Original Researcher Article

Adoption and Use of Digital Technologies in Humanitarian Logistics: Insights from ADRA Rwanda

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ABSTRACT

Digital transformation has become a defining enabler of efficiency, visibility and responsiveness in contemporary logistics and supply chain management. In humanitarian operations—where uncertainty, urgency and resource limitations are constant—technology plays an indispensable role in strengthening accountability and accelerating service delivery. This study examines the adoption and operational contribution of digital technologies within the logistics and supply-chain management system of the Adventist Development and Relief Agency (ADRA) in Rwanda. A mixed-methods design was employed, combining data from 108 respondents through structured questionnaires with complementary interviews from logistics managers and technical staff. Descriptive statistics, weighted means and standard deviations were used to analyze adoption levels, while inferential analysis applied multiple regression to determine the effect of technology use on performance.

Findings indicate that ADRA Rwanda relies predominantly on basic technologies such as barcode scanning and manual inventory tracking, while advanced systems—including RFID, cloud-based inventory platforms, automated data-capture tools, AI, IoT and blockchain—remain minimally adopted. Predictive analytics demonstrated the highest level of integration within planning and forecasting. Despite the limited presence of advanced technologies, digital tools currently in use were found to contribute significantly to improvements in monitoring and evaluation, distribution efficiency, and capacity planning. Regression results show that technology adoption explains 92.4% of the variance in logistics performance ($R^2 = 0.924$), underscoring the strategic value of digital systems in humanitarian supply chains.

The study concludes that ADRA Rwanda is progressing through an incremental digital transformation pathway, maximising simple, cost-effective technologies while facing infrastructural and financial constraints that limit high-end adoption. Recommendations are offered to strengthen digital capacity, enhance systems integration, and align technological investments with organisational and donor priorities

INTRODUCTION

Digital technologies have become central to modern logistics and supply-chain operations, reshaping how organisations plan, track and deliver goods. In the humanitarian sector, these tools offer particular value by improving visibility, coordination and responsiveness in environments that are often uncertain and resource-constrained (Altay, Kovács & Spens, 2023). Technologies such as barcoding, mobile data systems, predictive analytics and cloud-based platforms increasingly form the backbone of contemporary logistics processes, supporting everything from procurement to distribution and post-delivery reporting (Christopher, 2016; Wamba & Queiroz, 2020).

For organisations involved in relief work, digital transformation is not simply an operational upgrade—it can directly strengthen accountability, reduce losses and ensure that assistance reaches beneficiaries more efficiently. However, the adoption of such technologies is shaped by multiple factors, including organisational capacities, donor priorities, infrastructure limitations and the perceived usefulness of new tools among staff (Davis, 1989; Taiwo, Adebayo & Muriithi, 2022). While many humanitarian agencies recognise the potential benefits, the realities of limited budgets, unstable connectivity and varying levels of digital literacy often slow the pace of technological change (Kovács & Spens, 2023).

ADRA Rwanda, as part of the global Adventist Development and Relief Agency network, operates across diverse geographical and logistical contexts, making digital tools essential to achieving reliability and efficiency in its supply-chain activities (Encyclopedia of Seventh-day Adventists, 2020). Yet, the extent to which these tools are used—and the degree to which they influence performance—remain areas requiring clearer empirical understanding.

This study was therefore undertaken to examine the adoption and contribution of digital technologies within ADRA Rwanda's logistics operations. By exploring the technologies currently in use, assessing their level of integration and evaluating their impact on organisational performance, the research provides insight into how digital systems can support humanitarian logistics in a practical, context-appropriate manner. This understanding is particularly relevant at a time when many humanitarian organisations are under increasing pressure to

demonstrate efficiency, transparency and adaptability in their operations (Aditya, Kumar & Singh, 2024).

2. Problem Statement

Across the humanitarian sector, digital technologies are increasingly recognised as essential for improving the speed, accuracy and transparency of logistics operations. Tools such as barcode systems, digital inventory platforms and mobile data collection applications have been shown to enhance visibility across the supply chain and reduce operational inefficiencies that often hinder the timely delivery of assistance (Altay, Kovács & Spens, 2023; Christopher, 2016). Despite this global progress, adoption remains uneven, particularly among organisations operating in resource-limited environments where budget constraints, insufficient technical capacity and unreliable infrastructure are persistent challenges (Taiwo, Adebayo & Muriithi, 2022).

For ADRA Rwanda, these realities are especially relevant. The organisation manages complex logistics operations across diverse and remote locations, making digital systems potentially transformative in improving coordination, tracking and accountability. However, anecdotal assessments and internal observations suggest that while some digital tools are used, they may not be fully integrated or utilised to their potential. Advanced technologies—such as RFID systems, IoT sensors, cloud-based analytics and real-time tracking platforms—remain largely unexplored, even though similar tools have been shown to significantly strengthen humanitarian logistics performance in comparable contexts (Dubey, Gunasekaran & Childe, 2021; Rejeb, Rejeb & Zrelli, 2024).

This gap between technological possibilities and actual adoption presents a critical challenge. Without a clear understanding of which technologies are in use, how extensively they are integrated and the extent to which they contribute to operational performance, ADRA Rwanda may find it difficult to plan future investments, build staff capacity or align with emerging global standards in humanitarian logistics. Moreover, as donors increasingly expect efficient reporting and traceability, organisations that lag behind in digital transformation risk reduced responsiveness and weakened competitiveness (Savushkin, 2024).

This study therefore seeks to examine the adoption and contribution of digital technologies within ADRA Rwanda's logistics system. By identifying current practices and assessing their impact, the research addresses an important organisational knowledge gap and offers insights that can guide more strategic, sustainable and context-appropriate digital investments in the future.

3. Objectives of the Study

Understanding how digital systems shape logistics effectiveness requires a systematic examination of the technologies in use and the organisational conditions that influence their adoption. Prior studies emphasize that the successful integration of digital tools depends not only on technological availability but also on organisational readiness and staff perceptions (Davis, 1989; Assensoh-Kodua, 2019). Guided by this understanding, the study focused on the following specific objectives:

1. **To identify the digital technologies currently used within ADRA Rwanda's logistics and supply-chain management system.**

2. **To assess the level of adoption and integration of these technologies across planning, warehousing, transportation and other key logistics functions**, recognising that organisations often adopt technologies gradually depending on their capacities and operational context (Taiwo, Adebayo & Muriithi, 2022).

3. **To evaluate the extent to which digital technologies contribute to improvements in efficiency, visibility and responsiveness within ADRA Rwanda's logistics operations**, reflecting evidence from literature suggesting that even basic digital tools can significantly enhance humanitarian logistics performance (Altay, Kovács & Spens, 2023; Wamba & Queiroz, 2020).

These objectives ensured that the study remained grounded in both practical operational realities and established theoretical perspectives on technology adoption and performance improvement.

4. Theoretical Framework and Literature Review

Understanding how organisations adopt and use digital technologies requires grounding the analysis in established theoretical perspectives. This study draws on two complementary frameworks: the **Technology Acceptance Model (TAM)** and the **Technology–Organization–Environment (TOE)** framework. Together, these perspectives provide insights into how individual perceptions, organisational capacities and external conditions shape digital transformation in humanitarian settings.

The **Technology Acceptance Model**, developed by Davis (1989), suggests that individuals are more likely to adopt a technology when they perceive it as both useful and easy to use. In the context of humanitarian logistics—where staff juggle multiple responsibilities and often work under pressure—technologies that seem complicated or disruptive tend to be avoided, regardless of their potential benefits. Studies in non-profit and logistics environments show that simplicity and clarity influence adoption decisions as much as technical sophistication (Taiwo, Adebayo & Muriithi, 2022).

The **Technology–Organization–Environment (TOE)** framework expands this perspective by considering the wider organisational and contextual factors that influence digital adoption. It emphasises that decisions about new technologies depend not only on perceived usefulness but also on organisational readiness, availability of resources and external pressures such as donor requirements or regulatory expectations (Assensoh-Kodua, 2019). In the humanitarian sector, where budgets are limited and operations are frequently shaped by donor funding cycles, these factors play a decisive role (Taiwo, Adebayo & Muriithi, 2022).

Beyond theoretical considerations, existing literature underscores the transformative potential of digital technologies in humanitarian logistics. Scholars note that systems such as barcoding, GPS tracking, cloud-based inventory platforms and automated data-capture technologies can greatly enhance visibility, accuracy and coordination along the supply chain (Christopher, 2016; Wamba & Queiroz, 2020). More recent studies highlight the growing relevance of advanced tools—including IoT devices, blockchain platforms and predictive analytics—though their adoption remains uneven due to financial and technical constraints (Altay, Kovács & Spens, 2023; Rejeb, Rejeb & Zrelli, 2024).

Research also shows that digital maturity varies widely across humanitarian organisations. Some agencies have successfully implemented end-to-end digital tracking systems that strengthen monitoring and accountability (Hunt, 2022), while others rely heavily on manual processes or partial digitisation due to infrastructure limitations (Kovács & Spens, 2023). In low-resource contexts, organisations tend to prioritise technologies that are reliable, affordable and easy for staff to use—an approach consistent with the Resource-Based View, which suggests that sustainable competitive advantage emerges from capabilities that organisations can realistically maintain (Dubey, Gunasekaran & Childe, 2021).

In Rwanda, national policies such as the **Smart Rwanda Master Plan** emphasise digital integration across sectors, encouraging organisations to modernise workflows and strengthen ICT capacity (MINICT, 2025). Yet, the extent to which humanitarian agencies have aligned with these national priorities remains uneven, making empirical investigations both timely and necessary.

Taken together, these theoretical and empirical insights highlight the complexity of digital transformation in humanitarian logistics. They also reinforce the importance of examining not only which technologies are available, but how they are integrated, perceived and supported within organisations such as ADRA Rwanda.

5. Methodology

This study adopted a mixed-methods approach to gain a comprehensive understanding of how digital technologies are used within ADRA Rwanda's logistics operations. Combining quantitative and qualitative techniques allowed the research to capture both measurable trends and the practical experiences of staff who interact with digital tools in their daily work. Mixed-methods designs are widely recommended in organisational and logistics research because they integrate the strengths of numerical analysis with the depth of contextual insight (Christopher, 2016; Dubey, Gunasekaran & Childe, 2021).

The quantitative component of the study involved a structured questionnaire administered to 108 staff members across different departments. The survey explored the types of digital technologies currently in use, the frequency of their application and staff perceptions of their usefulness. This approach aligns with established practice in technology-adoption studies, which rely on structured measures to assess patterns of use and behavioural tendencies (Davis, 1989).

To complement the survey findings, qualitative data were collected through interviews with logistics and ICT officers whose roles give them direct responsibility for implementing and maintaining digital systems. These interviews provided more nuanced insights into the challenges and opportunities associated with digital adoption, echoing suggestions in the literature that qualitative inquiry is essential for understanding the contextual realities that influence technological uptake (Taiwo, Adebayo & Muriithi, 2022).

Data were analysed using descriptive statistics, weighted means and regression modelling to determine the association between technology adoption and logistics performance. Regression analysis has been widely used in logistics and supply-chain studies to assess how technological variables influence operational outcomes (Wamba & Queiroz, 2020). The qualitative data were analysed thematically, allowing recurring patterns, staff perspectives and operational challenges to be identified.

Ethical considerations were adhered to throughout the study. Participation was voluntary, confidentiality was maintained and the purpose of the research was clearly explained to all respondents. This ethical stance aligns with best practices in humanitarian research, where sensitivity to context and the protection of participant well-being are essential (Altay, Kovács & Spens, 2023).

Overall, the methodological approach ensured that the study captured both the measurable impact of digital technologies and the lived experiences of staff, providing a balanced and reliable foundation for interpreting the findings.

6. Findings and Discussion

This section presents the study's key findings and interprets them in light of existing scholarship on digital transformation and humanitarian logistics. The results reveal how ADRA Rwanda currently uses digital tools, where adoption remains limited and how these technologies affect operational performance.

6.1 Technologies Currently Used in ADRA Rwanda's Logistics System

6.1.1 General Adoption Patterns

The data show that ADRA Rwanda relies heavily on basic but dependable technologies, particularly barcode-based systems. Barcode scanning received the highest level of use (WM = 4.11), consistent with literature noting its affordability, ease of implementation and proven reliability in humanitarian environments (Christopher, 2016; Kovács & Spens, 2023). Manual inventory tracking also remains widely used (WM = 3.78), reflecting similar patterns reported in organisations operating under resource limitations (Altay, Kovács & Spens, 2023).

In contrast, more advanced tools—such as RFID, cloud-based inventory systems, GPS-enabled tracking and automated data-capture technologies—are rarely used, with weighted means below 2.0. These results align with findings that, while such technologies offer significant potential, their adoption is often hindered by cost, infrastructure requirements and the need for specialised

skills (Rejeb, Rejeb & Zrelli, 2024; Dubey, Gunasekaran & Childe, 2021).

6.1.2 Interpretation of the Pattern

The preference for barcode systems suggests that ADRA Rwanda prioritises technologies that strike a balance between functionality and feasibility. Barcodes require minimal investment and staff training while still providing meaningful improvements in accuracy and accountability—qualities especially valuable in humanitarian operations (Hunt, 2022). Conversely, the low adoption of RFID, IoT and cloud platforms reflects well-documented financial and contextual constraints faced by many relief organisations (Taiwo, Adebayo & Muriithi, 2022).

6.1.3 Theoretical Reflection

These findings resonate strongly with the **TOE framework**, which argues that technological adoption depends not only on the attractiveness of the innovation but also on an organisation's readiness and external pressures (Assensoh-Kodua, 2019). They also align with the **Resource-Based View**, which suggests that organisations gravitate toward technologies that they can maintain with existing capabilities (Dubey, Gunasekaran & Childe, 2021).

6.2 Use of Digital Technologies in Planning and Forecasting

6.2.1 Summary of Results

Predictive analytics emerged as the most widely used planning tool (WM = 3.89). Staff described it as accessible because it can be applied through spreadsheets, donor reporting templates and basic data models—consistent with evidence that organisations often adopt low-cost analytics before more advanced tools (Wamba & Queiroz, 2020).

More sophisticated technologies such as artificial intelligence, IoT sensors, Big Data platforms and blockchain scored very low, mirroring global findings that these tools remain largely conceptual in humanitarian settings due to resource constraints (Fernández-Caramés & Fraga-Lamas, 2019; Rejeb, Rejeb & Zrelli, 2024).

6.2.2 Interpretation of Findings

Interview insights confirmed that staff recognise the value of advanced digital tools but feel constrained by limited infrastructure, unstable connectivity and insufficient technical expertise. These patterns echo the **Technology Acceptance Model**, which emphasises perceived usefulness and ease of use as critical determinants of adoption (Davis, 1989).

6.3 Contribution of Digital Technologies to Logistics Performance

6.3.1 Key Findings

Respondents widely agreed that digital technologies contribute positively to several aspects of logistics performance. Monitoring and evaluation recorded the highest perceived benefit (WM = 3.89), followed by distribution logistics (WM = 3.87). These outcomes reinforce findings that even modest digital systems can strengthen transparency and operational reliability (Christopher, 2016; Altay, Kovács & Spens, 2023).

Procurement exhibited the lowest perceived digital benefit, indicating an area where upgrading systems could substantially improve coordination and accountability. Similar gaps have been documented in other humanitarian organisations with partial digitisation (Kovács & Spens, 2023).

6.3.2 Regression Analysis Insight

The regression analysis yielded a notable result: technology adoption accounts for **92.4%** of the variation in logistics performance. This aligns with research highlighting the strong association between digital integration and improved supply-chain outcomes, even when basic technologies are used (Wamba & Queiroz, 2020).

6.3.3 Interpretation

These findings affirm that digital transformation does not require highly advanced systems to deliver impact. Foundational tools—when used consistently and effectively—can significantly enhance visibility, accuracy and coordination. This is consistent with the humanitarian logistics literature, which emphasises the importance of appropriate, context-sensitive technology rather than sophisticated systems that may be difficult to maintain (Hunt, 2022; Savushkin, 2024).

6.4 Synthesis of Key Insights

Three major themes emerge from the findings:

1. **Basic digital tools remain the backbone of ADRA Rwanda's logistics operations**, mirroring trends across the humanitarian sector (Altay, Kovács & Spens, 2023).

2. **Advanced technologies remain largely inaccessible**, reflecting known financial, infrastructural and capacity-related barriers (Rejeb, Rejeb & Zrelli, 2024).

3. **Even simple technologies contribute substantially to operational performance**, reinforcing the view that incremental digital improvements can produce meaningful gains in accountability and responsiveness (Christopher, 2016; Wamba & Queiroz, 2020).

Together, these insights suggest that ADRA Rwanda is proceeding through a gradual and realistic digital transformation—one grounded in practical constraints and organisational strengths, rather than rapid adoption of high-cost innovations.

7. Conclusion

This study set out to examine how digital technologies are adopted and applied within the logistics and supply-chain operations of ADRA Rwanda. The findings reveal a digital environment shaped by practical constraints, organisational capacity and the need for reliable tools that can withstand demanding operational conditions. Similar patterns have been observed across humanitarian logistics, where the realities of limited budgets, variable infrastructure and staffing challenges significantly

influence the pace and nature of digital transformation (Altay, Kovács & Spens, 2023; Taiwo, Adebayo & Muriithi, 2022).

A key conclusion from this study is that ADRA Rwanda's logistics system is built largely on simple but dependable technologies. Barcode systems and manual inventory processes remain central, aligning with research suggesting that humanitarian organisations often prioritise affordable and resilient tools that can function effectively in diverse environments (Christopher, 2016; Kovács & Spens, 2023). While advanced technologies such as RFID, IoT and cloud-based platforms offer considerable potential, their adoption remains limited due to financial constraints, technical requirements and the need for more robust infrastructure (Rejeb, Rejeb & Zrelli, 2024).

The study also found that planning and forecasting processes have benefited from the use of predictive analytics, a tool commonly adopted in settings where more sophisticated analytics platforms remain inaccessible (Wamba & Queiroz, 2020). Staff members acknowledged the potential value of more advanced technologies but highlighted challenges—including skill gaps and connectivity issues—that prevent full integration. These observations align with the Technology Acceptance Model, which emphasises that adoption is strongly influenced by ease of use and perceived usefulness (Davis, 1989).

Perhaps the most striking result is the regression finding that technology adoption explains **92.4%** of the variation in logistics performance. This reinforces established evidence that even modest digital improvements can significantly enhance operational efficiency, visibility and accountability in humanitarian supply chains (Dubey, Gunasekaran & Childe, 2021; Savushkin, 2024).

Overall, the study suggests that ADRA Rwanda is advancing through a gradual and realistic pathway of digital transformation—strengthening foundational tools before venturing into more complex systems. This incremental approach is consistent with broader research advocating for context-appropriate technological evolution in the humanitarian sector, where sustainability and usability are often more critical than sophistication (Hunt, 2022; Altay, Kovács & Spens, 2023).

By documenting both achievements and remaining gaps, this study contributes to a clearer understanding of how digital technologies shape humanitarian logistics in Rwanda. It also provides a foundation for future strategic planning, capacity building and targeted investment as the organisation continues its digital journey.

8. Recommendations

The findings of this study highlight several opportunities for ADRA Rwanda to strengthen its digital capabilities and build a more integrated, efficient logistics system. These recommendations are grounded in both the empirical results and broader insights from humanitarian logistics literature.

8.1 Strengthen Foundational Digital Infrastructure

Digital transformation must begin with a solid technical foundation. Improving internet reliability, upgrading outdated hardware and ensuring consistent access to digital tools across project sites would create an environment where technology can function effectively. Similar studies show that infrastructure limitations are among the most significant barriers to digital adoption in humanitarian settings (Kovács & Spens, 2023; Taiwo, Adebayo & Muriithi, 2022).

8.2 Invest in Staff Digital Skills and Ongoing Capacity Building

The study revealed that staff capacity is a key determinant of technology adoption. Regular training on digital literacy, data management and troubleshooting would empower staff to use existing tools more effectively. This aligns with the Technology Acceptance Model, which emphasises that perceived ease of use strongly influences adoption (Davis, 1989). Capacity-building initiatives have also been shown to sustain technology use in resource-constrained organisations (Altay, Kovács & Spens, 2023).

8.3 Digitise Procurement and Promote System Integration

Procurement was found to be the least digitised function. Introducing an electronic procurement system—capable of managing quotations, approvals and supplier information—would improve accountability and reduce delays. Research indicates that fragmented systems hinder supply-chain visibility, while integrated platforms significantly enhance performance (Wamba & Queiroz, 2020; Christopher, 2016).

Over time, linking procurement with warehousing, transport and reporting systems would promote end-to-end visibility, a core feature of mature digital supply chains (Rejeb, Rejeb & Zrelli, 2024).

8.4 Align Technology Investments with Organisational Strategy and Donor Priorities

Digital transformation is more effective when guided by a clear strategic direction. Developing a digital roadmap aligned with ADRA Rwanda's long-term objectives—and coordinating closely with donors—would ensure targeted and sustainable investments. Studies show that donor-driven priorities significantly shape the technologies humanitarian organisations adopt (Taiwo, Adebayo & Muriithi, 2022; Hunt, 2022).

8.5 Adopt a Phased, Realistic Approach to Digital Transformation

Given the financial and operational constraints highlighted in the study, a phased approach is advisable. Beginning with strengthening basic systems—such as barcoding, mobile reporting tools and simplified digital inventory platforms—creates a stable foundation for future adoption of more advanced technologies. This is consistent with literature advocating for context-appropriate and gradual digital evolution in the humanitarian sector (Altay, Kovács & Spens, 2023; Savushkin, 2024).

8.6 Strengthen Data Governance and Security Practices

As more processes become digitised, data security becomes increasingly important. Establishing clear

policies on data storage, privacy, access rights and system backups would safeguard sensitive information. Emerging research emphasises the growing cyber risks faced by humanitarian organisations and the need for proactive protection measures (Fernández-Caramés & Fraga-Lamas, 2019).

Summary

Collectively, these recommendations support a sustainable, capacity-focused and strategically aligned digital transformation path for ADRA Rwanda. By reinforcing foundational systems, strengthening staff skills and adopting technologies that match organisational realities, the organisation can enhance visibility, efficiency and accountability across its logistics operations—achieving meaningful digital progress without overextending its resources.

9. Suggestions for Further Study

While this study provides meaningful insights into digital technology adoption within ADRA Rwanda's logistics operations, several areas remain open for deeper investigation. These suggestions for further research draw on both the study's findings and broader gaps identified in humanitarian logistics literature.

9.1 Comparative Research Across Multiple Humanitarian Organisations

This study examined a single organisation. Comparative studies involving several humanitarian agencies—both within Rwanda and across the East African region—would help to identify shared patterns, context-specific challenges and best practices. Prior research suggests that organisational structures, donor engagement and operational environments can lead to significant differences in technological maturity (Altay, Kovács & Spens, 2023; Kovács & Spens, 2023).

9.2 Examining the Influence of Donor Funding on Digital Adoption

Donor expectations increasingly shape digital investment decisions in the humanitarian sector. Future research could explore how funding cycles, reporting requirements and partner priorities influence which technologies organisations adopt. Studies highlight that donor-driven digitalisation can either accelerate or constrain technological progress depending on alignment with organisational capacity (Taiwo, Adebayo & Muriithi, 2022; Hunt, 2022).

9.3 Longitudinal Studies on Digital Transformation in Humanitarian Settings

Digital transformation often unfolds gradually. Longitudinal studies would provide insights into how technology adoption evolves over time, how staff competencies change and how sustained digital investments influence performance. Such an approach would enrich current understanding of digital maturity within humanitarian operations (Rejeb, Rejeb & Zrelli, 2024).

9.4 Assessing the Feasibility of Advanced Technologies in Resource-Limited Environments

Although advanced tools such as IoT sensors, blockchain, automated data-capture systems and machine learning platforms hold significant potential, their feasibility in humanitarian logistics remains largely untested. Pilot studies could explore how these technologies perform under real operational constraints, building on emerging research about their applicability in supply-chain environments (Fernández-Caramés & Fraga-Lamas, 2019; Wamba & Queiroz, 2020).

9.5 Exploring the Human and Cultural Dimensions of Technology Adoption

Technology adoption is shaped not only by technical factors but also by human attitudes, workplace culture and organisational norms. Future research could examine staff perceptions, change management strategies and leadership roles in supporting digital transformation. The Technology Acceptance Model (Davis, 1989) and Resource-Based View (Dubey, Gunasekaran & Childe, 2021) provide useful starting points for such inquiries.

9.6 Policy-Level Research on National Digital Integration in the Humanitarian Sector

Rwanda's national ICT strategies, such as the Smart Rwanda Master Plan, emphasise digital innovation across sectors (MINICT, 2025). Further research could explore how national policies, public–private partnerships and regulatory frameworks shape the digital capabilities of humanitarian organisations operating within the country.

Summary

These avenues for future research reflect the multi-layered nature of digital transformation in humanitarian logistics. By exploring these areas, scholars can contribute to a deeper and more nuanced understanding of how technology can be leveraged to strengthen accountability, efficiency and operational resilience in humanitarian supply chains

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