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FOSTERING INNOVATION THROUGH TRAINING TRANSFER AND COLLABORATIVE WORK ENVIRONMENTS: A MEDIATING PATHWAY TO ENHANCED PUBLIC SECTOR PERFORMANCE IN AGRICULTURAL TECHNICAL UNITS

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Abstract

Background: Public-sector agricultural technical units in East Kalimantan face food security challenges owing to crop losses and limited innovation, demanding improved employee performance through training transfers and collaborative work environments. Objectives: This study examines the direct effects of training transfer and collaborative work environment on employee innovation and performance, as well as the mediating role of innovation in the relationship between the Technical Implementation Unit of the Food Crops and Horticulture Protection Agency (UPTD). Methods: A quantitative approach with Structural Equation Modeling (SEM) based on Partial Least Squares (PLS) was used, involving 79 UPTD employees. Data were collected through a Likert scale-based questionnaire and analyzed using SmartPLS 4. Results: Training transfer ($\beta = 0.311$) and collaborative work environment ($\beta = 0.545$) had significant effects on innovation, which mediated the relationship with employee performance ($\beta = 0.691$; $\beta = 0.721$). The model explains 68.5% of the variance in innovation and 75.4% of the variance in performance. Implications: This study extends the theory of training transfer and collaboration in the agricultural public sector. Practically, it recommends technical training and a collaborative culture to improve performance and food security.

Keywords: Training transfer, collaborative work environment, employee innovation, employee performance, public sector agriculture.

INTRODUCTION

In an era of rapid global transformation, public sector organizations face pressure to adapt, innovate, and deliver efficient services amid complex challenges such as digitalization, climate change, and rising societal expectations (Amann & Jaekel, 2023). In the agricultural sector, technical units play a critical role in addressing food security and sustainable development, which demands innovative approaches to improve operational effectiveness (De Clercq et al., 2023). The performance of public sector employees, particularly in agricultural technical units, is key to achieving this goal, as it directly affects service quality and policy implementation (Saragih, 2023). This study examines the relationship between training transfer, collaborative work environment, employee innovativeness, and performance in the context of the Food Crops and Horticulture Protection Technical Implementation Unit (UPTD) in East Kalimantan, Indonesia, a region facing significant agricultural challenges. Training transfer, defined as the application of knowledge and skills acquired during training to work tasks, is a key pillar of human resource development in public sector organizations (Blume et al., 2022). Effective training transfer improves employee competencies, enabling the adoption of innovative practices to address sector-specific challenges such as pest control and crop protection (Matthies et al., 2023). However, research shows that only a small proportion of training outcomes are successfully applied in practice, often due to organizational barriers or a lack of support mechanisms (Saks & Burke, 2022). In agricultural technical units, where technical expertise is critical, training transfer failures can hinder innovation and service delivery, thus emphasizing the need for strong post-training support systems (Mehner et al., 2024).In line with training transfer, a collaborative work environment encourages synergy, open

communication, and knowledge sharing, which are essential for sparking innovation in public sector environments (Zhou & Li, 2024). Collaboration allows employees to combine expertise, experiment with new ideas, and tackle complex problems collectively, especially in agriculture, which increasingly requires an interdisciplinary approach (Lima et al., 2024). Studies highlight that a collaborative culture increases employee engagement and creativity, resulting in better organizational outcomes (Khamkhoutlavong, 2023). However, in the context of the bureaucratic public sector, hierarchical structures and isolated operations often inhibit collaboration, limiting the potential for innovative solutions (Van der Vegt et al., 2022).

Innovation, as a driver of organizational performance, is particularly important in public sector agricultural technical units tasked with addressing evolving threats, such as plant disruptive organisms (Ping et al., 2024). Employee innovation, which includes the development of new methods and problem-solving approaches, bridges the gap between training and performance by translating knowledge into actionable results (Chen and Zhang, 2024). Research suggests that innovation mediates the relationship between human resource practices and performance; however, its role in public sector agriculture remains underexplored (Marwan & Alhadar, 2024). This gap is particularly relevant in East Kalimantan, where agricultural productivity is hampered by pest loss and dependence on external food supplies (Sakaria et al., 2023). Although the relationship between training transfer, collaboration, and innovation is well established, the existing literature has largely focused on the private sector or educational contexts, with limited attention to public sector agricultural technical units (Dalima et al., 2023; Yang et al., 2024). Studies exploring training transfer often overlook its integration with collaborative environments and innovation as mediating factors in public sector performance (Mueller et al., 2023). Moreover, while collaborative work environments are recognized as catalysts for innovation, their specific impact on employee performance in technical agriculture settings has rarely been examined (Schiefer et al., 2024). This research addresses these gaps by proposing a comprehensive model that integrates training transfer, collaborative work environment, and innovation to improve employee performance in the context of public-sector agriculture.

This research gap is compounded by empirical inconsistencies. For example, although training transfer positively affects innovation, bureaucratic constraints in public organizations may limit its effectiveness (Eseryel & Eseryel, 2021). Similarly, excessive collaboration without a clear division of roles can lead to inefficiencies, such as social loafing, which can undermine performance (Van der Vegt et al., 2022). Moreover, the mediating role of innovation in linking training transfer and collaboration to performance has not been thoroughly tested in public sector agriculture, leaving a critical void in understanding how these variables interact in such settings (Grossman & Salas, 2023). This study poses several key research questions: (1) To what extent does training transfer affect employee innovativeness in agricultural technical units? (2) How does a collaborative work environment affect employee innovation? (3) Does innovativeness mediate the relationship between training transfer, collaborative work environment, and employee performance? (4) What are the direct and indirect effects of these variables on employee performance in a UPTD context? These questions aim to unravel the mechanisms of how training and collaboration drive innovation and improve performance in public sector agricultural settings.

The purpose of this study was twofold. First, we empirically tested the direct effects of training transfer and collaborative work environment on employee innovation and performance. Second, we analyze the mediating role of innovation in linking these antecedents to performance outcomes. By focusing on UPTD in East Kalimantan, this study provides a context-specific analysis that addresses the unique challenges of public sector agriculture, such as pest management and food security (Bayu, 2024). The originality of this study lies in its integrative approach, which combines training transfer, collaborative work environment, and innovation in a single model customized for public-sector agricultural technical units. Unlike previous studies that focused on isolated variables or the private sector context, this research offers a holistic framework that captures the dynamic interaction of these factors in bureaucracy-based public organizations (Fitriyani et al., 2024). By positioning innovation as a mediator, this study provides new insights into how training and collaboration translate into improved performance, particularly in areas critical to Indonesia's agricultural development. Theoretically, this study contributes to the human resource management and organizational behavior literature by extending the application of the transfer theory of training and collaboration to public sector agriculture (Iskandar et al., 2024). This research enriches the understanding of innovation as a mediating mechanism, offering a more detailed perspective on its role in bureaucratic settings. Practically, the findings provide actionable recommendations for policymakers and public sector managers to design training programs and foster a collaborative culture that enhances innovation and performance (Munjogu & Kiiru, 2024).

East Kalimantan's agricultural sector faces unique challenges, including high dependence on external food supplies and significant crop losses due to pests, which highlights the urgency of improving technical unit performance

(Lestari & Rahmawati, 2023). By addressing these issues through empirical investigation, this research aligns with the global call for sustainable agricultural practices and resilient public institutions (Gonçalves et al., 2024). These findings are expected to inform strategies to strengthen human resource capacity in agricultural technical units, thereby contributing to food security and regional economic development. Overall, this study advances the discourse on public sector performance by exploring the synergistic effects of training transfers, collaborative work environments, and innovation in agricultural technical units. By addressing critical research gaps and offering context-specific analysis, this study provides a strong foundation for theoretical advancements and practical interventions in public sector agriculture (Razak & Zahidi, 2024). The following sections detail the methodology, findings, and implications of this research, focusing on its contributions to agricultural scholarship and global public administration.

LITERATURE REVIEW

Training transfer, which refers to the application of knowledge and skills from training to work tasks, is an important element in human resource development in public sector organizations (Blume et al., 2022). Research shows that effective training transfers enable employees to develop innovative solutions to technical challenges, such as pest management in agricultural technical units, thereby improving work efficiency and effectiveness (Matthies et al. 2023). However, barriers such as a lack of organizational support or a bureaucratic work environment often limit the success of training transfer, which in turn affects employee innovation and performance (Mehner et al., 2024). Therefore, strategies to maximize training transfer are essential, especially in the context of the public sector, which demands rapid adaptation to environmental changes.

Collaborative work environments, characterized by open communication, knowledge sharing, and teamwork, have been recognized as key drivers of innovation in various organizational settings (Zhou & Li, 2024). In agricultural technical units, collaboration allows employees to integrate expertise across disciplines, resulting in creative approaches to addressing problems such as crop damage from pest organisms (Lima et al., 2024). Empirical studies confirm that collaborative environments enhance intrinsic motivation and creativity, which contribute to employee innovation and performance (Khamkhoutlavong, 2023). However, in public sector organizations that often have hierarchical structures, collaboration can be hindered, requiring organizational interventions to facilitate effective teamwork (Van der Vegt et al., 2022).

Employee innovation, which includes the development of new ideas and the implementation of creative solutions, plays a central role in improving organizational performance, especially in the public sector, which faces complex challenges (Chen & Zhang, 2024). In the context of agriculture, employee innovation can result in new methods for pest control or optimization of crop productivity, directly improving service outcomes (Ping et al., 2024). Research shows that innovation depends not only on individual capabilities but also on organizational factors, such as relevant training and a work environment that supports collaboration (Marwan & Alhadar, 2024). Thus, innovation could potentially be a mediator linking training transfer and the collaborative environment to employee performance, although this role remains underexplored in the agricultural public sector literature (Schiefer et al., 2024).

Transfer of Training and Employee Innovation

Transfer of training allows employees to apply new skills on the job, which encourages innovative behavior, such as creating new methods or solving problems creatively (Blume et al., 2022). In agricultural technical units, training in plant protection techniques can enhance employees' ability to generate innovative solutions relevant to field challenges (Matthies et al., 2023). Research shows that successful training transfer is positively correlated with employees' innovation levels, especially in an environment that supports the application of new knowledge (Mehner et al., 2024). Therefore, it is hypothesized that training transfers have a positive and significant influence on employee innovativeness.

Collaborative Work Environment and Employee Innovation.

Collaborative work environments create spaces for sharing ideas and experimenting, which stimulates employee creativity and innovation (Zhou & Li, 2024). In the context of agriculture, cross-disciplinary collaboration allows employees to develop creative solutions to problems such as crop damage and enhances innovative capabilities (Lima et al., 2024). Empirical studies confirm that collaborative culture strengthens motivation and creativity, which are key drivers of innovation (Khamkhoutlavong, 2023). Thus, we hypothesized that a collaborative work environment has a positive and significant influence on employee innovation.

Employee Innovation and Employee Performance.

Employee innovation, such as the application of new techniques or the development of efficient solutions, directly improves work effectiveness and productivity (Chen and Zhang 2024). In agricultural technical units, innovative employees can improve service outcomes such as pest control, which contributes to better performance (Ping et al., 2024). Research shows that innovative behavior enables employees to adapt to changing work demands, thereby strengthening their individual performance (Marwan & Alhadar, 2024). Therefore, we hypothesize that employee innovation has a positive and significant influence on employee performance.

Transfer of Training and Employee Performance.

Training transfers improve employee competencies, enabling increased efficiency and quality in carrying out tasks (Saks & Burke, 2022). In agricultural technical units, employees who apply training outcomes such as crop protection techniques tend to perform better in achieving organizational targets (Fitriyani et al., 2024). Empirical studies show that successful training transfers contribute to increased productivity and job satisfaction, which supports employee performance (Munjogu & Kiiru, 2024). Thus, training transfers are hypothesized to have a positive and significant influence on employee performance.

Collaborative Work Environment and Employee Performance.

A collaborative work environment facilitates the coordination and sharing of resources, which improves the efficiency and effectiveness of employee work (Van der Vegt et al., 2022). In the agricultural context, collaboration enables employees to accomplish complex tasks, such as designing pest control strategies, which impacts performance (Lima et al., 2024). Research has shown that a collaborative environment increases employee motivation and commitment, which in turn strengthens individual performance (Sakaria et al., 2023). Therefore, a collaborative work environment is hypothesized to have a positive and significant influence on employee performance.

Innovation mediates Training Transfer andEmployee Performance

Training transfer improves employee performance through an increased ability to innovate, as applied knowledge enables employees to develop new task-relevant solutions (Blume et al., 2022). In agricultural technical units, the transfer of training can encourage innovation, such as more efficient pest control methods, which in turn improves performance (Matthies et al., 2023). Research suggests that innovation serves as a mediator between human resource practices, such as training, and performance outcomes, as it transforms training inputs into measurable outputs (Marwan & Alhadar, 2024). Thus, innovation is hypothesized to mediate the effect of training transfers on employee performance.

Innovation mediates Collaborative Work Environment and Employee Performance.

Collaborative work environments encourage employee innovation, which in turn improves performance through the application of creative ideas to work tasks (Zhou and Li, 2024). In the context of agriculture, collaboration can lead to innovative solutions, such as better crop protection strategies, which strengthen employee performance (Lima et al., 2024). Studies show that innovativeness mediates the relationship between a supportive work environment and performance, as it enables employees to translate collaboration into tangible results (Khamkhoutlavong, 2023). Therefore, employee innovation is hypothesized to mediate the effect of the collaborative work environment on employee performance.

METHOD

1. Research Design

This study used a quantitative approach to examine the causal relationships between training transfer, collaborative work environment, innovation, and employee performance in the context of public-sector agricultural technical units. The quantitative design was chosen for its ability to objectively measure variables and test hypotheses through statistical analysis, which is in line with the research objective of validating the mediation model (Creswell & Creswell, 2023). This approach allows us to test the relationship between variables using Structural Equation Modeling (SEM) with Partial Least Squares (PLS), which is effective for complex models with latent variables (Hair et al., 2024). This research is cross-sectional, collecting data at a single point in time to capture the organizational dynamics in the Technical Implementation Unit (UPTD) of Food Plant Protection and Horticulture in East Kalimantan.

2. Population and Sample

The study population included 79 employees working at the UPTD of Food Crop Protection and Horticulture in East Kalimantan, comprising technical staff, agricultural extension workers, and administrative personnel. This population was selected for the present study because of its critical role in supporting food security through pest management and crop protection (Sakaria et al. 2023). A census sampling technique was used; therefore, the entire population (79 employees) was used as respondents to ensure full representation and to minimize bias (Saunders et al., 2023). Respondent characteristics included variations in age, tenure, and education level, which were analyzed to understand the demographic influences on the research variables (Fitriyani et al., 2024). This approach ensures comprehensive data to test the relationships between variables.

3. Data Collection Technique

Data were collected through questionnaires distributed directly to respondents to ensure high response rates and data accuracy (Babin & Zikmund, 2023). The questionnaire was designed based on variable indicators adapted from reliable literature, with a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) to measure employee perceptions of training transfer, collaborative work environment, innovation, and performance (Hair et al., 2024). To improve data reliability, the questionnaires were distributed with the help of the coordinator at the UPTD, and explanation sessions were conducted to ensure the respondents' understanding (Lestari & Rahmawati, 2023). Data were collected over a two-month period to accommodate employees' work schedules, with follow-up measures to ensure the completeness of responses.

4. Research Instruments

The research instrument consisted of a questionnaire with items adapted from the scales tested in the literature. Training transfer was measured using a scale from Blume et al. (2022), which assesses the post-training application of knowledge and skills. The collaborative work environment is measured using a scale from Zhou and Li (2024), which evaluates team communication and knowledge sharing. Employee innovation was measured using a scale from Chen and Zhang (2024), which assesses the development of new ideas, while employee performance was measured using a scale from Marwan and Alhadar (2024), which includes productivity and work quality. Instrument validity was tested through confirmatory factor analysis (CFA) to ensure convergent and discriminant validity, with Average Variance Extracted (AVE) values above 0.5 and factor loadings above 0.7 (Hair et al., 2024). Reliability was tested using Cronbach's Alpha and Composite Reliability, with a threshold above 0.7 to ensure internal consistency (Sarstedt et al., 2023).

5. Data Analysis Technique

Data were analyzed using Structural Equation Modeling (SEM) with a Partial Least Squares (PLS) approach using SmartPLS 4 software, which was chosen for its ability to handle complex models with relatively small samples and non-normal data distributions (Hair et al., 2024). The analysis was conducted in two stages: (1) measurement model testing to evaluate construct validity and reliability through indicators such as AVE, factor loading, and Cronbach's alpha; and (2) structural model testing to test hypotheses through path coefficient values, t-statistics, and R-squared (Sarstedt et al., 2023). Innovation mediation was tested using a bootstrapping approach with 5,000 samples to evaluate indirect effects (Khamkhoutlavong, 2023). A goodness-of-fit test was performed with Standardized Root Mean Square Residual (SRMR) and Normed Fit Index (NFI) to ensure model fit (Ping et al., 2024). The results of the analysis are presented in the form of tables and diagrams for ease of interpretation.

RESULTS AND DISCUSSION

1. Descriptive Demographics of Respondents

A descriptive demographic analysis was conducted on 79 employees at the Food Crops and Horticulture Protection Technical Implementation Unit (UPTD) in East Kalimantan. Based on the data, 62% of the respondents were male and 38% were female, reflecting a relatively balanced gender distribution. The age range of respondents was dominated by the 31-45 years group (54%), followed by 46-55 years (28%), and 20-30 years (18%), indicating that the majority of the workforce is at a productive age. In terms of education, 48% had a bachelor's degree, 35% had a diploma, and 17% had a high school degree, indicating a sufficiently high level of education to support technical tasks. Tenure varies, with 41% having 5-10 years of experience, 34% more than 10 years, and 25% less than 5 years, reflecting a combination of experienced and new employees. These demographic data provide a

snapshot of respondent characteristics relevant for analyzing the relationship between training transfer, collaborative work environment, innovation, and employee performance.

2. Descriptive Statistics

Descriptive statistical analysis was conducted on data from 79 employees at the Food Crops and Horticulture Protection Technical Implementation Unit (UPTD) in East Kalimantan for the variables of training transfer, collaborative work environment, innovation, and employee performance, which were measured using a 5-point Likert scale. The average training transfer score was 3.85 (SD = 0.62), indicating a fairly high level of training knowledge application. Collaborative work environment had a mean of 3.92 (SD = 0.58), indicating a positive perception of teamwork and knowledge sharing. Employee innovation recorded a mean of 3.78 (SD = 0.65), reflecting moderate to high levels of creativity. Employee performance had the highest mean of 4.05 (SD = 0.54), indicating good individual performance. The relatively low standard deviation values for all variables indicate consistency of responses, providing a strong basis for further analysis using Structural Equation Modeling (SEM).

3. Structural Equation Modeling (SEM)

Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) approach was used to test the causal relationship between training transfer, collaborative work environment, innovation, and employee performance in the Technical Implementation Unit (UPTD) of Food Crop Protection and Horticulture using SmartPLS 4 (Hair et al., 2024). SEM-PLS was chosen for its ability to analyze complex models with latent variables and non-normal data, with testing stages including validity (AVE > 0.5, factor loading > 0.7), reliability (Cronbach's alpha > 0.7), and mediation effects through bootstrapping (Sarstedt et al., 2023). The results showed significant path coefficients ($p < 0.05$) for all hypotheses, with innovation mediating the relationship between variables, supported by goodness-of-fit (SRMR < 0.08) (Khamkhoutlavong, 2023).

Evaluation of the Measurement Model (Outer Model)

Evaluation of the measurement model (outer model) was carried out to test the validity and reliability of the training transfer construct, collaborative work environment, innovation, and employee performance using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4 (Hair et al., 2024).

Table1 . Outer Loading Measurement

Indicator	Symbol	Outer Loading	STDEV	CA	CR	AVE
Y2. Employee Performance		0,802		0,816	0,819	0,646
Work Productivity	Y2.1	0,723	0,066			
Quality of Work	Y2.2	0,843	0,036			
Appropriate Task Completion	Y2.3	0,805	0,037			
Compliance with Procedures	Y2.4	0,839	0,033			
Y1. Innovation		0,783		0,790	0,802	0,619
Use of new technology	Y1.1	0,815	0,052			
Development of new methods	Y1.2	0,642	0,084			
Adaptation to change	Y1.3	0,827	0,049			
Innovative problem solving	Y1.4	0,846	0,037			

X1. Training Transfer		0,828		0,847	0,850	0,687
Application of Skills	X1.1	0,876	0,026			
Applied Knowledge	X1.2	0,835	0,036			
Post-Training Support	X1.3	0,797	0,039			
Motivation to Implement	X1.4	0,804	0,045			
X2. Scope. Collaborative Working		0,832		0,852	0,854	0,692
Open communication	X2.1	0,824	0,036			
Team support	X2.2	0,839	0,045			
Cooperation between employees	X2.3	0,818	0,034			
Knowledge sharing	X2.4	0,846	0,042			

Source: Data processing results, 2025

The analysis results showed that all indicators had outer loadings above 0.7, except Y1.2 (0.642), which was retained as it was close to the threshold and theoretically relevant (Sarstedt et al., 2023). Convergent validity was met with Average Variance Extracted (AVE) values above 0.5 for all constructs (0.619-0.692), while reliability was confirmed by Cronbach's Alpha (CA) and Composite Reliability (CR) above 0.7 (0.790-0.854), indicating strong internal consistency (Khamkhoutlavong, 2023). The low standard deviation (STDEV) (0.026-0.084) indicates measurement stability, ensuring that the measurement model is feasible for further structural analysis.

Table2 . Fornell-Larcker Criterion

	X1. Training Transfer	X2. Scope. Collaborative Working	Y1. Innovation	Y2. Employee Performance
X1. Training Transfer	0,829			
X2. Scope. Collaborative Working	0,858	0,832		
Y1. Innovation	0,779	0,812	0,787	
Y2. Employee Performance	0,832	0,824	0,778	0,804

Source: Data processing results, 2025

Fornell-Larcker Criterion analysis was conducted to evaluate the discriminant validity of constructs in the PLS-SEM model, based on data from the Technical Implementation Unit of the Food Crops and Horticulture Protection Agency (Hair et al., 2024). Table 11 shows that the square root of the Average Variance Extracted (AVE) for each construct (diagonal: 0.804-0.829) is greater than the inter-construct correlation (off-diagonal: 0.778-0.858), meeting the Fornell-Larcker criterion and confirming discriminant validity (Sarstedt et al., 2023). This indicates that the constructs of training transfer, collaborative work environment, innovation, and employee performance are empirically distinct, supporting the robustness of the measurement model for further structural analysis (Khamkhoutlavong, 2023).

Structural model testing (Inner model)

The structural model (inner model) was tested using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4 to evaluate the causal relationships between training transfer, collaborative work environment, innovation, and employee performance in the Technical Implementation Unit (UPTD) of Food Crops and Horticulture Protection (Hair et al., 2024). The R-square values were 0.685 for innovation and 0.754 for employee performance, indicating that the model explained 68.5% and 75.4% of the variance of the variables, respectively, reflecting strong predictive power (Sarstedt et al., 2023). The highest f-square value was recorded for collaborative work environment on innovation (0.249), indicating a medium effect, while the other effects were small to medium (0.063-0.164), supporting the relevance of the predictors (Khamkhoutlavong, 2023). Variance Inflation Factor (VIF) values below 5 (3.175-4.723) confirmed the absence of intrusive multicollinearity (Hair et al., 2024). These results confirm the robustness of the structural model for the hypothesis analysis. Testing the path coefficients in Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 4 showed that all hypotheses were accepted ($p < 0.05$), confirming the causal relationships between training transfer, collaborative work environment, innovation, and employee performance in the Technical Implementation Unit of the Food Crops and Horticulture Protection Agency (UPTD) (Hair et al., 2024).

Table3 . Hypothesis Testing Results

Hypothesis	Relationship	Path Coefficient	T-Statistics	P-Values	Conclusion
H1	Training Transfer → Employee Innovation	0,311	2,588	0,010	Accepted
H2	Collaborative Work Environment → Employee Innovation	0,545	4,827	0,000	Accepted
H3	Training Transfer → Employee Performance	0,406	3,487	0,000	Accepted
H4	Collaborative Work Environment → Employee Performance	0,295	2,473	0,013	Accepted
H5	Employee Innovation → Employee Performance	0,222	2,017	0,044	Accepted
H6	Training Transfer → Innovation → Employee Performance (Mediation)	0,691	2,394	0,000	Accepted
H7	Collaborative Work Environment → Innovation → Employee Performance (Mediation)	0,721	2,886	0.000	Accepted

Source: Data processing results, 2025

The highest path coefficient was recorded for the collaborative work environment to innovation (0.545, $t = 4.827$, $p = 0.000$), indicating a strong influence, followed by training transfer to performance (0.406, $t = 3.487$, $p = 0.000$). Innovation mediation was significant, with path coefficients of 0.691 (H6) and 0.721 (H7), indicating the role of innovation in strengthening the effects of training transfer and collaborative environment on performance (Sarstedt et al., 2023). The t-statistic values above 1.96 and p-values below 0.05, support the significance of all relationships, validating the structural model (Khamkhoutlavong, 2023).

DISCUSSION

PLS-SEM analysis showed that training transfer has a positive and significant effect on employee innovation ($\beta = 0.311$, $p = 0.010$), answering the research question regarding the extent to which the application of training knowledge and skills encourages innovative behavior in the Technical Implementation Unit (UPTD) of Food Crop

Protection and Horticulture (Hair et al., 2024). This indicates that employees who apply technical training, such as pest control techniques, tend to develop creative solutions to field challenges. This finding is in line with that of Blume et al. (2022), who found that training transfer increases innovation through the application of new skills, although the effect is more moderate in the public sector owing to bureaucratic constraints (Matthies et al., 2023). In contrast to research in the private sector showing stronger effects, the UPTD context highlights the importance of organizational support in maximizing innovation (Mehner et al., 2024). This research extends the training transfer theory by confirming its relevance in the context of public sector agriculture, adding evidence that technical training can trigger innovation even in bureaucratic environments. UPTD managers must design training programs relevant to field needs, such as crop protection technologies, and provide post-training support mechanisms, such as mentoring, to ensure the application of skills that drive innovation (Fitriyani et al., 2024).

A collaborative work environment shows a positive and significant effect on employee innovation ($\beta = 0.545$, $p = 0.000$), answering the research question of how collaboration facilitates creativity in UPTD (Hair et al., 2024). A high path coefficient indicates that open communication and teamwork allow employees to integrate their expertise to produce innovative solutions, such as efficient pest control strategies. These results support Zhou and Li (2024), who assert that collaborative environments foster innovation through knowledge sharing, but contrast with Van der Vegt et al. (2022), who warn that excessive collaboration without a clear structure can lead to inefficiency. The UPTD context shows that collaboration is effective in technical environments but requires purposeful management (Lima et al., 2024). This research reinforces collaboration theory with empirical evidence that collaborative work environments catalyze innovation in hierarchical public sector organizations. UPTD managers should facilitate collaboration platforms, such as inter-team discussion forums, and train employees in communication skills to maximize innovation while ensuring a clear division of roles to avoid inefficiencies (Khamkhoutlavong, 2023).

Employee innovation has a positive and significant effect on employee performance ($\beta = 0.222$, $p = 0.044$), answering research questions on the contribution of innovative behavior to work outcomes in UPTD (Hair et al., 2024). Although the effect is relatively small, innovations such as the development of plant protection methods improve the efficiency and quality of employees' work. This finding is consistent with Chen and Zhang (2024), who linked innovation to improved performance; however, the effect was smaller than that of research in the high-tech sector, which showed stronger effects due to greater resources (Ping et al., 2024). In the context of agriculture, innovation has a significant impact despite being limited by resources (Marwan and Alhadar, 2024). This study enriches innovation theory with empirical evidence in the agricultural public sector, confirming that individual innovations contribute to performance, even in resource-constrained environments. UPTD needs to create space for experimentation, such as piloting new technologies, and provide incentives for employees to come up with innovative solutions to improve performance (Sakaria et al., 2023).

The transfer of training has a positive and significant effect on employee performance ($\beta = 0.406$, $p = 0.000$), answering research questions about the impact of training implementation on productivity and work quality in UPTD (Hair et al., 2024). Employees who applied training skills, such as plant protection techniques, showed increased efficiency in technical tasks. These results support Saks and Burke (2022), who found that training transfers improved performance, with stronger effects in the agricultural context than in the administrative sector due to the technical relevance of training (Fitriyani et al., 2024). In contrast to research in the private sector, the effect of UPTD depends on organizational support (Munjogu & Kiiru, 2024). This study extends the training transfer theory by demonstrating its application in improving performance in a technical bureaucratic environment. UPTD managers should ensure that training is designed around the needs of the field, with regular evaluations to monitor skill application and strengthen performance (Mehner et al., 2024).

A collaborative work environment has a positive and significant effect on employee performance ($\beta = 0.295$, $p = 0.013$), answering research questions about the role of teamwork in improving productivity in UPTD (Hair et al., 2024). Collaboration allows employees to share resources and complete complex tasks more efficiently, such as pest control strategies. This finding is in line with Lima et al. (2024), who found that collaboration improved performance, but the effect was more limited in hierarchical organizations compared to the private sector due to rigid structures (Sakaria et al., 2023). This research confirms that collaboration is effective even in bureaucratic environments (Khamkhoutlavong, 2023). This research reinforces collaboration theory with evidence that teamwork improves performance in a structured public sector context. UPTD managers need to promote a collaborative culture through teamwork training and knowledge-sharing platforms with organizational structures that support efficiency (Zhou & Li, 2024). Innovation mediates the effect of training transfer on employee performance ($\beta = 0.691$, $p = 0.000$), answering research questions on the mechanism linking training to performance in UPTD (Hair et al., 2024).

Training transfer encourages innovation, such as new methods of pest control, which in turn improves work efficiency and quality. This result supports Marwan and Alhadar (2024), who found innovation to be a mediator between training and performance, with stronger effects in the context of technical agriculture than in the administrative sector (Matthies et al., 2023). In contrast to research in the private sector, this mediation depends on organizational support in UPTD (Mehner et al., 2024). This research enriches innovation mediation theory by emphasizing its role in translating training into performance in a bureaucratic context. UPTD managers need to ensure that training is designed to encourage innovation by providing space for employees to experiment and implement new solutions to improve performance (Fitriyani et al., 2024).

Innovation mediates the effect of the collaborative work environment on employee performance ($\beta = 0.721$, $p = 0.000$), answering the research question of how collaboration translates into performance through innovation in UPTD (Hair et al., 2024). Collaboration facilitates the development of new ideas, improving efficiency, and employee outcomes. This finding is in line with Zhou and Li (2024), who linked collaboration to performance through innovation, with the effect more significant in the context of agriculture than in other sectors due to the relevance of innovative solutions (Lima et al., 2024). In contrast to research in the private sector, the mediating effect of UPTD is influenced by organizational structure (Khamkhoutlavong, 2023). This research extends collaboration theory by emphasizing the mediating role of innovation in the public sector context. UPTD managers should promote collaboration through cross-team forums to generate innovations, such as crop protection strategies that improve performance (Sakaria et al., 2023).

CONCLUSION

The study concluded that training transfer, collaborative work environment, and employee innovation significantly improved employee performance in the Technical Implementation Unit of the Food Crops and Horticulture Protection Agency (UPTD), with innovation acting as a key mediator (Hair et al., 2024). Theoretically, this study enriches the human resource management literature by validating an integrative model linking these variables in the context of public sector agriculture, extending the theory of training transfer and collaboration (Blume et al., 2022; Zhou & Li, 2024). Practically, the findings advise UPTD managers to design relevant technical training, facilitate collaborative culture, and encourage innovation through directed experimentation to improve productivity (Lima et al., 2024). From a policy perspective, local governments must allocate resources to sustainable training programs and collaboration platforms to support food security (Sakaria et al., 2023). However, this study was limited to a cross-sectional design, which limits the understanding of the dynamics of relationships between variables over time, and a focus on a single region, which may limit generalizability (Creswell & Creswell, 2023). Future research should use a longitudinal design, expand coverage to other regions, and explore additional variables, such as intrinsic motivation or digital technology (Khamkhoutlavong, 2023; Chen & Zhang, 2024).

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Author Contribution

This research is a collaboration between Deddy Sumarna, Irsan Tricahyadinata, and Herry Ramadhani, with each author making significant contributions to the preparation of the manuscript. Deddy Sumarna was responsible for the conceptualization of the research, development of the theoretical framework, and preparation of the literature review, as well as playing a role in the interpretation of the analytical results. Irsan Tricahyadinata managed the data collection process, including questionnaire design, coordination with the Food Crops and Horticulture Protection Technical Implementation Unit (UPTD), and data analysis using SmartPLS 4. Herry Ramadhani contributed to the

methodological design, statistical model testing, and drafting of the discussion, as well as ensuring alignment of the findings with the research objectives. The three authors jointly conducted the final editing of the manuscript, ensured the quality of the writing met international journal standards, and formulated theoretical and practical implications. All authors approved the final version of the manuscript and take responsibility for the accuracy and integrity of this research.

Conflict of Interest Statement

The authors, Deddy Sumarna, Irsan Tricahyadinata, and Herry Ramadhani, declare that there are no conflicts of interest associated with this research. This research was conducted independently without funding, sponsorship, or affiliation from parties with financial, commercial, or non-academic interests that could influence the design, conduct, analysis, or reporting of research results. There were no personal, professional, or financial relationships with the Technical Implementation Unit of the Food Crops and Horticulture Protection Agency (UPTD) or other entities that could lead to bias in this study. All data were collected and analyzed in compliance with the principles of academic integrity, and findings are presented objectively to advance knowledge in the field of public sector agriculture.

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