extension workers as effectively performing their responsibilities by providing technical knowledge and training, facilitating communication and collaboration with relevant stakeholders, motivating farmers to adopt innovations, improving access to agricultural inputs and financial institutions, and conducting regular monitoring and evaluation of farming activities. Among the five indicators, the motivator role received the highest positive rating, indicating that extension workers play a crucial role in encouraging farmers to innovate, improve their farming practices, and enhance farm performance. Nevertheless, a proportion of respondents still provided low ratings across all indicators, suggesting that further improvements in extension workers' capacity, the intensity of field assistance, and the quality of extension services are needed. Overall, these findings demonstrate that the role of agricultural extension workers is a key external factor supporting the successful adoption of the recommended shallot cultivation practices in Monta District.

4. Adoption of the Recommended Shallot Cultivation Practices (Y)

The descriptive analysis indicates that the adoption of the recommended shallot cultivation practices was generally at a favorable level among farmers in Monta District. This is reflected by the predominance of respondents selecting the agree (score 4) category across all indicators, including the adoption of all recommended cultivation components (42.4%), increased crop yield (43.5%), ease of implementing the recommended practices (42.4%), and improved shallot quality following adoption (39.1%). These findings suggest that most farmers have implemented the recommended cultivation package and perceived tangible benefits, particularly in terms of increased productivity and improved crop quality. Among the four indicators, the perception that the recommended cultivation practices increase crop yield received the highest positive response, indicating that yield improvement is the primary benefit perceived by farmers after adopting the recommended practices. Nevertheless, a proportion of respondents still reported low levels of agreement regarding the implementation of all cultivation components and the ease of adoption. This finding suggests that

some farmers continue to face constraints in fully adopting the recommended practices, which may be attributed to limited knowledge, technical skills, financial resources, or access to agricultural inputs. Overall, these results demonstrate that the adoption of the recommended shallot cultivation practices in Monta District is relatively high. However, further efforts are required to enhance farmers' adoption through continuous agricultural extension services, technical training, field assistance, and improved access to production.

Structural Equation Modeling (SEM-PLS) Analysis

The quantitative relationships between the variables were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) processed via SmartPLS software

Evaluation of the Outer Measurement Model

Before testing the hypotheses, the measurement model was checked to ensure it met standard validity and reliability criteria:

1. Convergent Validity

The results of the convergent validity assessment indicate that all indicators measuring the constructs of Farmer Characteristics, Farmer Behavior, Role of Agricultural Extension Workers, and Adoption of the Recommended Shallot Cultivation Practices achieved outer loading values above the recommended threshold of 0.70, ranging from 0.706 to 0.857. These findings demonstrate that each indicator adequately represents its respective latent construct and satisfies the criterion for convergent validity. Therefore, all measurement indicators were considered valid and appropriate for subsequent SEM-PLS analysis. The results confirm that the measurement instrument possesses satisfactory convergent validity, indicating that the indicators reliably measure their intended constructs and provide a sound basis for structural model evaluation and hypothesis testing.

2. Discriminant Validity

The discriminant validity assessment demonstrated that all measurement indicators exhibited the highest cross-loading values on their respective latent constructs compared with other constructs. In addition, all cross-loading values met the recommended criterion, indicating that each indicator was more strongly associated with its intended construct than with other variables in the model. These findings confirm that the constructs are empirically distinct and adequately represent different conceptual dimensions. Overall, the results indicate that the measurement model possesses good discriminant validity, confirming that all constructs are sufficiently differentiated from one another. Therefore, the measurement instrument is considered appropriate for further structural model evaluation and hypothesis testing using the SEM-PLS approach.

3. Reliability Analysis

The reliability assessment demonstrated that all research constructs achieved Cronbach's Alpha and Composite Reliability values above the recommended threshold of 0.70. Cronbach's Alpha values ranged from 0.741 to 0.850, while Composite Reliability values ranged from 0.837 to 0.889. These results indicate that all constructs, namely Farmer Characteristics, Farmer Behavior, Role of Agricultural Extension Workers, and Adoption of the Recommended Shallot

Cultivation Practices, satisfied the required reliability criteria. Among the constructs, the Role of Agricultural Extension Workers exhibited the highest level of reliability, with a Cronbach's Alpha of 0.850 and a Composite Reliability of 0.889, indicating excellent internal consistency. Overall, the findings confirm that the measurement instrument possesses high internal consistency, demonstrating that all indicators consistently and reliably measure their respective latent constructs. Therefore, the measurement model is considered reliable and appropriate for subsequent structural model evaluation and hypothesis testing using the SEM-PLS approach.

Evaluation of the Inner Structural Model and Hypothesis Testing

The structural path model measured the predictive power of the independent variables using the Coefficient of Determination (R-Square), Effect Size f^2 (f-square) and path coefficients tested via bootstrapping

1. Coefficient Of Determination (R-Square)

The coefficient of determination (R-Square) analysis showed that the Adoption of the Recommended Shallot Cultivation Practices construct achieved an R-Square value of 0.585 and an Adjusted R-Square value of 0.571. These results indicate that 57.1% of the variance in the adoption of the recommended shallot cultivation practices can be jointly explained by Farmer Characteristics, Farmer Behavior, and the Role of Agricultural Extension Workers, while the remaining 42.9% is attributable to other factors not included in the research model. The Adjusted R-Square value of 0.571 falls within the moderate category, indicating that the three exogenous variables possess a satisfactory explanatory capability in predicting the adoption of the recommended shallot cultivation practices. Overall, the structural model demonstrates an adequate level of predictive accuracy, suggesting that Farmer Characteristics, Farmer Behavior, and the Role of Agricultural Extension Workers collectively exert a moderate influence on the adoption of the recommended shallot cultivation practices in Monta District.

2. Effect Size f^2 (f-square)

The effect size (f^2) analysis revealed that the exogenous variables contributed differently to the Adoption of the Recommended Shallot Cultivation Practices. Farmer Characteristics recorded an f^2 value of 0.123, while Farmer Behavior obtained an f^2 value of 0.083, indicating that both variables exerted small to moderate effects on the adoption of the recommended shallot cultivation practices. In contrast, the Role of Agricultural Extension Workers achieved an f^2 value of 0.281, representing a moderate effect and the largest contribution among the three exogenous variables. Overall, the effect size results demonstrate that the Role of Agricultural Extension Workers contributes the most to the adoption of the recommended shallot cultivation practices, whereas Farmer Characteristics and Farmer Behavior make comparatively smaller contributions. These findings suggest that the successful adoption of the recommended shallot cultivation practices is influenced more strongly by the effectiveness of extension workers in providing technical guidance, field assistance, motivation, and facilitation to farmers.

3. Path Coefficients

No	Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistic (O/STDEV)	P Value
1.	Karakteristik Petani -> Penerapan Paket Budidaya Bawang Merah	0,286	0,295	0,124	2,31	0,021
2.	Perilaku Petani -> Penerapan Paket Budidaya Bawang Merah	0,237	0,242	0,115	2,059	0,040
3.	Peran Penyuluh Lapangan -> Penerapan Paket Budidaya Bawang Merah	0,407	0,401	0,101	4,045	0,000

Based on the bootstrapping results used to test the research hypotheses, the findings indicate that H_0 was rejected and H_1 was accepted, confirming that all three hypothesized relationships among the study variables were positive and statistically significant. The hypothesis testing results are summarized as follows:

1. The relationship between Farmer Characteristics and the Adoption of the Recommended Shallot Cultivation Practices was found to be positive and statistically significant, with a t-statistic of 2.310 (> 1.96), a p-value of 0.021, and a path coefficient (β) of 0.286. These results indicate that farmer characteristics have a significant positive effect on the adoption of the recommended shallot cultivation practices in Monta District.
2. The relationship between Farmer Behavior and the Adoption of the Recommended Shallot Cultivation Practices was also positive and statistically significant, with a t-statistic of 2.059 (> 1.96), a p-value of 0.040, and a path coefficient (β) of 0.237. This finding demonstrates that farmer behavior significantly influences the adoption of the recommended shallot cultivation practices in Monta District.
3. The relationship between the Role of Agricultural Extension Workers and the Adoption of the Recommended Shallot Cultivation Practices exhibited the strongest positive and statistically significant effect, with a t-statistic of 4.045 (> 1.96), a p-value of < 0.001 , and a path coefficient (β) of 0.407. These findings indicate that the role of agricultural extension workers is the most influential factor in promoting the adoption of the recommended shallot cultivation practices among farmers in Monta District.

Conclusion

Based on the results of the data analysis using Structural Equation Modeling-Partial Least Squares (SEM-PLS) and the discussion of the factors influencing the Adoption of the Recommended Shallot Cultivation Practices in Monta District, Bima Regency, the following conclusions can be drawn:

1. Farmer Characteristics (X_1) have a positive and statistically significant effect on the Adoption of the Recommended Shallot Cultivation Practices (Y). This finding indicates that farmers' internal attributes, including age, educational attainment, farming experience, and household dependency, play an important role in promoting the adoption of the recommended cultivation practices.
2. Farmer Behavior (X_2) also has a positive and statistically significant effect on the Adoption of the Recommended Shallot Cultivation Practices (Y). Higher levels of farmers' knowledge, attitudes, skills, and farming practices encourage the implementation of recommended cultivation technologies, thereby improving the effectiveness of shallot farming.
3. The Role of Agricultural Extension Workers (X_3) has a positive and statistically significant effect on the Adoption of the Recommended Shallot Cultivation Practices (Y) and represents the most influential variable in the structural model. This finding suggests that the successful adoption of the recommended cultivation practices largely depends on the effectiveness of extension workers in performing their roles as educators, mediators, motivators, facilitators, and evaluators.
4. Collectively, Farmer Characteristics, Farmer Behavior, and the Role of Agricultural Extension Workers explain 57.1% of the variance in the Adoption of the Recommended Shallot Cultivation Practices, while the remaining 42.9% is explained by other factors not included in the research model. These findings indicate that the proposed structural model has a moderate explanatory power in explaining the factors influencing the adoption of the recommended shallot cultivation practices in Monta District.

Recommendations

1. For Farmers: Farmers are encouraged to consistently adopt the recommended shallot cultivation practices and continuously improve their knowledge, skills, and farming practices by actively participating in extension programs and technical training to enhance productivity and farm sustainability.
2. For Agricultural Extension Workers: Extension workers should strengthen their roles as educators, facilitators, motivators, mediators, and evaluators by providing more intensive, participatory, and need-based extension services to accelerate farmers' adoption of the recommended cultivation practices.
3. For the Government: The government should support the adoption of recommended shallot cultivation practices by improving the quality and capacity of agricultural extension services, facilitating farmers' access to quality production inputs, and implementing policies that encourage the dissemination of agricultural innovations at the farmer level.
4. For Future Researchers: Future studies are recommended to incorporate additional variables, such as farmers' motivation, access to information, institutional support, innovation attributes, and farm income, to develop a more comprehensive model explaining the adoption of recommended shallot cultivation practices.

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