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DIGITAL TRANSFORMATION IN IRRIGATION MANAGEMENT: EVIDENCE FROM ACEH PROVINCE

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Abstract

This study examines the role of Human Resource Management (HRM) in supporting the digital transformation of irrigation management in Aceh Province, Indonesia. Digital transformation has become a strategic priority in public sector modernization; however, its implementation in irrigation management remains constrained by limited digital competencies and organizational challenges. This study aims to analyze the relationships among HRM, Digital Competence, Organizational Culture, and Digital Transformation in irrigation management. A quantitative approach with an explanatory research design was employed. Data were collected from 100 irrigation management personnel of the Aceh Water Resources Agency through structured questionnaires and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results indicate that HRM has a significant positive effect on Digital Competence, while Digital Competence significantly influences Digital Transformation. HRM also exerts a direct effect on Digital Transformation, although its indirect effect through Digital Competence is stronger. Furthermore, Organizational Culture significantly strengthens the relationship between Digital Competence and Digital Transformation. The findings demonstrate that successful digital transformation in irrigation management is not solely determined by technological availability but also by human resource readiness and organizational culture. This study contributes to the literature by integrating Human Resource Management, Digital Competence, Organizational Culture, and Digital Transformation into a comprehensive framework for explaining digital transformation in public sector irrigation management.

Keywords: Human Resource Management, Digital Transformation, Digital Competence, Irrigation Management

INTRODUCTION

Irrigation management plays an important role in ensuring food security and supporting agricultural productivity, particularly in Aceh Province, Indonesia (Muharomah et al., 2025). Along with increasing demands for efficient water resource management, organizational capacity, human resource development, and technological innovation have become increasingly important in irrigation governance (Kumar & Choudhury, 2024). Digital technologies have created new opportunities to improve irrigation management through enhanced monitoring, information sharing, and data-driven decision-making processes (Abdelmoneim et al., 2025).

Digital Transformation has emerged as a strategic priority in organizational modernization across both private and public sectors. According to Vial (2021), Digital Transformation refers to a process whereby digital technologies induce significant changes in organizational structures, processes, strategies, and value creation mechanisms. Similarly,

Mergel et al (2019) define Digital Transformation in the public sector as a comprehensive organizational change enabled by digital technologies that improves service delivery, operational efficiency, transparency, and stakeholder engagement. Unlike digitization, which focuses on converting analog information into digital formats, and digitalization, which emphasizes the use of digital technologies to improve existing processes, Digital Transformation involves fundamental changes in organizational operations, governance systems, and organizational culture (Kraus et al., 2022).

In the public sector, Digital Transformation is increasingly recognized as a critical strategy for improving organizational effectiveness and responsiveness (Goraya et al., 2026). The Organisation for Economic Co-operation and Development (OECD, 2021) emphasizes that successful Digital Transformation requires not only technological infrastructure but also competent human resources, supportive organizational cultures, and adaptive governance mechanisms. Therefore, Digital Transformation should be viewed as a socio-technical process in which technological innovation, human capabilities, organizational structures, and cultural factors interact to produce sustainable organizational change (Nambisan et al., 2019).

Within irrigation management, Digital Transformation offers significant opportunities to improve water resource governance through the adoption of Internet of Things (IoT) technologies, irrigation information systems, Geographic Information Systems (GIS), remote monitoring applications, and data analytics tools. These technologies can enhance operational efficiency, improve infrastructure maintenance planning, facilitate real-time monitoring of water distribution, and strengthen evidence-based decision-making. Consequently, Digital Transformation has become an important component of irrigation modernization strategies worldwide (Wang et al., 2025).

However, the implementation of Digital Transformation in irrigation management remains constrained by limited technological readiness, human resource capacity, and organizational adaptability. These challenges are evident in Aceh Province, where irrigation institutions manage approximately 38,462 hectares of irrigation service areas supported by 248 operation and maintenance personnel. Despite the importance of irrigation services, most monitoring and operational activities are still conducted manually, indicating a gap between the need for digital-based irrigation management and existing organizational capabilities.

Previous studies have emphasized the importance of digital competence and human resource readiness in supporting Digital Transformation. Human Resource Management Theory suggests that employee development and organizational support are essential for improving organizational performance (Dessler, 2019), while Competency Theory highlights the importance of individual competencies in achieving organizational objectives (Spencer & Spencer, 2008). Furthermore, Digital Transformation Theory emphasizes the interaction between technology and human capabilities in facilitating organizational change (Vial, 2021), whereas Organizational Culture Theory explains the role of organizational values and norms in promoting innovation and adaptability (Schein, 2010).

Despite extensive research on Digital Transformation, previous studies have primarily focused on general public sector contexts and have tended to examine Human Resource Management, Digital Competence, Organizational Culture, and Digital Transformation

separately. Empirical evidence integrating these variables within the context of irrigation management remains scarce. Moreover, limited studies have investigated how Digital Competence mediates the relationship between Human Resource Management and Digital Transformation while simultaneously considering the moderating role of Organizational Culture.

Therefore, this study develops and empirically tests a framework explaining how Human Resource Management influences Digital Transformation directly and indirectly through Digital Competence, while Organizational Culture acts as a moderating factor. The findings are expected to contribute to the literature and provide practical implications for accelerating irrigation modernization in Aceh Province.

METHODS

This study employs a quantitative approach with an explanatory research design to examine the relationships among Human Resource Management (HRM), Digital Competence, Organizational Culture, and Digital Transformation in irrigation management. The explanatory design was selected to test the causal relationships among the proposed variables and to evaluate the research model empirically using statistical analysis.

The study was conducted at the Aceh Water Resources Agency (Dinas Pengairan Aceh) and its related irrigation management units. The target population consisted of personnel directly involved in irrigation planning, operation, maintenance, monitoring, and supervision activities. These personnel included Irrigation Observers, Irrigation Observer Staff, Irrigation Watermen, Weir Operation Personnel, Reservoir Operation Personnel, and Water Gate Operation Personnel responsible for managing irrigation systems across Aceh Province. In total, the population comprised 248 operation and maintenance personnel involved in irrigation management.

To ensure adequate representation of different occupational groups, the study employed Proportionate Stratified Random Sampling. The population was divided into strata based on job categories, and respondents were selected proportionally from each stratum. This sampling technique was chosen to minimize sampling bias and ensure that all relevant groups involved in irrigation management were adequately represented. A total of 100 respondents were selected as the research sample, which satisfies the minimum requirements for Partial Least Squares Structural Equation Modeling (PLS-SEM). The distribution of the population and sample across occupational strata is presented in Table 1.

Table 1. Distribution of Population and Sample

Stratum	Population (N)	Sample (n)
Irrigation Observer	4	2
Irrigation Observer Staff	20	8
Irrigation Waterman	26	10
Weir Operation Personnel	32	13
Reservoir Operation Personnel	12	5
Water Gate Operation Personnel	154	62
Total	**248**	**100**

Source: Processed by the Authors, 2026

According to Hair et al (2022), PLS-SEM is appropriate for studies with relatively small sample sizes. Therefore, the sample size of 100 respondents was considered adequate for the proposed model involving both mediation and moderation effects. Human Resource Management (HRM) refers to organizational practices aimed at planning, developing, managing, and optimizing human resources to achieve organizational objectives. In this study, Human Resource Management is measured through four indicators, namely human resource planning, training and development, performance management, and talent management. These indicators reflect the organization's efforts to enhance employee capabilities and support digital transformation initiatives (Armstrong & Taylor, 2023; Dessler, 2019).

Digital Competence is defined as the ability of employees to effectively utilize digital technologies and adapt to technological changes in carrying out their work. In this study, Digital Competence is measured by digital literacy, technology utilization skills, data analysis capability, and adaptability to technological change. These indicators represent the knowledge and skills required to support digital transformation processes (Spencer & Spencer, 2008). Organizational Culture refers to the shared values, norms, and beliefs that influence employees' attitudes and behaviors toward organizational change and innovation. In this study, Organizational Culture is measured through openness to innovation, change orientation, and collaboration. These indicators reflect the extent to which the organizational environment supports adaptation and continuous improvement (Schein, 2010).

Digital Transformation is defined as the process of integrating digital technologies into organizational activities to improve operational efficiency and service performance. In this study, Digital Transformation is measured through technology adoption, information system utilization, monitoring effectiveness, and service performance improvement. These indicators represent the organization's ability to implement and utilize digital technologies to enhance irrigation management performance (Mergel et al., 2019; Vial, 2021). Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The analysis included measurement model assessment (validity and reliability testing), structural model assessment, and hypothesis testing. Furthermore, mediation analysis was conducted to examine the mediating role of Digital Competence, while moderation analysis was performed to assess the moderating role of Organizational Culture within the proposed research model (Creswell & Creswell, 2018).

This study is grounded in Human Resource Management Theory, Competency Theory, Digital Transformation Theory, and Organizational Culture Theory. Human Resource Management is expected to enhance employees' Digital Competence, which subsequently contributes to Digital Transformation. Furthermore, Organizational Culture is proposed to strengthen the influence of Digital Competence on Digital Transformation. Accordingly, Human Resource Management affects Digital Transformation both directly and indirectly through Digital Competence, while Organizational Culture serves as a moderating variable.

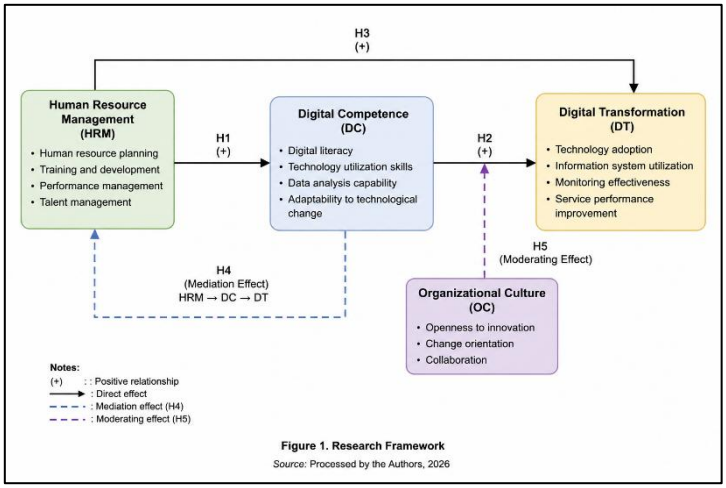

Figure 1. Research Framework

Source: Developed by the Authors, 2026

The hypotheses proposed in this study are as follows:

H1 : Human Resource Management positively influences Digital Competence.
H2 : Digital Competence positively influences Digital Transformation.
H3 : Human Resource Management positively influences Digital Transformation.
H4 : Digital Competence mediates the relationship between Human Resource Management and Digital Transformation.
H5 : Organizational Culture moderates the relationship between Digital Competence and Digital Transformation.

RESEARCH RESULT AND DISCUSSION

Result

Based on data collected from 100 respondents involved in irrigation management in Aceh Province, the majority were male (88%), aged 30–45 years (54%), and held a bachelor's degree (60%). Water Gate Operation Personnel represented the largest occupational group (62%). These characteristics indicate favorable conditions for digital transformation, although challenges remain in strengthening digital competencies.

Table 2. Respondent Profile

Characteristic	Category	Percentage
Gender	Male	88%
	Female	12%
Age	30 – 45 Years	54%
Education	Bachelor's Degree	60%

Source: Processed by the Authors, 2026

The measurement model results indicate that all indicators have outer loading values above 0.70. Furthermore, all constructs achieved Average Variance Extracted (AVE) values above 0.50 and composite reliability values exceeding 0.70, confirming satisfactory convergent validity and internal consistency. In addition, HTMT values below 0.90 indicate adequate discriminant validity among the constructs.

Table 3. Validity and Reliability Test Results

Variable	AVE	Composite Reliability	Description
Human Resource Management	0.65	0.88	Valid and Reliable
Digital Competence	0.67	0.89	Valid and Reliable
Organizational Culture	0.63	0.87	Valid and Reliable
Digital Transformation	0.69	0.90	Valid and Reliable

Source: SmartPLS Output, 2026

The structural model evaluation showed that the coefficient of determination (R^2) for Digital Transformation was 0.68, indicating that Human Resource Management, Digital Competence, and Organizational Culture explained 68% of the variance in Digital Transformation. This result suggests that the proposed model possesses substantial explanatory power, while the remaining 32% may be explained by other factors outside the model.

Table 4. Hypothesis Testing Results

Relationship	Coefficient (β)	T-statistic	p-value	Description
HRM → Digital Competence	0.62	8.45	0.000	Significant
Digital Competence → Digital Transformation	0.55	7.12	0.000	Significant
HRM → Digital Transformation	0.30	2.35	0.019	Significant
Mediation Effect	0.34	5.10	0.000	Significant
Moderation Effect	0.21	2.80	0.006	Significant

Source: SmartPLS Output, 2026

The hypothesis testing results demonstrated that all proposed relationships were statistically significant, indicating support for all hypotheses. Human Resource Management significantly influenced Digital Competence (β = 0.62; p < 0.001) and Digital Transformation (β = 0.30; p = 0.019). Digital Competence also had a significant positive effect on Digital Transformation (β = 0.55; p < 0.001). Furthermore, Digital Competence significantly mediated the relationship between Human Resource Management and Digital Transformation (β = 0.34; p < 0.001), while Organizational Culture significantly moderated the relationship between Digital Competence and Digital Transformation (β = 0.21; p = 0.006). The structural model results are illustrated in Figure 2, which presents the path coefficients among the latent variables.

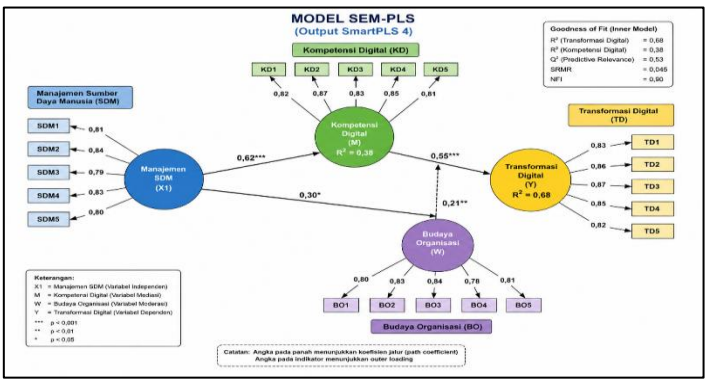

Figure 2. Structural Equation Model (SEM-PLS) Showing the Path Coefficients Between Variables

Source: SmartPLS Output, 2026

Discussion

The findings demonstrate that Human Resource Management (HRM) plays an important role in supporting digital transformation in irrigation management. The results show that HRM significantly enhances Digital Competence and also exerts a direct positive effect on Digital Transformation. However, the indirect effect through Digital Competence is stronger, indicating that employee capabilities constitute the primary mechanism through which organizational policies are translated into transformation outcomes. These findings emphasize the importance of training, competency development, performance management, and talent management in improving employees' readiness to adapt to digital technologies. The results support Human Resource Management Theory proposed by Dessler (2019), which highlights the strategic role of employee development in enhancing organizational capabilities.

Furthermore, Digital Competence was found to be one of the most influential determinants of Digital Transformation. This finding indicates that successful digital transformation depends not only on technological infrastructure but also on employees' ability to utilize digital systems effectively. In the context of irrigation management, digital competencies are essential for supporting monitoring activities, information management, and data-driven decision-making processes. Consequently, investments in digital infrastructure should be accompanied by continuous efforts to strengthen employees' digital capabilities. This result is consistent with Competency Theory proposed by Spencer & Spencer (2008) and Digital Transformation Theory (Vial, 2021), which emphasize the interaction between human capabilities and technological development.

The study also confirms that Digital Competence acts as a significant mediating variable in the relationship between Human Resource Management and Digital Transformation. This indicates that human resource policies do not automatically lead to successful digital transformation unless they are translated into improved digital capabilities. In other words, the contribution of HRM to organizational transformation is largely realized through competency development. This finding reinforces the importance of human capital as a strategic resource in achieving sustainable digital transformation.

In addition, Organizational Culture significantly strengthens the relationship between Digital Competence and Digital Transformation. Organizations characterized by openness to innovation, collaboration, and adaptability are more likely to transform employees' digital competencies into successful transformation outcomes. This finding supports Organizational Culture Theory proposed by Schein (2010), which emphasizes the importance of organizational values and norms in facilitating change and innovation. Therefore, fostering an adaptive organizational culture is essential for ensuring the sustainability of digital transformation in irrigation management.

From the perspective of Digital Transformation Theory, the findings indicate that digital transformation in irrigation management should not be viewed merely as the adoption of digital technologies but as a broader organizational change process. Vial (2021) argues that digital transformation involves fundamental changes in organizational processes, structures, and capabilities enabled by digital technologies. The results of this study support this perspective by demonstrating that the successful implementation of digital transformation depends not only

on technological availability but also on the ability of employees to utilize technology effectively and adapt to new ways of working. In the context of irrigation management, technologies such as irrigation information systems, Geographic Information Systems (GIS), and digital monitoring applications can only generate organizational benefits when supported by adequate digital competencies and organizational readiness. Therefore, digital transformation should be understood as a socio-technical process in which technological innovation, human resources, and organizational culture interact to produce sustainable improvements in operational performance and service delivery.

Overall, these findings suggest that digital transformation in irrigation management is not solely technology-driven but also depends on human resource readiness, digital competencies, and a supportive organizational culture. The findings provide empirical evidence that the integration of Human Resource Management, Digital Competence, Organizational Culture, and Digital Transformation constitutes a comprehensive framework for understanding digital transformation in public sector irrigation management. Therefore, strengthening employee competencies and fostering an adaptive organizational culture are essential strategies for accelerating irrigation modernization in Aceh Province.

CONCLUSION

This study examined the role of Human Resource Management (HRM) in supporting the digital transformation of irrigation management in Aceh Province by considering the mediating role of Digital Competence and the moderating role of Organizational Culture. The findings indicate that HRM significantly enhances Digital Competence and positively influences Digital Transformation, with the indirect effect through Digital Competence being stronger than the direct effect. In addition, Organizational Culture strengthens the relationship between Digital Competence and Digital Transformation, highlighting the importance of an adaptive and innovation-oriented organizational environment.

Overall, the findings demonstrate that digital transformation in irrigation management is not solely technology-driven but also depends on human resource readiness, digital competence, and organizational culture. The novelty of this study lies in integrating Human Resource Management, Digital Competence, Organizational Culture, and Digital Transformation into a single empirical framework within the context of public sector irrigation management. The results provide empirical evidence that Digital Competence serves as a strategic mediating mechanism, while Organizational Culture acts as an enabling factor that strengthens digital transformation outcomes.

Despite these contributions, this study is limited to irrigation management institutions in Aceh Province and the use of cross-sectional and self-reported data. Other factors, such as digital leadership, policy support, and technological infrastructure readiness, were not included in the research model. Therefore, future studies are encouraged to expand the geographical scope, incorporate additional organizational and technological variables, and employ longitudinal approaches. From a practical perspective, government agencies responsible for irrigation management should strengthen HRM practices through continuous digital skills development, capacity-building programs, and technology-oriented talent management, while

fostering an organizational culture that promotes innovation, collaboration, and openness to change to accelerate digital transformation initiatives.

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