Digital Transformation and Technological Competencies in Community Water Management Organizations: Evidence from Rural Costa Rica

Juan Carlos Sandí-Delgado[1] Rosa Julia Cerdas-González[2] Yaret Alexander Paniagua-Chavarría[3] Joshua Mauricio Paniagua-Chavarría[4] Alexandra Yuleisy Cruz-Garro[5] Katherine Rocío Cerdas-Morales[6] Thierry Stalin Galdamez-Serrano[7] and Jesua Antonio Zumbado-Bermúdez[8]

[1] Recinto de Guápiles - Sede del Atlántico, Universidad de Costa Rica, Guápiles-Pococí, Costa Rica
JUAN.SANDIDELGADO@ucr.ac.cr
[2] Vicerrectora de Administración, Universidad de Costa Rica, San José, Costa Rica
ROSA.CERDAS@ucr.ac.cr
[3] Campus Sarapiquí, Universidad Nacional de Costa Rica, Sarapiquí-Heredia, Costa Rica
YARET.PANIAGUA.CHAVARRIA@est.una.ac.cr
[4] Recinto Siquirres – Sede del Caribe, Universidad de Costa Rica, Siquirres-Limón, Costa Rica
JOSHUA.PANIAGUA@ucr.ac.cr
[5] Campus Sarapiquí, Universidad Nacional de Costa Rica, Sarapiquí-Heredia, Costa Rica
ALEXANDRA.CRUZ.GARRO@est.una.ac.cr
[6] Campus Sarapiquí, Universidad Nacional de Costa Rica, Sarapiquí-Heredia, Costa Rica
KATHERINE.CERDAS.MORALES@est.una.ac.cr
[7] Campus Sarapiquí, Universidad Nacional de Costa Rica, Sarapiquí-Heredia, Costa Rica
THIERRY.GALDAMEZ.SERRANO@est.una.ac.cr
[8] Campus Sarapiquí, Universidad Nacional de Costa Rica, Sarapiquí-Heredia, Costa Rica
JESUA.ZUMBADO.BERMUDEZ@est.una.ac.cr

Abstract. Digital transformation has become a key driver of organizational change across multiple sectors, including community-based organizations responsible for delivering essential public services in rural areas. In Costa Rica, potable water services in rural communities are frequently managed by community organizations known as Asociaciones Administradoras de Sistemas de Acueductos y Alcantarillados Sanitarios (ASADAS). Despite their importance for local governance and sustainable development, many of these organizations face challenges related to technological adoption and the development of digital competencies. This study analyzed the technological competencies required for the effective integration of digital tools within community water management organizations. This study adopts a case study approach that focuses on the Rural Aqueduct Administrative Association of La Unión de Guápiles (AAARLU), located in Pococí, Costa Rica. This study integrates the Technology Acceptance Model (TAM) with a competency-based perspective to evaluate technological capabilities among personnel responsible for managing community water services. The results indicate that, while basic digital literacy and Internet use are relatively common among personnel, competencies related to cloud technologies and digital administrative systems remain limited. However, the respondents reported positive attitudes toward technological adoption. Based on these findings, this study proposes a technological competency framework aimed at strengthening digital capabilities in community water management organizations and supporting digital transformation processes in rural governance contexts.

Keywords: Digital transformation, digital competencies, technology adoption, community water management, rural digitalization, TAM.

Transformación digital y competencias tecnológicas en organizaciones comunitarias de gestión del agua: evidencia desde Costa Rica

Resumen. La transformación digital se ha convertido en un factor clave para el cambio organizacional en múltiples sectores, incluyendo organizaciones comunitarias responsables de brindar servicios públicos esenciales en territorios rurales. En Costa Rica, el suministro de agua potable en zonas rurales es gestionado frecuentemente por organizaciones comunitarias conocidas como Asociaciones Administradoras de Sistemas de Acueductos y Alcantarillados Sanitarios (ASADAS). A pesar de su relevancia para la gobernanza local y el desarrollo sostenible, muchas de estas organizaciones enfrentan

desafíos asociados con la adopción tecnológica y el desarrollo de competencias digitales. Este estudio analiza las competencias tecnológicas necesarias para la integración efectiva de herramientas digitales en organizaciones comunitarias encargadas de la gestión del agua. La investigación adopta un enfoque de estudio de caso centrado en la Asociación Administradora del Acueducto Rural de La Unión de Guápiles (AAARLU), ubicada en el cantón de Pococí, Costa Rica. El estudio integra el Modelo de Aceptación Tecnológica (TAM) con un enfoque basado en competencias para evaluar las capacidades tecnológicas del personal responsable de la gestión del servicio de agua comunitario. Los resultados indican que, aunque existen niveles adecuados de alfabetización digital básica y uso de internet, las competencias relacionadas con tecnologías en la nube y sistemas administrativos digitales aún presentan limitaciones. A partir de estos hallazgos se propone un marco de competencias tecnológicas orientado a fortalecer las capacidades digitales en organizaciones comunitarias de gestión del agua y apoyar procesos de transformación digital en contextos rurales.

Palabras clave: Transformación digital, competencias digitales, adopción tecnológica, gestión comunitaria del agua, digitalización rural, TAM.

1 Introduction

Digital transformation is a central component of organizational development worldwide. Organizations across multiple sectors increasingly rely on digital technologies to improve their operational efficiency, decision-making processes, and service delivery. However, the adoption of digital technologies in rural community organizations responsible for managing essential public services remains limited.

In Costa Rica, rural water supply is frequently administered by community-based organizations known as Asociaciones Administradoras de Sistemas de Acueductos y Alcantarillados Sanitarios (ASADAS). These organizations play a fundamental role in ensuring access to potable water for rural populations. Despite their importance to local development and public health, many ASADAS face technological limitations that hinder the adoption of digital tools in their administrative and operational processes.

This research analyzes the technological competencies of community water management organizations and proposes a framework that supports digital transformation processes in rural community-based water governance systems.

Understanding how digital competencies influence the adoption of technological systems in community service organizations represents an important research problem in the broader field of information systems and digital transformation.

This study contributes to the literature on digital transformation and community governance by proposing a technological competency framework that supports the adoption of digital tools by rural water management organizations. Specifically, this study provides empirical evidence from a rural community water management organization and proposes a technological competency framework to guide digital transformation processes in similar community-based service organizations.

2 Literature Review

2.1 Digital competencies

Digital competencies have become a fundamental element of organizational development and the effective integration of information and communication technologies (ICT) into professional environments (Young et al., 2026). In general, digital competencies refer to the combination of knowledge, skills, and attitudes required to effectively use digital technologies for information management, communication, collaboration, and problem-solving (Mohommoud Zayid et al., 2026).

Digital competencies are closely linked to the use and integration of ICT in different contexts, including education, public administration, and organizational management (Thoms et al., 2026). ICT can be understood as a set of technological tools and resources used to process, store, manage, and transmit information through digital systems and communication networks (Wach et al., 2026). These technologies enable access to information and facilitate communication, knowledge creation, and collaboration.

From an educational and professional perspective, technological competencies represent the abilities required to effectively use digital technologies and ICT tools to perform tasks, solve problems, and generate knowledge in different domains (Bour & Adu, 2026). These competencies include not only technical skills

related to the use of software and digital platforms but also cognitive and attitudinal dimensions associated with digital literacy and technological adaptation (Rahman & Hossain, 2025).

Several studies (Hagerer, 2025; Lee et al., 2023; Sandí-Delgado et al., 2022; Sandí-Delgado & Bazán, 2024) highlight the importance of developing technological competencies in professional environments. According to Aguaded and Cabero (2014), one of the main challenges faced by professionals and educators is the need to continuously update their technological skills in order to integrate digital technologies into their daily activities. Similarly, other researchers (Gutiérrez & Serrano, 2016; Knezek et al., 2023; Sandí-Delgado et al., 2022) have indicated that, despite the availability of technological infrastructure, the effective use of digital technologies often remains limited because of insufficient digital competencies among users.

Technological competencies and the capacity to integrate digital technologies into professional processes are frequently associated with the ability to use ICT tools effectively. These competencies include digital literacy, information management, communication through digital platforms, and the ability to adapt to emerging technology. Consequently, strengthening digital competencies is a key factor in promoting digital transformation processes in organizations and institutions.

2.2 Technology acceptance model (TAM)

Understanding the adoption of technological systems requires consideration of the factors that influence users' attitudes toward technology. One of the most widely used theoretical frameworks for analyzing technology adoption is the Technology Acceptance Model (TAM) proposed by Davis (1989).

Technology Acceptance Model explains how users accept and use a technological system (Venkatesh & Davis, 2000). According to TAM, two key factors determine technology adoption: perceived usefulness and perceived ease of use. Perceived usefulness refers to the degree to which a person believes that using a particular system will enhance their job performance, while perceived ease of use refers to the degree to which a person believes that using a system will be free of effort (Loredo-Figueroa et al., 2016).

These two variables influence users' attitudes toward technology, which in turn affects their behavioral intention to use technological systems and ultimately determines actual technology use (Sandí-Delgado & Bazán, 2024). Over time, TAM has been extended and validated in multiple contexts, including education, organizational management, and digital transformation processes (Scherer et al., 2019).

Research in the fields of educational technology and digital competencies has shown that users' attitudes toward digital technologies significantly influence their willingness to adopt technological tools in professional environments. Studies indicate that, even when technological infrastructure is available, adoption may remain limited if users do not perceive technologies as useful or easy to use (Tbaishat et al., 2026).

In the context of digital transformation in organizations, TAM provides a valuable analytical framework for understanding how individuals interact with digital technologies and how technological competencies influence technology adoption processes. Integrating the concept of digital competencies with TAM allows researchers to analyze not only users' attitudes toward technology, but also their ability to effectively use digital tools in organizational contexts (Schittko et al., 2026).

Therefore, the combination of digital competency development and technology acceptance is important for promoting digital transformation processes in community-based organizations and public service management environments.

2.3 Rural digitalization

Rural digitalization refers to the process through which digital technologies reshape economic activities, governance structures, and social practices in rural territories. In recent decades, the diffusion of digital technologiessuch as broadband infrastructure, digital platforms, data systems, and mobile applicationshas significantly transformed the ways rural communities produce, interact, and organize their daily activities.

Digital technologies have become one of the main drivers of change in rural regions, influencing not only economic development, but also the meaning and experience of rural life. For instance, in agriculture, digital technologies enable the monitoring of environmental conditions through sensors and data-driven decision-making systems, allowing farmers to optimize production processes and resource management. Simultaneously, digital communication tools and social media platforms reshape everyday rural interactions and economic opportunities (He & Leszczynski, 2026).

From a spatial perspective, the concept of digital rurality highlights how digital technologies increasingly mediate rural space. According to this approach, rural areas are not merely locations where digital technologies are implemented; rather, rural spatial and social relationships are actively produced through digital mediation. Digital technologies transform rural localities, shape formal representations of rural development, and influence everyday practices within rural communities (He & Leszczynski, 2026).

Digitalization also plays a significant role in reshaping rural governance and development models. Recent research indicates that digital transformation can enhance rural governance efficiency by integrating multiple stakeholders through digital platforms and facilitating coordination between governments, communities, and private actors. Digital technologies also support new organizational structures that improve decision-making processes, resource allocation, and community participation in rural development initiatives (Ji et al., 2026).

Another important dimension of rural digitalization is the emergence of digital rural livelihoods, which refers to livelihood strategies enabled by digital technologies and online platforms. Digital platforms create new economic opportunities for rural residents by enabling access to broader markets, supporting e-commerce, and facilitating online services. In this context, rural communities are increasingly integrated into global digital economic networks through platform-based economies, in which individuals participate in digital markets as producers, entrepreneurs, or service providers (Li et al., 2026).

Furthermore, digital technologies have contributed to the improvement of financial inclusion in rural areas. Digital inclusive finance, enabled by mobile technologies, online financial services, and data-driven risk assessment systems, helps overcome traditional barriers to financial access faced by rural populations. Through these technologies, farmers and rural entrepreneurs can access credit, digital payments, and financial services that support economic development and entrepreneurial activities (Yang, 2026).

Despite these opportunities, rural digitalization also presents challenges related to infrastructure gaps, digital literacy, and unequal access to technological resources. The persistence of the digital divide between urban and rural regions may limit the potential of digital transformation in rural contexts (Wu, 2026). Consequently, strengthening digital competencies, technological infrastructure, and institutional support mechanisms is essential to ensuring that rural communities can fully benefit from digital transformation processes.

In this context, understanding the relationship between digital competencies and technology adoption is particularly relevant for organizations responsible for managing essential services in rural territories. The integration of digital technologies into community-based organizations, such as rural water management associations, depends not only on technological availability but also on the capacity of individuals and institutions to effectively adopt and use digital tools.

2.4 Community governance

Community governance refers to institutional arrangements, participatory mechanisms, and collaborative processes through which different actors collectively manage resources, services, and decision-making at the local level. Rather than relying solely on hierarchical government structures, community governance emphasizes the interaction between public institutions, civil society organizations, and citizens in shaping local development and addressing shared challenges. Governance can, therefore, be understood as the structures, relationships, and processes through which multiple actors coordinate actions, negotiate interests, and manage common affairs within communities (Abrantes et al., 2026). These governance arrangements often operate through networks of cooperation and trust, in which community members actively participate in decision-making processes and in the management of collective initiatives.

Citizen participation represents a central dimension of community governance and plays a critical role in strengthening the local development processes. Studies conducted in rural and indigenous contexts demonstrate that active participation by community members significantly contributes to sustainable development by enhancing local institutional capacity, promoting environmental management practices, and strengthening collective responsibility for natural resources. Participatory governance frameworks also facilitate the integration of local knowledge, environmental education, and conservation initiatives, which together support long-term sustainability and resilience in rural territories (Bueloth et al., 2026). In addition, individual capabilitiessuch as financial literacy and knowledge of public systemscan further enhance citizens' engagement in governance processes by improving their ability to understand public policies, participate in decision-making, and influence the allocation of community resources (Zhou & Cheng, 2026).

The recent literature also highlights the growing influence of digital technologies in transforming community governance structures. Digital platforms and smart governance systems can facilitate

coordination among stakeholders, enhance transparency, and support responsive and data-driven public services. In digitally enabled communities, technological infrastructure may improve communication between governments and citizens, and strengthen collaborative governance networks. However, the effectiveness of these systems depends on inclusive and human-centered governance approaches that consider factors such as digital literacy, social trust, and community participation. Without these elements, digital governance initiatives can exacerbate existing inequalities or reinforce digital divides within communities (Wang et al., 2026; Wei et al., 2026).

2.5 Water management technologies

Water management technologies encompass a wide range of engineering, digital, and monitoring systems designed to improve the efficiency, sustainability, and resilience of water resource use in different sectors. As global water scarcity intensifies owing to climate change, population growth, and increasing agricultural demand, the adoption of advanced technological solutions has become essential for optimizing water use and minimizing environmental impacts. For instance, in agriculture, technological innovations such as precision irrigation systems, remote sensing, artificial intelligence, and Internet of Things (IoT) sensors allow farmers to monitor soil moisture and crop water requirements in real time, enabling more accurate irrigation scheduling and reducing water loss (Parra-López et al., 2025). These technologies are increasingly integrated within digital agriculture frameworks, where data-driven decision making supports sustainable water management practices and enhances productivity while preserving natural resources.

Beyond agriculture, technological innovations play a critical role in improving water management in urban and environmental systems. Modern water management frameworks incorporate advanced monitoring technologies, pollution control mechanisms, and ecological restoration approaches to improve water quality and restore degraded aquatic ecosystems. These technologies often include integrated monitoring systems, real-time evaluation tools, and engineered solutions for pollution reduction and ecological recovery, allowing for a more precise assessment and management of water bodies affected by urbanization and industrial activities (Lu et al., 2025). Such technological frameworks contribute to more resilient urban water systems by supporting data-driven planning and enabling coordinated management among environmental, infrastructure, and institutional actors.

Technological innovation in water management is also expanding toward integrated resource systems that combine water conservation with energy and environmental efficiency. For example, emerging solutions, such as floating photovoltaic systems installed on reservoirs, demonstrate how energy production infrastructure can simultaneously reduce water evaporation and enhance resource efficiency in water-stressed regions (Ranjbaran et al., 2025). In addition, advanced analytical and simulation technologies are being increasingly applied to better understand water flow dynamics and optimize the performance of complex water distribution systems through digital twins and AI-based decision support frameworks (Locatelli et al., 2026). From a resource efficiency perspective, the adoption of improved irrigation technologies and eco-efficiency evaluation models has also shown the potential to enhance water use efficiency while balancing economic and environmental objectives (Ait Sidhoum & Vrachioli, 2025). These technological approaches illustrate how water management is increasingly supported by interdisciplinary innovations that integrate digital monitoring, engineering design, and sustainability principles.

3 Methodology

3.1 Research Design

This study adopted a descriptive case study research design to analyze technological competencies and digital technology adoption within a community-based water management organization in rural Costa Rica. Case study research is particularly appropriate for exploring complex organizational processes in real-world contexts, where the boundaries between the phenomenon and context are not clearly defined.

This study focuses on the Rural Aqueduct Administrative Association of La Unión de Guápiles (AAARLU), located in the canton of Pococí in the Caribbean region of Costa Rica. This organization is responsible for managing potable water services for the rural population through a community-based governance structure, which makes it an appropriate case for examining the relationship between digital competencies, technology adoption, and community governance in water management organizations.

This study integrated two analytical perspectives. First, it considers the Technology Acceptance Model (TAM) as a theoretical framework for understanding attitudes toward technological adoption. Second, it incorporates a competency-based perspective to evaluate the digital capabilities required for the effective use of technological tools in organizational processes. By combining these perspectives, this study seeks to identify the technological competencies that influence the adoption of digital tools within community water management organizations.

3.2 Case Study Context

This case study focuses on the Rural Aqueduct Administrative Association of La Unión de Guápiles (AAARLU), a community-based organization responsible for managing potable water services in the canton of Pococí, located in the Caribbean region of Costa Rica. In rural areas of Costa Rica, water supply systems are frequently administered by community organizations known as the Asociaciones Administradoras de Sistemas de Acueductos y Alcantarillados Sanitarios (ASADAS). These organizations operate under community governance structures and play a critical role in ensuring access to potable water for rural populations.

AAARLU is a typical example of a community-managed water system in which administrative and operational responsibilities are carried out by local personnel and community representatives. The organization manages water distribution, infrastructure maintenance, administrative processes, and coordination with governmental institutions responsible for water regulation and public health.

Despite their importance in ensuring essential public services, many ASADAS face limitations related to the technological infrastructure and digital competencies among personnel. Administrative processes are often conducted using traditional methods and the integration of digital technologies remains limited. Therefore, AAARLU provides an appropriate context for examining the relationship between technological competencies, digital tool adoption, and community governance in rural water management organizations.

3.3 Participants and Sampling

The participants in this study were personnel directly involved in administrative and operational activities within the selected community water management organization. This includes individuals responsible for administrative management, the technical operation of the water system, and members of the governing board participating in organizational decision-making processes.

Given the specialized organizational scale of the case study institution, this research targeted the entire administrative and operational workforce of the association. This study employed a non-probabilistic purposive sampling strategy involving a **total population sample of twelve (n = 12) participants**. This cohort comprised the general manager, administrative assistants, operational technical staff, and active members of the governing board who guided the local water governance policies. Bounding the sample size to this absolute internal universe ($n = 12$) is standard and highly appropriate in descriptive single-case studies, where the objective is to obtain comprehensive, high-fidelity diagnostic insights from every single actor directly engaged in the phenomenon under investigation.

Participants were selected based on their involvement in activities such as administrative management, system operations, community coordination, and decision-making processes related to water service provision. This allowed the study to capture perceptions and experiences of individuals with practical knowledge of the organization's technological practices and operational challenges.

3.4 Data Collection Instrument

Data were collected through a structured survey designed to assess technological competencies and attitudes toward technology adoption among personnel involved in community water management processes. The questionnaire was developed based on concepts derived from the literature on digital competencies and the TAM.

The survey included a set of items measured using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The instrument evaluates several dimensions related to technological competencies and technology adoption, including (a) digital literacy, (b) Internet and communication technologies, (c) cloud technologies, (d) digital administrative systems, and (e) attitudes toward technological adoption.

The design of the instrument aimed to capture both technical competencies related to the use of digital tools and the perceptual factors associated with the acceptance of technological systems. This combination allows us to analyze not only the level of digital capability among personnel but also their willingness to adopt digital technologies in organizational processes.

Prior to data collection, the survey instrument was reviewed to ensure clarity and relevance of the items in relation to the research objectives.

3.5 Data Analysis Procedures

The collected data were analyzed using descriptive statistical techniques to identify patterns related to technological competencies and attitudes toward technology adoption among participants. Responses obtained through the Likert scale instrument were aggregated to evaluate the relative presence of different technological competencies within the organization.

The analysis focused on identifying competency areas where participants demonstrated stronger digital capabilities, as well as areas where technological limitations remained evident. This approach allows us to understand the distribution of digital competencies across the different dimensions of technological use in an organization.

The results were subsequently interpreted in relation to the theoretical framework that integrates digital competencies and TAM. This analytical approach makes it possible to explore how technological capabilities and perceptions of technology influence the potential adoption of digital tools in community-based water-management organizations.

Additionally, the analysis supports the development of a technological competency framework aimed at strengthening digital capabilities and facilitating digital transformation processes in community water management organizations.

4 Results

The results of the survey provided an overview of the technological competencies present among personnel involved in the management and operation of the community water system. The analysis focused on five key dimensions derived from the research instrument: digital literacy, Internet competencies, cloud technologies, digital administrative systems, and attitudes toward technology adoption.

Table 1 summarizes the main indicators obtained from the descriptive analysis of the Likert-scale responses. The table presents the average scores for each technological competency dimension, allowing the identification of areas where personnel demonstrate stronger digital capabilities, as well as areas where technological limitations remain evident.

These results provide insights into the current technological readiness of organizations and help identify potential opportunities for strengthening digital competencies that support digital transformation processes in community water management organizations.

Table 1. Descriptive indicators of technological competencies based on survey responses ($n = 12$).

Dimension	Indicator	Mean Score (1–5)	Standard Deviation (σ)	Interpretation
Digital literacy	Basic computer use	4.2	0.42	High competency
	Use of office software	3.9	0.51	Moderate competency
Internet competencies	Email and online communication	4.3	0.39	High competency
	Information search and online resources	4.0	0.45	Moderate competency
Cloud technologies	Use of cloud storage (Drive, Dropbox)	2.8	0.88	Limited competency
	Collaborative cloud tools	2.6	0.92	Limited competency
Digital administrative systems	Use of digital records for administration	2.9	0.81	Limited competency
	Use of digital management platforms	2.5	0.76	Low competency
Technology adoption attitudes	Perceived usefulness of digital tools	4.4	0.31	Positive attitude
	Perceived ease of use of technologies	4.1	0.48	Positive attitude

The results indicate that personnel demonstrate relatively strong competencies in basic digital literacy and internet use. Indicators related to basic computer operations, email communication, and online information search yielded the highest average scores. These results suggest that fundamental digital skills are already present among the personnel responsible for the operation and administration of the water management system.

However, competencies associated with more advanced digital technologies remain limited. In particular, indicators related to cloud technologies and digital administrative systems obtained lower scores, suggesting that the organization has not yet fully integrated these technological tools into its administrative and operational processes. This situation may limit the potential benefits associated with digital transformation such as improved data management, operational efficiency, and service coordination.

Despite these limitations, the results also revealed generally positive attitudes toward technological adoption. Respondents reported relatively high scores for perceived usefulness and perceived ease of use of digital tools, which indicates favorable conditions for the future implementation of digital technologies within community water management organizations.

To facilitate the interpretation of the results, the indicators presented in Table 1 were aggregated according to the technological competency dimensions evaluated in this study. This aggregation allowed for the identification of the overall competency level associated with each technological domain evaluated in this study. Table 2 presents the average score for each dimension, providing a clearer overview of the relative strengths and weaknesses of the organization's technological capabilities.

The average scores were calculated by aggregating Likert-scale responses associated with each competency dimension.

Table 2. Average technological competency level by evaluated dimension (n = 12).

Dimension	Average Mean Score	Average Standard Deviation (σ)	Competency Level
Digital literacy	4.05	0.47	High
Internet competencies	4.15	0.42	High
Cloud technologies	2.70	0.90	Low
Digital administrative systems	2.70	0.79	Low
Technology adoption attitudes	4.25	0.40	High

The aggregated results confirmed the patterns observed in the indicator-level analysis. Digital literacy and Internet competencies presented the highest average scores, indicating that personnel possess adequate basic technological skills required for routine digital tasks such as communication, document management, and information retrieval. These competencies represent an important foundation for the potential integration of digital technologies into organizational processes.

In contrast, competencies related to cloud technologies and digital administrative systems had significantly lower average scores. This suggests that the organization has limited experience with advanced digital tools that support collaborative work, digital record management, and administrative automation. These limitations may restrict organizations' ability to fully leverage digital technologies to improve operational efficiency and data management.

Interestingly, attitudes toward technology adoption had the highest average values among the evaluated dimensions. Participants reported strong perceptions of the usefulness and relative ease of use of digital technologies. This finding suggests that, although advanced competencies are still limited, the organizational environment may be favorable for implementing training initiatives and technological capacity-building programs aimed at strengthening digital transformation processes within community water management organizations.

To facilitate the interpretation of the results, Figure 1 provides a visual representation of technological competency distribution across the evaluated dimensions. The graphical representation allows for easier comparison between the different technological domains assessed in this study.

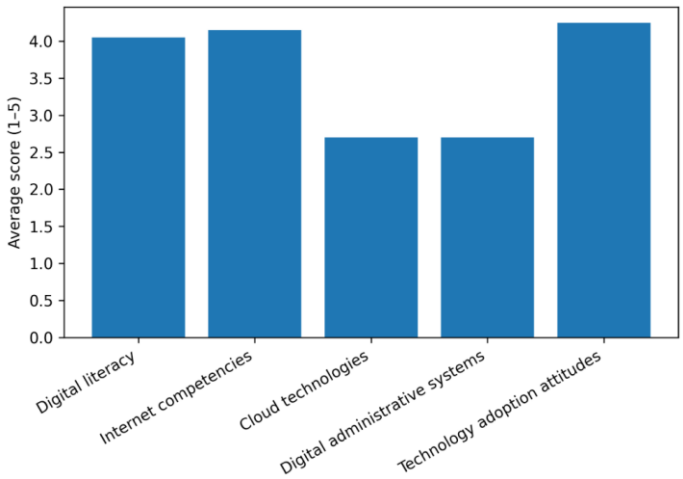

Figure 1. Distribution of technological competency levels across the evaluated dimensions.

The graphical representation confirms the patterns observed in previous tables. Digital literacy, Internet competencies, and attitudes toward technology adoption had the highest scores, indicating that personnel possessed adequate digital capabilities and positive perceptions of technological use. Conversely, competencies associated with cloud technologies and digital administrative systems showed considerably lower values, reinforcing the presence of technological gaps that may limit the effective digital transformation of community water management organizations.

5 Discussion

The results obtained in this study highlight several relevant aspects of the relationship between technological competencies and digital transformation processes in community-based organizations responsible for water management. The findings indicate that personnel possess relatively strong competencies in basic digital literacy and internet use, suggesting that fundamental technological skills are already present within the organization. These competencies constitute an important foundation for the integration of digital technologies into administrative and operational processes. Similar findings have been reported in studies on digital competencies in professional environments, which emphasize that basic digital literacy is often the first stage in broader digital transformation processes (Knezek et al., 2023; Young et al., 2026).

However, the significant limitations observed in cloud technologies (mean = 2.70, $\sigma = 0.90$) and digital administrative systems (mean = 2.70, $\sigma = 0.79$) introduce a critical tension that transcends individual technical deficiencies. Within the SCTS framework, these competency gaps must be problematized as manifestations of deep-rooted structural barriers specific to rural Latin American reality, rather than being reductionistically attributed solely to a lack of training sessions.

First, the low performance of cloud-based architectures directly correlates with asymmetric territorial issues of connectivity in the Pococí region, where fluctuating bandwidth and deficient telecommunications infrastructure impede stable, real-time remote operations.

Second, the adoption of advanced digital administrative tools is severely restricted by economic barriers, specifically the prohibitive licensing costs of proprietary software, which place an unfeasible financial strain on the self-sustaining budgets of community-based organizations, such as ASADAS.

Therefore, these findings reveal that providing physical infrastructure is fundamentally insufficient if rural communities are forced into techno-dependency cycles. To ensure true digital appropriation, public policies must pivot local strategies grounded in **technological sovereignty**. Promoting open-source software, localized data architectures, and community-governed digital platforms represents a critical political pathway to safeguard rural autonomy, lower operational costs, and align digital transformation with the social preservation of common goods such as rural water management (Gutiérrez & Serrano, 2016; Rahman & Hossain, 2025).

An interesting finding of this study is the relatively positive attitude toward technology adoption reported by participants. High scores for perceived usefulness and perceived ease of use indicate that

personnel generally recognize the potential benefits of digital technologies in improving organizational processes. These results align with TAM, which suggests that users' perceptions of usefulness and ease of use play a critical role in shaping their willingness to adopt technological systems (Davis, 1989; Venkatesh & Davis, 2000). Therefore, although advanced technological competencies remain limited, the presence of favorable attitudes toward technology adoption suggests that training initiatives and institutional support programs could significantly facilitate digital transformation within community water management organizations.

These findings contribute to the growing literature on rural digitalization and community governance by highlighting the role of technological competencies as key enabling factors for digital transformation in community-based service organizations. Community-based organizations, such as ASADAS, play a crucial role in ensuring access to essential public services in rural territories. However, the effective integration of digital technologies into these organizations requires not only technological infrastructure, but also the development of human capabilities that enable the effective use of digital tools. Therefore, strengthening digital competencies within community governance structures may represent a key strategy to improve service efficiency, transparency, and decision-making processes in rural public service management. The technological competency framework proposed in this study provides a practical approach for supporting digital transformation initiatives in community water management organizations.

6 Implications for Public Policy and Rural Governance

The findings of this study highlight the importance of developing public policies that strengthen digital capabilities within community-based organizations responsible for managing essential services in rural territories. The results showed that personnel involved in community water management possess relatively strong basic digital competencies and positive attitudes toward technological adoption. However, the limited competencies related to cloud technologies and digital administrative systems suggest that community organizations still face significant barriers to the effective integration of digital tools in administrative and operational processes. These findings indicate that digital transformation in rural public service organizations requires targeted capacity-building strategies that focus not only on technological infrastructure, but also on human capability development.

From a public policy perspective, universities, government institutions, and local development agencies must carefully reengineer their approaches to digital inclusion within rural governance systems. Rather than replicating historical, top-down, and vertical knowledge-transfer models, in which external academic institutions impose technocratic systems on passive recipients, the articulation between higher education and community organizations must be fundamentally horizontal.

Collaborative university-community initiatives must be structured around a genuine dialogue of saberes (knowledge dialogue) and a rigorous process of socio-technical co-design. Crucially, this horizontal framework does not treat rural organizations as deficient, but actively leverages the significant local capabilities already present within the community. As demonstrated empirically in our TAM assessment, the personnel already possess remarkably high foundational competencies in basic digital literacy (Mean = 4.05) and fluent Internet use (Mean = 4.15).

Utilizing these strong pre-existing community assets as a baseline, university extension programs can co-create tailor-made digital strategies that are contextually responsive to the territorial social governance of water. This non-vertical synergy ensures that administrative platforms, data tools, and technical solutions are collectively designed to align with specific values, community trust networks, and long-term sustainability models of rural territories, transforming digital transformation into a true vehicle for democratic local empowerment.

Finally, strengthening digital capabilities in community-based organizations may contribute to broader rural development and governance processes. Digital technologies can improve the coordination between community organizations and governmental institutions, facilitate access to information, and enhance citizen participation in local governance structures. Therefore, public policies that support digital transformation in community organizations responsible for essential services, such as rural water management associations, can play an important role in improving service efficiency, institutional transparency, and long-term sustainability in rural territories.

7 Technological Competency Framework

Based on the empirical findings of this study, a technological competency framework was proposed to support digital transformation processes in community-based organizations responsible for water management in rural territories. The framework integrates three key components: the development of digital competencies, perception and acceptance of technology, and adoption of digital tools for organizational management. These components interact dynamically to influence how community organizations incorporate digital technologies into their administrative and operational processes.

The first component of the framework focuses on the development of technological competencies among personnel involved in water management. The results indicate that basic competencies, such as digital literacy and Internet use, are relatively well developed within the organization. However, advanced competencies related to cloud technologies and digital administrative systems remain limited. Strengthening these competencies through training initiatives and capacity-building programs is essential to enable the effective use of digital technologies in community water management processes. Therefore, this competency dimension represents a foundational layer that supports digital transformation in rural community organizations.

The second component relates to the perception and acceptance of digital technologies, which is explained through the Technology Acceptance Model (TAM). According to TAM, perceived usefulness and perceived ease of use significantly influence individuals' attitudes toward technology adoption (Davis, 1989; Venkatesh & Davis, 2000). The results of this study indicate that personnel generally perceive digital technologies as useful and relatively easy to use, suggesting favorable conditions for the introduction of digital tools. These positive perceptions can facilitate the transition from basic digital practices to advanced technological integration within an organization.

Finally, the framework highlights how the interaction between technological competencies and acceptance leads to the adoption of digital tools that support organizational management and community governance processes. The effective use of digital administrative systems, cloud-based platforms, and data management tools can improve the coordination, transparency, and operational efficiency of rural water management organizations. In this context, digital technologies can strengthen community governance structures by facilitating communication among stakeholders, improving information management, and supporting more efficient service deliveries.

Figure 2 illustrates the proposed technological competency framework and the relationships between its main components. The framework suggests that strengthening digital competencies and fostering positive perceptions of technology adoption can create the necessary conditions for implementing digital tools that improve governance processes and operational efficiency in community-based water management organizations.

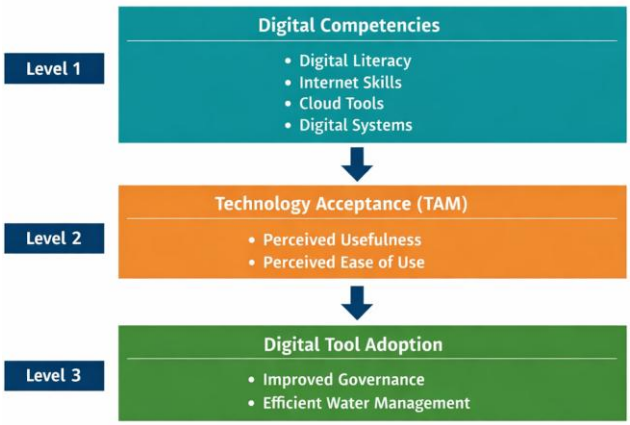

Figure 2. Technological Competency Framework for Digital Transformation in Community Water Management Organizations

The framework illustrates how digital competencies influence technology acceptance among personnel in community water management organizations. Positive perceptions of usefulness and ease of use facilitate the adoption of digital tools that can improve governance processes and operational efficiency in rural water management.

8 Conclusions

This study examined the critical nexus between technological competencies, human capabilities, and the social appropriation of technology within community-based water governance organizations in rural Costa Rica. By evaluating personnel through an integrated Technology Acceptance Model (TAM) framework, the empirical findings reveal a significant, situated paradox within the Latin American rural reality: while community operators possess highly positive attitudes toward adoption and robust baseline competencies in basic computer literacy (mean = 4.05) and Internet communication (mean = 4.15), they simultaneously experience steep limitations in integrating cloud architectures and digital administrative systems (Mean = 2.70).

Rather than viewing these competency gaps through a reductionist, technocratic lens that merely blames insufficient technical training, this study concludes that these limitations are deeply tethered to the asymmetric structural barriers inherent to rural territories. The lack of digital expansion in community governance is actively produced by fluctuating regional connectivity infrastructure and the prohibitive, exclusionary licensing costs of proprietary administrative software. Consequently, sustainable digital transformation in rural areas cannot be achieved through the uncritical importation of generic global technologies, which often foster compliance with empowerment and result in techno-dependency cycles.

To safeguard the long-term sustainability of common resources and public health managed by structures such as ASADAS, public policies must urgently transition toward frameworks of **technological sovereignty** and localized open-source platforms. Furthermore, future institutional linkages must reject vertical paternalistic knowledge transfer mechanisms. Higher education networks and development agencies must engage in horizontal participatory co-design models that actively leverage and honor solid foundational digital assets already cultivated by rural communities. Only through this democratic dialogue of Saberes can digital systems effectively augment local autonomy, strengthen social governance, and foster equitable digital inclusion across rural territories.

Based on these findings, this study proposes a technological competency framework that integrates digital competency development, technology acceptance, and digital tool adoption as key elements for supporting digital transformation in community water management organizations. The framework provides a conceptual and practical reference for policymakers, community organizations, and development institutions seeking to strengthen digital capabilities in rural public service management.

Finally, this study had certain limitations that should be acknowledged. This research is based on a single case study of a community water management organization, which may limit the generalizability of the findings to other contexts. Future research could expand the analysis to multiple ASADAS or similar community-based organizations in different rural regions, allowing for a comparative analysis of digital competency development and technological adoption processes. Additionally, future studies could incorporate mixed-method approaches that combine quantitative surveys with qualitative interviews to deepen the understanding of digital transformation dynamics in rural governance systems.

These findings highlight the importance of strengthening digital competencies as a key element in enabling sustainable digital transformation in rural governance systems.

Authors' Contribution

The authors contributed to the study as follows: Conceptualization, methodology, investigation, validation, writing—original draft preparation, and writing—review and editing.

Competing Interests

The authors have declared that no competing interests exist.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT to improve the language and readability of the manuscript. After using this tool, the authors reviewed and edited the content as necessary and took full responsibility for the content of the publication.

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