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RESEARCH ARTICLE

LEVERAGING ICT FOR SUSTAINABLE SUPPLY CHAIN MANAGEMENT IN MALAWI ENHANCING TRANSPARENCY, EFFICIENCY, AND SUSTAINABLE PRACTICES

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ABSTRACT

This study, titled *Leveraging ICT for Sustainable Supply Chain Management in Malawi: Enhancing Transparency, Efficiency, and Sustainable Practices*, explores the transformative potential of Information and Communication Technology (ICT) tools within Malawi's supply chain sector. Despite its critical role in economic development, the sector's integration of advanced ICT solutions, such as Artificial Intelligence (AI), Blockchain, Internet of Things (IoT), and Enterprise Resource Planning (ERP) systems, remains underdeveloped. The research aims to assess ICT adoption levels, identify associated benefits and challenges, and propose actionable recommendations to enhance operational efficiency and sustainability. Employing a mixed-methods approach, the study integrates qualitative interviews with supply chain professionals from key organizations Rab's Processors, Ethanol Company Limited, BNC Packaging Limited, and Lujeri Tea Estate and quantitative surveys targeting IT managers, procurement officers, warehouse supervisors, and logistics managers. Comparative secondary data analysis, including insights from Hsin's (2008) study in Tunisia, further contextualizes the findings. Results indicate limited adoption of advanced ICT tools, with no evidence of AI or Blockchain implementation among the surveyed organizations. However, ERP systems and IoT tools were widely used, contributing to improved cost management and operational efficiency. Despite challenges such as resource constraints and respondent bias, the study highlights significant opportunities for advancing ICT integration. The findings emphasize the urgency for policymakers to incentivize ICT adoption through targeted training, infrastructure development, and public-private partnerships. Embracing these technologies can enhance transparency, competitiveness, and sustainable economic growth. Future research should focus on identifying barriers to ICT adoption and conducting cross-country comparisons to establish a comprehensive framework for ICT integration in developing economies.

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INTRODUCTION

In an increasingly globalized economy, supply chain management has emerged as a cornerstone of economic development, particularly for developing countries like Malawi. Supply chains serve as the backbone of various industries, from agriculture to manufacturing, driving economic growth and societal progress. However, the dynamic nature of supply chains necessitates the adoption of innovative tools to ensure efficiency, transparency, and sustainability (Christopher, 2016). Information and Communication Technology (ICT) has revolutionized global supply chains by enabling real-time data sharing, automation, and enhanced collaboration. Tools such as Artificial Intelligence (AI), Blockchain, Internet of Things (IoT), and Enterprise Resource Planning (ERP) systems have proven instrumental in improving operational efficiency and transparency across supply chains in developed economies (Wang et al., 2020). Despite these advancements, Malawi's supply chain sector remains largely traditional, characterized by limited integration

of advanced ICT tools. This presents a significant hurdle to achieving economic resilience and sustainability in the country. Given the critical role of supply chains in addressing Malawi's socio-economic challenges, leveraging ICT has become a pivotal conversation to enhance competitiveness and foster sustainable growth. While ICT adoption in supply chain management has been extensively studied in developed nations, research in the context of developing economies like Malawi remains scarce. Existing studies highlight the potential benefits of ICT, such as improved cost management, waste reduction, and enhanced decision-making processes (Kamble et al., 2019). However, the adoption of cutting-edge ICT tools like AI and Blockchain in Malawi's supply chain sector remains almost non-existent. Organizations in Malawi, such as Rab's Processors and Lujeri Tea Estate, have implemented ERP systems and IoT technologies to streamline operations, but the lack of advanced ICT adoption limits their ability to address challenges such as inefficiencies, lack of transparency, and unsustainable practices. Moreover, the absence of policy frameworks, infrastructure, and technical expertise further

exacerbates this gap, hindering the potential for ICT-driven transformation in the sector. This study aims to address the existing research gap by evaluating the current state of ICT adoption in Malawi's supply chain sector. Through a mixed-methods approach combining qualitative interviews, quantitative surveys, and secondary data review, the study seeks to:

- Assess the adoption levels of ICT tools, including ERP systems, IoT, AI, and Blockchain.
- Identify the benefits and challenges faced by organizations in implementing these technologies.
- Provide actionable recommendations to accelerate ICT adoption for enhanced transparency, efficiency, and sustainability in supply chains.

By offering a comprehensive analysis of the opportunities and challenges associated with ICT integration, this research contributes to the body of knowledge on sustainable supply chain management in developing economies. Furthermore, the findings aim to guide policymakers, industry stakeholders, and organizations in fostering a more efficient and sustainable supply chain ecosystem in Malawi.

LITERATURE REVIEW

Introduction: The increasing integration of information technology (IT) into supply chain management has opened new pathways for achieving sustainability. This literature review examines the role of IT in fostering sustainable supply chains by exploring its applications, benefits, and challenges. The reviewed literature spans studies on IT tools such as enterprise resource planning (ERP), the Internet of Things (IoT), artificial intelligence (AI), and blockchain technology, emphasizing their impact on sustainability.

The Concept of Sustainability and Supply Chain Management: Sustainability, as defined by the Brundtland Commission, is "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (Ramaswamy, 2017). Sustainable supply chain management (SSCM) extends this concept by incorporating social and environmental considerations into supply chain operations, thereby enhancing long-term organizational success (Ramadhan & Haidir, 2023). Supply chain management (SCM) involves the flow of materials, information, and finances from producers to consumers (Ramadhan & Haidir, 2023). Incorporating sustainability into SCM requires leveraging IT to enhance transparency, efficiency, and collaboration across all supply chain levels (Corallo et al., 2024).

IT Tools and Techniques for Sustainable Supply Chains: Enterprise Resource Planning (ERP) and Supplier Management While ERP systems are fundamental to supply chain operations, they are insufficient for achieving full transparency and addressing issues at supplier, factory, and subcontractor levels (Ramaswamy, 2017). Advanced IT tools such as supplier management systems and business process engineering have proven effective in enhancing supplier

relations and assessing sustainability performance (Watson et al., 2010).

Internet of Things (IoT) and Big Data Analytics: IoT enables machine-to-machine interactions through interconnected devices, decentralizing decision-making and enhancing data collection (Xu et al., 2014). In agriculture, IoT sensors monitor air quality and CO2 emissions, promoting environmentally sustainable practices (Corallo et al., 2024). Big data analytics, characterized by its volume, variety, velocity, and value, facilitates forecasting, quality control, and risk prevention in supply chains (Witkowski, 2017).

Artificial Intelligence (AI) and Blockchain Technology: AI supports decision-making by offering predictive analytics and enabling autonomous production systems, such as driverless vehicles and smart manufacturing (Sharma et al., 2018). Blockchain technology enhances supply chain transparency and data security through immutable records, ensuring trust and reliability in sustainability efforts (Esmaelian et al., 2020).

Green Supply Chain Management (GSCM) and Supply Chain Resilience (SCR): ICT adoption significantly improves GSCM and SCR by enabling efficient communication, real-time data sharing, and risk mitigation (Papachristos et al., 2023). Firms with robust ICT systems can optimize inventory, implement flexible sourcing, and enhance overall resilience (Papachristos et al., 2023).

Advanced IT Applications: Emerging technologies such as cloud computing, 3D printing, and advanced robotics further enhance SSCM by streamlining operations and reducing environmental impact. For instance, real-time data from IoT devices can identify disruptions early, mitigating risks and improving sustainability (Ramadhan & Prastya, 2023).

Challenges in IT-Driven SSCM: The adoption of IT for SSCM faces several barriers, including high implementation costs, personnel training requirements, and the need for redesigning business processes (Papachristos et al., 2023). Smaller firms, in particular, struggle with resource constraints, which limit their ability to adopt advanced IT systems (Papachristos et al., 2023). Additionally, balancing profitability with sustainability and resilience remains a critical challenge (Papachristos et al., 2023).

Future Research Directions: Further research is needed to develop SSCM maturity models that assess the soundness of supply chains and guide industries towards sustainable development (Chiang et al., 2021). Studies should also explore the integration of diverse IT tools to create more adaptable and efficient supply chain systems (Thöni & Tjoa, 2017).

METHODOLOGY

This study has been conducted using a mixed methods approach, which is a combination of the quantitative and qualitative research methods into a single study. Mixed methods are more often employed when there is need to get a broader comprehension of the gap that is at hand (Almeida, 2018). According to Almeida (2018), this approach offers

advantages that using either the quantitative or qualitative method alone can not offer. This is mainly because the method allows the researcher to obtain knowledge that could not be apprehended from using each of the methods alone by overcoming the limitations that come with each. The study by Almeida (2018) has shown that mixed methods are gaining a popularity in the research community, hence it is only right that this study follows this approach due to its many proven benefits. The approach incorporated the quantitative part of the mixed methods through the use of an online survey, so as to allow for easy accessibility and distribution of the survey. Online surveys play an important role in ensuring that the collection of data is available to large numbers of individuals and it also exposes researchers to unbelievable number of respondents without making a dent in their pockets (Couper, 2000). Arguably, some believe that online surveys will take over traditional data collection methods due to their fast growth on the internet (Couper, 2000). Therefore, it was the right thing to use an online survey for the quantitative part of the research to ensure a wider reach without breaking the bank.

The survey was structured in a way that is easy to follow and understand. The first section requested the demographic information, the second section enquired about the ICT tools they use, the third section focused on the benefits that they have from using the stated tools, the fourth section examined challenges to ICT adoption, and the last section explored future plans for adopting ICT tools. In the survey critical questions were structured with options for respondents to choose from, which enabled an easy analysis of the data. Please refer to the appendix for the survey's format.

On the other hand, the qualitative side of the research was attained by conducting interviews with industry professionals that are directly involved in supply chain management. "The purpose of the qualitative research interview is to contribute to a body of knowledge that is conceptual and theoretical and is based on the meanings that life experiences hold for the interviewees" (DiCicco-Bloom, 2006). In an interview specific questions are asked to get an in-depth understanding on different aspects of the research topic. Interviewees often answer these questions according to their life experiences and the knowledge they have obtained along the way related to the topic at hand. That's why this research made use of interviews to obtain qualitative data. The Interview targeted Industry professionals in the supply chain sector, so that the data collected data is relevant and has an impact on the results we get after analysis. Appointments with the procurement officer from the Malawi Institute of Tourism, an operations manager from Lujeri Tea Estate and an ICT manager from Catholic University of Malawi were scheduled to interview them and gather insights on the topic at hand. To ensure relevance similar questions to those in the survey were asked during the interview, only that interviewees gave descriptive answers, detailing the reasons behind their answers. Please refer to the appendix for an Interview transcript with the procurement officer from the Malawi Institute of Tourism. The sample size of this study was determined as ten companies, specifically focusing on the top ten major companies in supply chain management. These companies were selected based on their significant influence and leadership within the industry. This ensured that the data collected provided a comprehensive understanding of ICT adoption trends and challenges among leading industry players. The data analysis combined quantitative and qualitative techniques, leveraging the strengths

of the mixed methods approach. For the quantitative data from the online survey, descriptive statistics were used to summarize key findings. Responses were categorized and analyzed using statistical tools to identify trends, frequencies, and relationships. Visual representations, such as graphs and charts, were created to simplify interpretation. Key metrics analyzed included ICT tool usage frequency, perceived benefits, challenges in adoption, and future ICT adoption plans. This provided a detailed overview of the quantitative aspects of the research questions (Creswell, 2014). For qualitative data from the interviews, thematic analysis was conducted to identify recurring themes and patterns. Interview transcripts were thoroughly reviewed, and data were coded into overarching themes, such as "benefits of ICT tools," "adoption challenges," and "future ICT strategies." Thematic coding involved several stages: familiarizing with the data, generating initial codes, identifying themes, refining themes, and defining their scope. NVivo software facilitated systematic coding and organization of qualitative data (Braun, 2006). The integration of quantitative and qualitative findings was achieved through triangulation. This involved comparing survey results with interview insights to identify consistencies and discrepancies. Triangulation provided a nuanced understanding of ICT adoption in supply chain management, highlighting both general trends and in-depth perspectives. The synthesis of findings ensured the study's conclusions were robust, comprehensive, and reflective of diverse viewpoints (Tashakkori, 2010).

The ethical considerations of this study adhered to principles of respect for persons, beneficence, and justice to ensure responsible research practices. Before data collection began, ethical approval was secured to safeguard participants' rights and well-being. Participants were informed about the study's purpose, the data collection methods, and the intended use of the findings. Informed consent was obtained from all participants prior to their involvement. For the online survey conducted using Google Forms, a consent statement was included at the start of the survey, requiring participants to agree before proceeding. Interview participants received detailed explanations of the research and provided verbal or written consent before participating. Confidentiality and anonymity were prioritized throughout the research. Survey responses were collected without identifying information, ensuring participants' anonymity, and interview data were anonymized to protect their identities. All collected data were securely stored on password-protected devices, accessible only to the researcher. Participants were also informed of their voluntary participation and their right to withdraw at any stage without penalty. These measures adhered to ethical standards and fostered trust between the researcher and the participants (BERA, 2018).

RESULTS

Upon gathering all the information from the online survey and the interviews, the data was analyzed based on its qualitative or quantitative nature. The findings from the interviews were used to complement those from the online survey, creating a cohesive presentation of results. This section outlines the adoption levels of ICT tools within Malawi's supply chain sector, along with the associated challenges and benefits. The analysis provides a comprehensive overview of how ICT tools are currently utilized, the advantages they offer, and the obstacles organizations face during implementation.

Adoption of ICT Tools: The results reveal the current landscape of ICT adoption in Malawi’s supply chain sector. Respondents were asked to identify the ICT tools their organizations currently use for supply chain management (e.g., Enterprise Resource Planning (ERP) systems, IoT, Blockchain and AI). A significant portion of organizations (exactly 50%) reported using ERP systems, while others (around 40%) adopted the use of Internet of Things (IoT). Please refer to Figure 1.



Figure 1. Adopted ICT Tools

When rating the importance of ICT in supply chain processes, 80% of respondents acknowledged it as either “important” or “critical,” indicating widespread recognition of ICT’s role in optimizing operations (Mentzer et al., 2001). Please refer to figure 2.

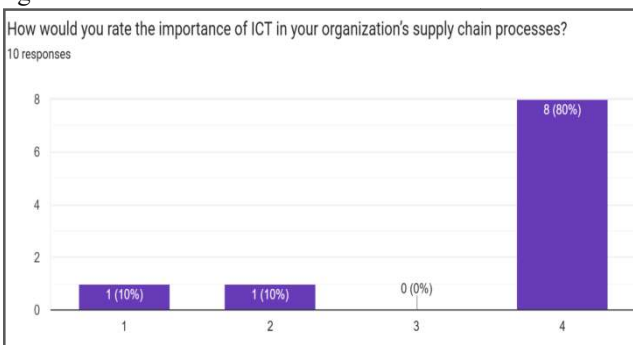


Figure 2. Importance of ICT tools

Additionally, data on the duration of ICT usage in supply chain management showed varying levels of maturity, with 50% of organizations having integrated these tools for over five years, while 10% were relatively new adopters. Please refer to figure 3.

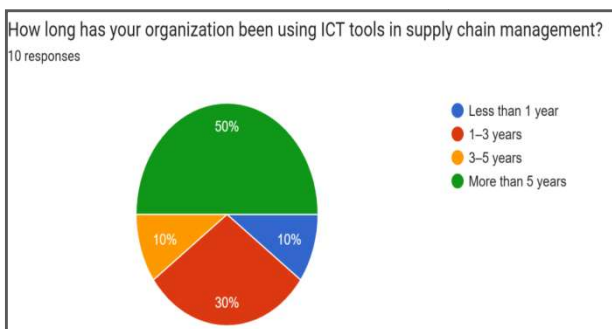


Figure 3. Duration of ICT tools usage in SCM

Benefits of ICT Adoption: The adoption of ICT tools has contributed significantly to improving various aspects of supply chain. Respondents evaluated the extent of

improvement in areas such as transparency, process efficiency, sustainability, decision making, and cost management. The responses, rated on a scale of 1 to 5 (1 = No improvement, 5 = Significant improvement), highlighted significant improvement, particularly in efficiency and cost management. Refer to figure 4.

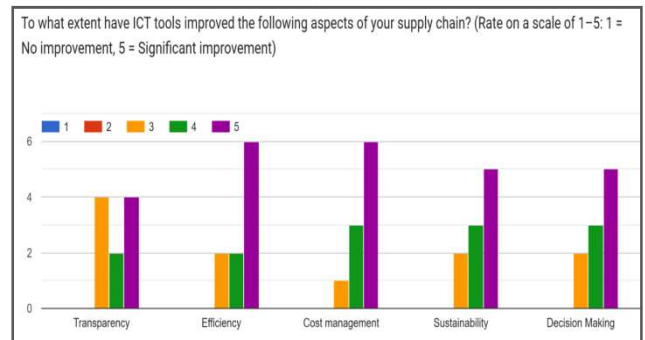


Figure 4. Aspects improved by ICT tools

Furthermore, a substantial proportion of organizations (90%) confirmed that ICT adoption positively contributed to achieving their sustainability goals. These findings underscore the transformative potential of ICT in enhancing operational efficiency and promoting sustainable practices (Bowersox et al., 2013). Refer to figure 5



Figure 5. ICT adoption contribution to sustainability goals

Challenges of ICT adoption: Despite the benefits, organizations in Malawi’s supply chain sector face considerable challenges in adopting ICT tools. Key challenges identified include high implementation costs (reported by 60% of respondents), lack of digital skills (40%), resistance to change (30%), and limited infrastructure (10%). Refer to figure 6.

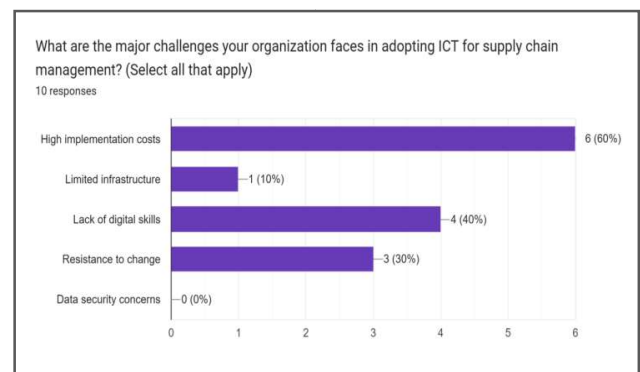


Figure 6. Challenges faced in adopting ICT for supply chain management

These challenges were further corroborated by qualitative insights from interviews. For instance, one respondent stated, "The cost of implementing ERP systems is prohibitive, and we lack the local expertise to maintain these systems effectively." Another emphasized the importance of government support, saying, "Without infrastructure development and affordable internet access, ICT adoption will remain limited." Participants were asked to rate the impact of these challenges on ICT adoption on a scale of 1 to 5 (1 = No impact, 5 = Major impact). Among the most significant barriers were Technological complexity and poor internet connectivity. Refer to figure 7.

How would you rate the following challenges in terms of their impact on ICT adoption? (Rate on a scale of 1-5: 1 = No impact, 5 = Major impact)

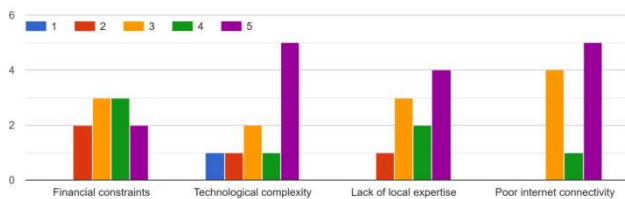


Figure 7. Challenges and their impact on ICT adoption

Practical Implications: The findings emphasize the need for strategic interventions to enhance ICT adoption in Malawi's supply chain sector, necessitating collaboration among stakeholders such as policymakers, training institutions, and supply chain managers to address the identified challenges. Government and private sector partnerships could provide financial support through subsidies or low-interest loans to reduce implementation costs, while training programs should focus on building local expertise in ICT for supply chain management. Additionally, investments in reliable internet connectivity and power supply are essential to support ICT tools. In conclusion, although ICT adoption in Malawi's supply chain sector offers significant benefits, overcoming the challenges will require coordinated efforts to unlock its full potential.

DISCUSSION

After conducting a successful review across several organizations in Malawi's supply chain sector, including Rab's Processors, Ethanol Company Limited, BNC Packaging Limited, Lujeri Tea Estate, and others, key findings revealed that none of these organizations have adopted Artificial Intelligence (AI) and Blockchain as tools for supply chain management. However, the majority have implemented Enterprise Resource Planning (ERP) systems and the Internet of Things (IoT) to manage their supply chain processes effectively. This review required a comprehensive analysis of the entire country, which presented certain limitations. The first challenge was ensuring participation from all regions of Malawi. Limited financial resources restricted our ability to conduct in-person reviews across the country. To address this, a survey was conducted online, enabling wider and more efficient distribution across the country. This approach reduced geographical bias and ensured more inclusive responses. Another limitation was the potential for respondents to provide inaccurate or unreliable answers, which could affect data

quality. To mitigate this, the survey specifically targeted relevant stakeholders, including IT managers, procurement officers, warehouse supervisors, and logistics managers. Screening questions were also used to filter out unqualified respondents, ensuring that the data collected was both reliable and relevant. To the best of our knowledge, this is the first study assessing the adoption of ICT tools in supply chain management within Malawi. This represents a significant strength, as it sets a foundation for future research in this area. The findings serve as an eye-opener for organizations to start embracing advanced ICT tools, such as AI and Blockchain, to improve operational efficiency and remain competitive. According to a study conducted in Tunisia by Hsin (2008), titled '*Adoption of Supply Chain Management Technologies by Small and Medium Enterprises in the Manufacturing Sector*', companies that adopted ICT tools reported a decrease in labor used for the purchasing process, leading to significant cost reductions. This finding is consistent with our study in Malawi, where most companies reported improved cost management after adopting ICT tools for similar processes. The practical implications of this study are significant. Organizations in Malawi's supply chain sector can improve efficiency and transparency by embracing technologies such as AI and Blockchain. Policymakers may use these findings to create targeted initiatives that encourage ICT adoption through incentives, training, and infrastructure development. Additionally, this study provides a foundation for future research to investigate specific barriers to AI and Blockchain adoption or conduct cross-country comparisons. This will help create a clearer roadmap for advancing ICT integration in supply chain management across developing economies.

CONCLUSION

The reviewed literature highlights the transformative role of IT in achieving sustainable supply chains. From ERP systems to blockchain technology, IT tools enhance transparency, efficiency, and resilience in supply chain operations. However, addressing challenges such as high costs and resource constraints is essential to maximize the benefits of IT-driven SSCM. Continued innovation and research will be critical in advancing sustainable supply chains for a more sustainable future.

Conclusion

This study provides a comprehensive analysis of the adoption, benefits, and challenges of ICT tools in Malawi's supply chain sector. The results reveal that while there is notable progress in the adoption of ERP systems (50%) and IoT technologies (40%), advanced tools such as Blockchain and AI remain largely unexplored. This reflects both the potential for growth and the necessity for deliberate strategies to bridge the technological gaps. ICT adoption has already demonstrated significant improvements in operational efficiency, cost management, and sustainability. An overwhelming 90% of respondents confirmed ICT's positive contribution to achieving sustainability goals, emphasizing its transformative potential. Furthermore, 80% of respondents identified ICT as critical to optimizing supply chain processes, reinforcing its strategic importance. Despite these benefits, substantial challenges persist, including high implementation costs, limited digital skills, resistance to change, and inadequate infrastructure.

These barriers significantly impede broader ICT adoption, as confirmed by both quantitative data and qualitative insights. Key informants highlighted the need for enhanced government support, affordable internet access, and targeted capacity-building initiatives. The study emphasizes practical implications, urging stakeholders to collaborate on solutions to these challenges. Policy interventions, such as subsidies and low-interest loans, can mitigate financial constraints, while partnerships between the public and private sectors can address infrastructure deficiencies. Training programs to enhance local expertise and the promotion of digital literacy are essential to overcoming skill gaps. Future research should explore advanced ICT tools like Blockchain and AI, which were notably absent in the studied organizations, and investigate cross-sector comparisons to draw broader conclusions. Such efforts will deepen understanding and provide actionable frameworks to accelerate ICT integration in Malawi's supply chain sector. By addressing these challenges through coordinated efforts, Malawi can unlock the full potential of ICT to enhance transparency, efficiency, and sustainability, contributing to the country's economic growth and alignment with global supply chain standards.

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