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# UNLOCKING SACCOS' POTENTIAL THROUGH IOT TO ENHANCE EFFICIENCY, RISK PROFILING, AND MEMBER ENGAGEMENT: A CASE OF KILIMANJARO REGION, TANZANIA.

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**ABSTRACT:** Savings and Credit Cooperative Organisations (SACCOS) underpin financial inclusion for underserved and rural communities, yet they struggle with service-delivery inefficiencies, weak member engagement, high loan-default risk, and opaque operations that fuel membership churn. As digital transformation sweeps the financial sector, Internet-of-Things (IoT) technologies have emerged as a promising catalyst for stronger SACCOS performance and sustainability. This study evaluates the feasibility and perceived value of IoT integration in SACCOS performance across Tanzania using a cross-sectional survey as the sole data-collection method. Structured questionnaires were administered to 131 board members, managers, loan officers, and ordinary members across 10 SACCOS. Using multiple linear regression, the study assessed ten digital - transformation predictors against overall SACCOS performance. The model demonstrated excellent fit ( $R = 0.990$ ;  $R^2 = 0.980$ ; Adjusted  $R^2 = 0.978$ ;  $SE = 0.160$ ;  $F(10, 120) = 578.320$ ,  $p < 0.001$ ). Statistically significant positive predictors included Perceived Organizational Support for Digital Transformation ( $B = 0.701$ ,  $p < 0.001$ ), Perceived Benefits of IoT Applications ( $B = 0.142$ ,  $p = 0.008$ ), Loan - Repayment Alert System ( $B = 0.105$ ,  $p = 0.006$ ), Digital Record - Keeping Implementation ( $B = 0.074$ ,  $p = 0.020$ ), Infrastructure and Technical Challenges ( $B = 0.082$ ,  $p = 0.026$ ), and Cybersecurity and Data Privacy ( $B = 0.113$ ,  $p = 0.046$ ). In contrast, Asset - Tracking Beacon Deployment exhibited a negative association ( $B = -0.117$ ,  $p = 0.010$ ), suggesting premature or unsupported deployments that hinder performance. These findings imply that successful IoT integration in SACCOS requires more than procuring ICT devices, it depends critically on robust organizational backing, clear demonstration of practical benefits, comprehensive digital - record processes, and strong security measures. The study recommends that, SACCOS must secure visible commitment from leadership on establishing ICT governance structures, allocating dedicated digital - transformation budgets, and setting clear performance targets to ensure technology initiatives align with strategic goals. It is equally important to provide hands - on training and change - management support for both staff and members, ensuring that everyone adopt new IoT workflows confidently.

**Keywords:** Savings and Credit Cooperative Organizations (SACCOS), Internet of Things (IoT), Financial Inclusion, Digital Transformation, Cyber Security.

## INTRODUCTION

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Proceedings of the 8<sup>th</sup> CUK Annual Scientific Conference, 2025, on Co-operatives Build a Better World: Re-energizing the Collective Power of Co-operatives in Africa.

Savings and Credit Cooperative Organisations (SACCOS) are widely recognized as vital instruments for promoting financial inclusion where a significant portion of the population faces economic hardship (Aouedi et al., 2024). They bridge the gap in areas with limited conventional banking infrastructure, empowering low-income individuals and small businesses to build economic resilience and alleviate poverty. In Tanzania, SACCOS facilitate savings mobilization and provide affordable credit, driving socio-economic progress by enhancing living standards, supporting income-generating activities, and fostering community development (Wang et al., 2021). The performance and continuity of SACCOS depend on multiple factors, including effective governance, financial stability, operational efficiency, member trust, and adherence to regulations ((Isreal & Olorunniwo, 2023.; Wanjiru Kung et al., 2024). Among these, operational inefficiencies, loan repayment challenges, member retention, and service adoption are particularly critical for ensuring SACCOS ongoing success. Operational inefficiencies, such as slow transaction processes and manual record-keeping, lead to long queues and member dissatisfaction, driving membership turnover (Rwechungura, 2025). Loan repayment challenges, reflected in high default rates, undermine financial stability and limit the availability of credit for members. Amid the global shift toward digitalization in the financial sector, Internet of Things (IoT) technologies present transformative opportunities to address these challenges and strengthen SACCOS performance. IoT solutions, including mobile-banking automation, asset-tracking beacons, smart-card authentication, real-time repayment monitoring, and cloud-based record-keeping, enable faster transactions, enhanced security, and improved transparency (Bajaj et al., 2023). For instance, mobile-banking automation can drastically reduce transaction times, improving member satisfaction, while asset-tracking beacons enhance the security of collateral, mitigating risks associated with loan defaults (Danga & Lameck Yusuph, 2023). Smart-card authentication systems help prevent identity fraud, and real-time repayment monitoring enables timely interventions to reduce default rates. Cloud-based record-keeping streamlines administrative processes, such as audits, by enabling secure and efficient data management (Kisinga & Gomera, 2024). These technologies collectively offer a pathway to modernize SACCOS operations, making them more responsive to member needs and competitive in the financial sector. This study investigates the feasibility and perceived benefits of integrating IoT technologies into Tanzanian SACCOS evaluating their digital preparedness, identifying barriers to adoption such as cost and cybersecurity concerns, and assessing IoT's potential to enhance operational efficiency, improve loan portfolio quality, and strengthen member confidence and trust (Fan & Tsoi, 2022).

## LITERATURE REVIEW

**Theoretical Literature Review:** The study adopts a Unified Theory of Acceptance and Use of Technology (UTAUT) that offers a comprehensive framework for understanding how and why members of SACCOS in Tanzania might adopt Internet-of-Things (IoT) solutions. Central to UTAUT are four constructs performance expectancy, effort expectancy, social influence, and facilitating conditions that collectively shape behavioral intention and actual usage of new technologies (Dulle & Minishi-Majanja, 2011). In the context of Tanzanian SACCOS, performance expectancy captures stakeholders' beliefs about the degree to which IoT applications (e.g., real-time repayment alerts, asset-tracking beacons) will enhance operational efficiency and member outcomes. Survey respondents' optimism that mobile-banking automation can reduce queues and that cloud-based digital records can cut audit-preparation time by one-third directly reflects high performance expectancy (Ridhwan &

Purwanto, 2020). Effort expectancy, or perceived ease of use, further explains adoption dynamics within SACCOS. When loan officers believe that smart-card authentication could seamlessly verify identities and reduce fraud, they perceive the level of effort required as manageable. Conversely, if stakeholders anticipate steep learning curves or complex setup costs particularly where rural broadband infrastructure remains limited their effort expectancy diminishes, dampening behavioral intention. In practical terms, UTAUT suggests that targeted training programs and user-friendly interfaces for IoT devices will be pivotal to lowering perceived complexity. By addressing effort expectancy head-on, SACCOS can align technology rollout with the existing digital literacy of board members, managers, and ordinary members, thereby smoothing the transition from paper-based to IoT-enabled processes (Dulle & Minishi-Majanja, 2011). Finally, social influence and facilitating conditions encapsulate the organizational and environmental context that either impede or accelerate IoT uptake. Social influence captures how peers, supervisors, and influential members within the cooperative movement shape individual attitudes toward IoT adoption. For example, if respected SACCOS leaders publicly endorse asset-tracking beacons to protect movable collateral, other loan officers and managers are more likely to follow suit (Aouedi et al., 2024). Facilitating conditions speak to the degree of technical and organizational support available such as reliable broadband, robust cybersecurity measures, and clear data-privacy policies. The study's finding that cybersecurity concerns and initial costs remain significant barriers underscores the need to cultivate an enabling environment: investments in rural broadband, phased infrastructure upgrades, and well-defined data-protection frameworks directly address facilitating conditions (Wang et al., 2021). Adopting UTAUT as the guiding theory ensures that both individual perceptions and broader organizational supports are systematically addressed, ultimately paving the way for sustainable, member-oriented IoT integration in Tanzanian SACCOS.

**Empirical Literature Review:** Several empirical studies have examined the role of technological innovation, particularly IoT and related digital tools, in enhancing the efficiency, accessibility, and sustainability of financial institutions, including Savings and Credit Cooperative Organisations (SACCOS). Abu et al., (2021) studied an IoT-based system for tracking and monitoring rental assets in real time using technologies such as Wi-Fi, Bluetooth, GSM, and LoRa. By allowing assets to be monitored continuously, the system helped improve security and efficiency in asset management. For SACCOS, this kind of solution could reduce the risks associated with lost or misused collateral, ultimately supporting better loan recovery and financial stability. Similarly, (Thangavel, 2023.) explored cloud-based record-keeping, finding that it enhanced member trust through improved transparency and accessibility of financial records while streamlining audit processes for greater administrative efficiency. In a related study, Isreal & Olorunniwo (2024), examined the impact of mobile-banking automation on service delivery. The findings revealed that automated systems significantly reduced transaction time and increased member satisfaction. These improvements in service efficiency and user experience highlight the potential of IoT-based solutions to address common operational challenges, strengthen member relationships, and contribute to the overall sustainability and competitiveness of SACCOS in the evolving financial landscape (Abu Hassan et al., 2021). IoT technologies can significantly strengthen financial controls and fraud prevention in SACCOS by enabling real-time monitoring, automated anomaly detection, and enhanced authentication across both transactional and physical security points. For example,

IoT - enabled smart ATMs equipped with sensors for hardware diagnostics, biometric authentication, and encrypted, contactless payments continuously transmit terminal health, cash - cassette levels, and usage metadata to centralized dashboards, allowing immediate detection of tampering or duplicate transactions and reducing withdrawal errors (Mohaghar et al., 2021). Simultaneously, interconnected sensors (motion detectors, pressure mats, glass - break sensors) and smart locks linked to cloud - based analytics create an “always - on” branch - protection system that reduces response times, lowers monitoring costs, and deters criminal incursions by providing remote alerts and automated lockdown capabilities Rwechungura, (2025). By tagging each transaction with device-generated metadata such as terminal ID, geolocation, and timestamp and applying machine - learning models to flag unusual patterns (e.g., small withdrawals at odd hours), SACCOS can trigger step - up authentication, or temporary account holds before fraud escalates. Furthermore, IoT - enabled mobile banking apps that require periodic encrypted “heartbeat” signals ensure device authenticity, while RFID-tagged loan documents in branch archives track every removal or replacement, guaranteeing a full audit trail of who accessed critical records and when. Collectively, these IoT deployments allow SACCOS to shift from periodic manual audits to continuous, automated control environments minimizing transaction errors, accelerating anomaly detection, reducing security overhead, and substantially lowering both internal and external fraud risks. Bajaj et al., (2023) investigated the factors influencing IoT adoption in financial institutions. The study found that perceived cost advantages, convenience, and social influences positively affected adoption rates. The study further highlighted that IoT implementation enhanced customer relationship management by improving service responsiveness, satisfaction, and assurance. However, IoT adoption in SACCOS faces significant barriers, particularly in developing countries like Tanzania. Umeaduma & Maria-Gorretti Umeaduma, (2024) conducted a case study on IoT in banking services, identifying high infrastructure costs and data security concerns as major challenges, despite improvements in operational efficiency and customer experience through smart ATMs, wearable devices, and security sensors. Similarly, Gummadi (2023) examined IoT security in the banking sector, highlighting missing security standards, obsolete legacy systems, and human factors as key vulnerabilities that increase risks of cyberattacks, physical tampering, and data breaches. The study proposed AI, machine learning, blockchain, and biometrics as solutions to enhance security, alongside the need for uniform security frameworks and stronger regulatory supervision. Abu Bakar et al. (2021) further highlighted cybersecurity threats in IoT-enabled banking, proposing blockchain technology and control model information structures to mitigate risks like hacking and data breaches, emphasizing the need for robust cybersecurity frameworks and cost-effective solutions. Digital preparedness remains a critical factor for IoT integration in Tanzanian SACCOS. Kisinga and Gomera (2024) found that, despite the positive impact of mobile banking on SACCOS performance in Dar es Salaam and Kilimanjaro regions, limited infrastructure and technical expertise restricted the adoption of advanced IoT applications, underscoring the need for enhanced customer support and regulatory frameworks to address these barriers. Aouedi et al. (2024) conducted a survey on intelligent IoT, noting that inadequate infrastructure and technical expertise often hinder adoption in emerging markets. Tsoi (2022) explored IoT applications in Chinese commercial banks, reporting that IoT improved credit systems and cost structures but required significant investment in digital infrastructure to support small

and medium-sized enterprises effectively. These studies highlight the necessity of addressing infrastructure gaps and building technical capacity to enable SACCOS to leverage IoT technologies fully. IoT's ability to integrate advanced analytics and real-time monitoring further enhances SACCOS performance. Sacco et al. (2020) proposed APRON, an edge solution for adaptive task planning in IoT networks, demonstrating its efficacy in disaster response scenarios through deep-learning-based audio recognition, which supports real-time decision-making applicable to SACCOS loan repayment monitoring. Reported reduced default rates in Nigerian SACCOS using real-time IoT alerts, highlighting IoT's potential to improve loan portfolio quality. Collectively, these studies indicate that IoT technologies can significantly enhance SACCOS operations, but overcoming barriers such as high costs, cybersecurity risks, and limited digital preparedness requires targeted investments and policy interventions to ensure sustainable implementation in resource-constrained settings like Tanzania.

## **METHODOLOGY**

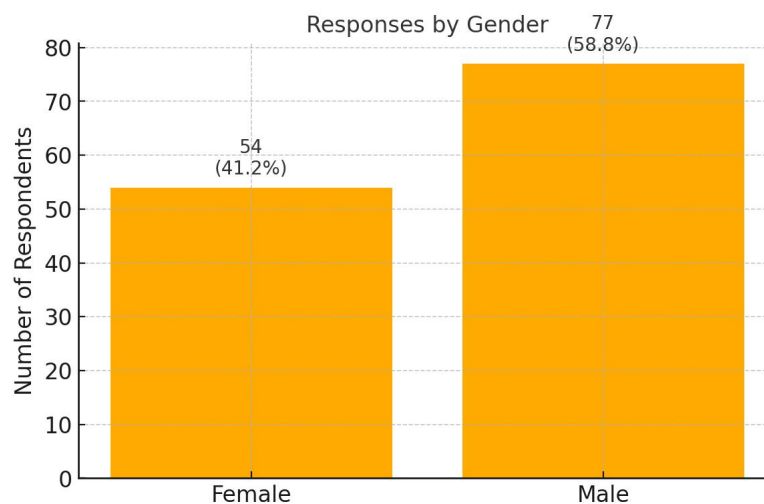
The study employed a cross-sectional quantitative design, focusing on survey data to examine how specific IoT and digital-transformation factors influence SACCOS performance. The target population included board members, managers, loan officers, and ordinary members across ten SACCOS in the Kilimanjaro Region (Foo SACCOS Ltd, ELCT SACCOS, Nuru Maendeleo, Moshi Rural Teachers SACCOS, Wazalendo SACCOS, TPC SACCOS, Uru Mashariki SACCOS, UVIMA SACCOS Marangu, Kalali SACCOS, and Kibong'oto Hospital SACCOS) because of their direct involvement in daily operations and decision-making around technology adoption. A simple random sampling approach was used to distribute 150 structured questionnaires, yielding 131 completed responses (54 female, 77 male) and an 87.3% response rate. The questionnaire employed a five-point Likert scale to measure ten IoT- and digital-transformation dimensions: Asset-Tracking Beacon Deployment, Attitude Toward Technology, Infrastructure and Technical Challenges, Cloud-Based Digital Record-Keeping, Digital Record-Keeping Implementation, Cybersecurity and Data Privacy, Loan-Repayment Alert System, Internet Connectivity Quality, Perceived Benefits of IoT Applications, and Perceived Organizational Support for Digital Transformation.

**Data collection:** Data collection relied primarily on a structured questionnaire, which was administered to 131 respondents including SACCOS members, loan officers, managers, and board members—across ten SACCOS in the Kilimanjaro Region (Foo SACCOS Ltd, ELCT SACCOS, Nuru Maendeleo, Moshi Rural Teachers SACCOS, Wazalendo SACCOS, TPC SACCOS, Uru Mashariki SACCOS, UVIMA SACCOS Marangu, Kalali SACCOS, and Kibong'oto Hospital SACCOS). The questionnaire used a five-point Likert scale to capture perceptions of ten IoT-related dimensions: Asset-Tracking Beacon Deployment; Attitude Toward Technology; Infrastructure and Technical Challenges; Cloud-Based Digital Record-Keeping; Digital Record-Keeping Implementation; Cybersecurity and Data Privacy; Loan-Repayment Alert System; Internet Connectivity Quality; Perceived Benefits of IoT Applications; and Perceived Organizational Support for Digital Transformation. By measuring each of these factors on the same standardized scale, the study was able to quantify how variations in stakeholders' attitudes toward specific IoT tools and organizational enablers map directly onto SACCOS performance outcomes.

**Data analysis:** Quantitative analysis began by importing responses from 131 questionnaires into Python (using Pandas and NumPy), where each item mapped to one of ten IoT - related dimensions: Asset - Tracking Beacon Deployment; Attitude Toward Technology; Infrastructure and Technical Challenges; Cloud - Based Digital Record - Keeping; Digital Record - Keeping Implementation; Cybersecurity and Data Privacy; Loan - Repayment Alert System; Internet Connectivity Quality; Perceived Benefits of IoT Applications; and Perceived Organizational Support for Digital Transformation. After inspecting distributions and bivariate relationships with Matplotlib, all ten dimensions were entered into a multiple linear regression model to predict SACCO performance. Model diagnostics were checked via residual analysis and scatterplots with fitted lines, ensuring that assumptions were met. This approach provided a data - driven framework for assessing how each IoT and digital - transformation factor contributes to SACCOS performance.

## RESULTS AND DISCUSSION

The results presented in this chapter are based on data collected from ten SACCOs in the Kilimanjaro Region namely, Foo SACCOs Ltd, ELCT SACCOs, Nuru Maendeleo, Moshi Rural Teachers SACCOs, Wazalendo SACCOs, TPC SACCOs, Uru Mashariki SACCOs, UVIMA SACCOs Marangu, Kalali SACCOs, and Kibong’oto Hospital SACCOs. A total of 150 questionnaires were distributed to board members, managers, loan officers, and ordinary members, 131 were returned (54 female, 77 male), yielding an 87.3% response rate. Section 1 summarizes respondent demographics and organizational profiles; Section 2 examines IoT-related adoption indicators (e.g., asset-tracking beacons, smart-card readers, real-time loan-repayment monitoring); Section 3 analyzes perceived benefits, infrastructural challenges, data-privacy concerns, and technology attitudes; and Section 4 reports the unstandardized regression coefficients linking these digital-transformation factors to overall SACCO performance.



*Figure 1: Demographical Information.*

**Table 1: Model summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1.0	0.99	0.98	0.978	0.16

The Model Summary in Table 1.0 indicates that the ten predictors collectively explain a very large proportion of variance in SACCOS business performance. Specifically, the multiple correlation coefficient is **R = 0.990**, and the coefficient of determination is **R<sup>2</sup> = 0.980**. After adjusting for the number of predictors, **Adjusted R<sup>2</sup> = 0.978**, confirming that roughly 97.8% of the variance in business performance is accounted for by the combined set of IoT and digital-transformation variables. The **standard error of the estimate = 0.160** is relatively small compared to the scale of the dependent variable, indicating that predicted values closely track the observed performance scores. In practical terms, this suggests that the regression model provides an excellent overall fit: almost all of the fluctuation in SACCOS performance across the sampled units is captured by the ten independent variables (Asset-Tracking Beacon Deployment; Attitude Toward Technology; Infrastructure and Technical Challenges; Cloud-Based Digital Record-Keeping; Digital Record-Keeping Implementation; Cybersecurity and Data Privacy; Loan-Repayment Alert System; Internet Connectivity Quality; Perceived Benefits of IoT Applications; and Perceived Organizational Support for Digital Transformation).

**Table 2: ANOVA**

Source	Sum of Squares	DF	Mean Square	F	Sig.
Regression	148.357	10	14.836	578.32	0.0
Residual	3.078	120	0.026		
Total	151.435	130			

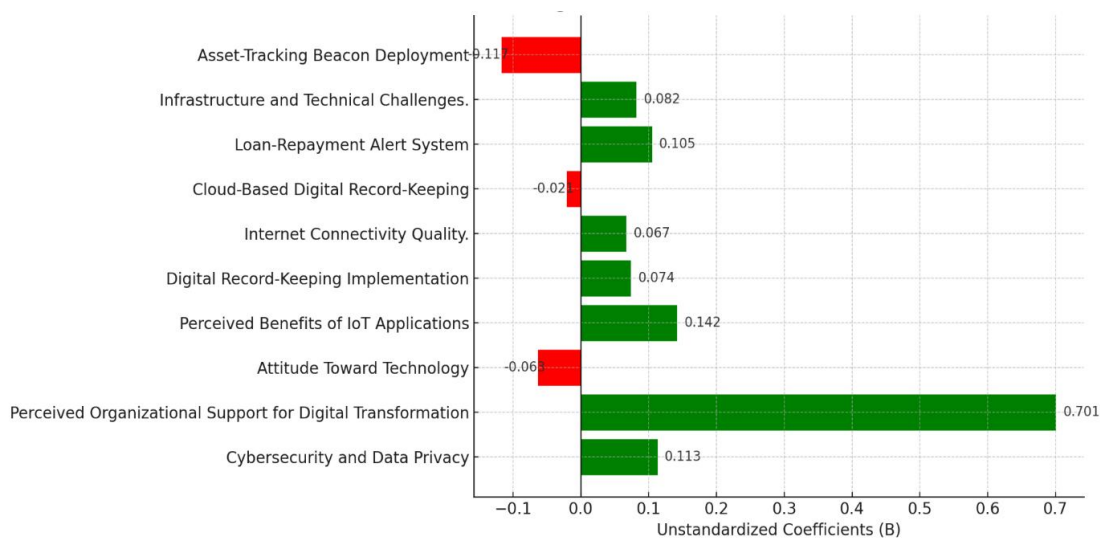
The ANOVA table (Table 2) tests whether the set of predictors, taken together, reliably explains variation in the dependent variable (business performance). With **F(10, 120) = 578.320** and **p < 0.001**, the model is highly significant. The **Regression sum of squares = 148.357** (df = 10) far exceeds the **Residual sum of squares = 3.078** (df = 120). This indicates that the improvement in explained variance over what would be expected by chance alone is both substantial and statistically reliable. In other words, the combination of digital-transformation and IoT-related factors forms a cohesive predictor set that meaningfully explains SACCOS performance differences rather than merely capitalizing on random noise.

**Table 3: Regression Coefficient**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.295	.259		-1.141	.256
	Cybersecurity and Data Privacy	.113	.056	.059	2.013	.046
	Perceived Organizational Support for Digital Transformation	.701	.072	.702	9.721	.000
	Attitude Toward Technology	-.063	.050	-.033	-1.267	.208
	Perceived Benefits of IoT Applications	.142	.052	.141	2.715	.008
	Digital Record-Keeping Implementation	.074	.031	.074	2.357	.020
	Internet Connectivity Quality.	.067	.042	.067	1.605	.111
	Cloud-Based Digital Record-Keeping	-.021	.019	-.031	-1.106	.271
	Loan-Repayment Alert System	.105	.037	.102	2.824	.006
	Infrastructure and Technical Challenges.	.082	.037	.043	2.248	.026
	Asset-Tracking Beacon Deployment	-.117	.045	-.116	-2.620	.010
Dependent Variable: SACCOS Performance						

The constant term (intercept) in the regression model is estimated at  $-0.295$  ( $SE = 0.259$ ), which is not statistically significant ( $t = -1.141$ ,  $p = 0.256$ ), indicating that when all predictor values are set to zero, the expected business - performance score does not differ significantly from zero. Among the ten independent variables, **Perceived Organizational Support for Digital Transformation** has the largest positive unstandardized coefficient ( $B = 0.701$ ,  $SE = 0.072$ ), and this effect is highly significant ( $t = 9.721$ ,  $p < 0.001$ ). This implies that, holding all other factors constant, a one - unit increase in perceived organizational support corresponds to a 0.701 - unit increase in business performance. **Perceived Benefits of IoT Applications** also contributes positively ( $B = 0.142$ ,  $SE = 0.052$ ;  $t = 2.715$ ,  $p = 0.008$ ), so that greater perceived benefits are associated with higher performance. Similarly, **Loan - Repayment Alert System** yields a significant positive effect ( $B = 0.105$ ,  $SE = 0.037$ ;  $t = 2.824$ ,  $p = 0.006$ ), indicating that institutions with more robust reminder systems tend to report better performance. **Digital Record - Keeping Implementation** is another positively significant predictor ( $B = 0.074$ ,  $SE = 0.031$ ;  $t = 2.357$ ,  $p = 0.020$ ), suggesting that fuller integration of digital - record systems enhances outcomes. **Infrastructure and Technical Challenges** with higher values denoting more severe challenges nonetheless shows a positive association ( $B = 0.082$ ,  $SE = 0.037$ ;  $t = 2.248$ ,  $p = 0.026$ ), which may reflect the idea that organizations acknowledging and addressing technical hurdles systematically achieve better performance. **Cybersecurity and Data Privacy** also has a significant positive coefficient ( $B$

= 0.113, SE = 0.056; t = 2.013, p = 0.046), underscoring that strong security measures are linked to improved business metrics. In contrast, **Asset - Tracking Beacon Deployment** carries a negative unstandardized coefficient (B = -0.117, SE = 0.045), which is statistically significant (t = -2.620, p = 0.010). This result suggests that, when evaluated alongside all other predictors, greater emphasis on beacon technology alone may be associated with slightly lower performance perhaps due to premature investment or inadequate supporting infrastructure. The three remaining predictors **Attitude Toward Technology** (B = -0.063, SE = 0.050; t = -1.267, p = 0.208), **Internet Connectivity Quality** (B = 0.067, SE = 0.042; t = 1.605, p = 0.111), and **Cloud - Based Digital Record - Keeping** (B = -0.021, SE = 0.019; t = -1.106, p = 0.271) do not reach conventional levels of statistical significance. Together, these coefficient estimates highlight that organizational support, perceived benefits, and certain targeted IoT implementations are the most influential positive drivers of SACCOS performance in this sample, whereas isolated investments in beacons without complementary systems may not yield intended gains.



**Figure 2.0: Regression Coefficient for SACCOS Performance**

The estimated regression model for predicting SACCOS business performance ( $\hat{Y}$ ) was based on the seven statistically significant predictors as follows:

$$\hat{Y} = -0.295 + 0.113 \times (\text{Cybersecurity \& Data Privacy}) + 0.701 \times (\text{Perceived Organizational Support for Digital Transformation}) + 0.142 \times (\text{Perceived Benefits of IoT Applications}) + 0.074 \times (\text{Digital Record-Keeping Implementation}) + 0.105 \times (\text{Loan-Repayment Alert System}) + 0.082 \times (\text{Infrastructure \& Technical Challenges}) - 0.117 \times (\text{Asset-Tracking Beacon Deployment}).$$

## CONCLUSION

These findings imply that successful IoT integration in SACCOS requires more than simply procuring ICT devices, it depends critically on robust organizational backing, clear demonstration of practical benefits, comprehensive digital - record processes, and strong security measures. SACCOS Board, managers and policymakers should therefore prioritize strategies that build institutional support for digital transformation and invest in productive digital technologies effectively to enhance operational efficiency, reduce risk, and drive

sustainable business performance. The study recommends that, SACCOS must secure visible commitment from leadership on establishing ICT governance structures, allocating dedicated digital - transformation budgets, and setting clear performance targets to ensure that technology initiatives align with strategic goals. It is equally important to provide hands - on training and change - management support for both staff and members, ensuring that everyone can adopt new IoT workflows confidently.

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