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Towards a green integrated financial management information system: Evaluating energy consumption and usability for sustainable public finance management in Kenya

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Abstract

Integrated Financial Management Information Systems (IFMIS) are central to public financial reforms globally, enhancing transparency, accountability, and service delivery. However, their implementation often overlooks sustainability dimensions, particularly energy consumption and usability. This study investigated the energy consumption patterns and usability challenges of Kenya's IFMIS and developed a Green IFMIS Framework integrating energy-efficient computing and user-centred design to promote sustainable public financial management. Guided by pragmatism and an abductive approach, the study adopted a mixed methods design combining experimental and descriptive surveys among 227 ICT officers, accountants, and departmental heads in Nakuru County and the National Treasury. Data were collected through questionnaires, interviews, and direct measurements. Results revealed average device consumption of 85 watts per session, with over 60% of devices lacking Energy Star certification and operating at suboptimal energy-saving configurations. Usability evaluation indicated low effectiveness, efficiency, learnability, and user satisfaction, with 58% rating the system as ineffective for seamless transaction processing. The developed Green IFMIS Framework incorporates energy-efficient hardware and software design, user-centred interface development, organisational Green IT policies, and capacity building. Expert validation confirmed high applicability and potential to improve system sustainability and user experience. The study recommends adoption of the framework to reduce costs, enhance efficiency, and promote environmental conservation, contributing to the growing literature on sustainable public sector IS in developing contexts.

Keywords: Green IFMIS; Energy Consumption; Usability; Public Financial Management; Sustainability; Kenya; Green ICT

1. Introduction

For years, Information Systems (IS) have been vital for modernizing government services and stimulating economic growth globally. These systems have transformed how governments manage finances, deliver services, and maintain transparency and accountability. A key innovation in financial governance is the Integrated Financial Management Information System (IFMIS), a centralized digital platform that streamlines various financial processes like budgeting, procurement, and expenditure tracking. Fueled by increasing demands for efficient resource management and widespread digitization, IFMIS has become a cornerstone of Public Finance Management (PFM) reforms worldwide.

In Africa and other developing regions, governments have increasingly adopted IFMIS to combat institutional inefficiencies. The rise of Information and Communication Technology (ICT), spurred by international trade and knowledge sharing, has accelerated the integration of these systems into public finance. However, many countries struggle with the sustainable scaling of IFMIS, particularly concerning Energy Efficiency and system usability. As

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governments digitize more infrastructure, the environmental impact of ICT systems, from their high electricity consumption to their carbon footprint, has become a significant concern for policymakers and sustainability experts.

Kenya's government has implemented IFMIS across all national ministries and 47 county governments to boost transparency and streamline financial operations. The system has enhanced budget formulation, procurement processes, and expenditure visibility (National Treasury, 2022). Nevertheless, two major issues have emerged: high energy demands from the system's hardware-intensive infrastructure and persistent usability problems. Users frequently report delays, complex navigation, transaction errors, and inadequate support, which hinders service delivery and leads to backlogs in fund disbursement and procurement workflows.

Several studies have explored how IS can impact the environment (Ijab et al., 2011; Dedrick, 2010). Scholars have highlighted the potential of Green Information Systems (Green IS) to improve energy efficiency by redesigning software and hardware to be more eco-friendly. Similarly, usability is crucial for system adoption and productivity, requiring intuitive interfaces and a positive user experience (Singh et al., 2022). While these dimensions have been studied independently, a comprehensive framework that addresses both sustainability and usability within the context of IFMIS, especially in developing countries, is lacking. This research aims to fill that void by examining the Energy Efficiency patterns and usability challenges of Kenya's IFMIS. It seeks to develop a Green IFMIS Framework that integrates energy-efficient technologies with user-centered design, promoting a more sustainable and effective system for public financial management.

Research objective

The purpose of this study was to evaluate the energy efficiency and usability performance of Kenya's Integrated Financial Management Information System (IFMIS), with the aim of developing a sustainable and responsive Green IFMIS framework

2. Literature review

2.1. IFMIS in Public Financial Management

IFMIS enhances budget planning, execution, procurement, accounting, and reporting by integrating financial processes across government departments. The National Treasury (2022) identifies IFMIS as a central pillar in Kenya's PFM reforms, improving financial transparency and efficiency. However, successful implementation requires addressing operational sustainability challenges including energy demands and usability barriers Okundaye et. al. (2019).

2.2. Energy Consumption and Green Computing

Green computing practices emphasize environmentally friendly ICT use without compromising performance. High energy consumption by ICT devices leads to elevated operational costs and GHG emissions, contributing to climate change (Belkhir and Elmeligi, 2019; Malmodin and Lunden, 2020). The Energy Cost Theory (Vosooghzadeh, 2020) argues that while technological innovations initially increase energy use, consequential innovations should reduce energy costs and environmental impacts. Moore's Law, Koomey's Law, and Landauer's Principle (Shalf, J., 2020, Prieto, et. al, 2025, Hsieh, C. Y., 2025) underscore the energy-performance trade-offs in computing, emphasizing the need for energy-efficient hardware and software designs. Lack clear Green ICT policies, hinders effective implementation and awareness of green computing practices. (Wabwoba F, 2019)

2.3. Usability in Information Systems

Usability is defined by ISO 9241-11 as the extent to which users can achieve goals effectively, efficiently, and satisfactorily in a specific context. Nielsen (1992), Shneiderman (1998), and Quesenbery (2004) identify usability dimensions including learnability, efficiency, memorability, error tolerance, and satisfaction. Poor usability leads to delays, user errors, dissatisfaction, and underutilization of systems (Gregersen et. al, 2025, Raudina et. al, 2025, Mynott et. al, 2024). In IFMIS, usability challenges impede financial transactions, procurement processes, and reporting, undermining PFM goals (Ouko, 2016).

2.4. Green IS Frameworks

Green IS frameworks integrate environmental sustainability into IS design and management, promoting energy efficiency, carbon footprint reduction, and user-centred designs (Dedrick, 2010; Ijab et al., 2011). However, few

frameworks address public financial management systems in developing countries, necessitating context-specific models integrating energy efficiency and usability enhancements.

3. Methodology

Guided by pragmatism and an abductive approach, the study adopted a mixed methods design combining experimental measurements and descriptive surveys. This approach enabled triangulation of quantitative energy consumption data with qualitative usability insights to develop a comprehensive framework. The study was conducted in Nakuru County Government offices and the National Treasury Headquarters in Kenya. The target population included ICT officers, accountants, finance officers, departmental heads, and other IFMIS users. A sample of 227 respondents was selected using purposive and stratified sampling. Data collection tools comprised structured questionnaires assessing usability dimensions, key informant interviews capturing qualitative experiences, and experimental measurements of device energy consumption using watt meters and system logs.

Quantitative data were analysed using descriptive and inferential statistics. Factor analysis and Principal Component Analysis (PCA) guided framework construct development. Qualitative data were thematically analysed to extract usability challenges and user experiences informing framework design.

A pilot study in Machakos County established instrument reliability through test-retest methods and internal consistency analysis. Validity was ensured through expert review of instruments and triangulation of multiple data sources. Approvals were obtained from relevant university ethics committees and organizational authorities. Informed consent was obtained from all participants, with confidentiality and data security maintained throughout the study.

4. Results

4.1. Energy Consumption Patterns

4.1.1. Device Consumption

The study assessed device energy consumption among IFMIS users across sampled departments. Findings indicated that the average energy consumption per device per user session was 85 watts. This consumption level is notable considering typical user sessions span several hours, translating into substantial cumulative daily energy usage. Desktops and laptops emerged as the primary contributors to overall energy consumption, with desktops recording slightly higher wattage than laptops due to additional peripherals such as monitors, uninterruptible power supplies (UPS), and external storage devices.

Moreover, analysis revealed that over 60% of devices did not possess Energy Star certification, suggesting low compliance with international energy efficiency standards. This has critical implications for institutional operational costs, as non-certified devices tend to consume higher power and generate more heat, leading to increased cooling requirements. The lack of energy-efficient devices in IFMIS infrastructure indicates procurement and policy gaps that could be addressed to enhance environmental sustainability and cost-effectiveness within public sector ICT operations.

4.1.2. Hardware Contributions

A detailed breakdown of hardware component contributions to overall energy usage showed that processors, memory modules, and peripheral devices collectively accounted for approximately 72% of total IFMIS-related energy consumption. Processors, especially high-speed CPUs used for intensive IFMIS computations, emerged as the most energy-demanding components, followed by memory modules (RAM) which maintain system operations and data processing capabilities. Peripheral devices, including printers, scanners, and external storage, further increased aggregate energy demands.

Additionally, device settings such as high screen brightness levels were observed to exacerbate power consumption. Many user terminals operated at maximum or near-maximum brightness throughout usage sessions despite indoor ambient lighting being sufficient for reduced settings. This operational practice indicates user behaviour gaps and absence of enforced institutional guidelines promoting energy-conscious computing practices. Cumulatively, these hardware-related consumption patterns highlight the need for procurement of energy-efficient components and establishment of standard operating procedures to minimize unnecessary power usage.

4.2. Usability Evaluation

4.2.1. Effectiveness

Usability evaluation findings indicated significant concerns regarding system effectiveness. 58% of respondents rated IFMIS as ineffective in facilitating seamless transaction processing, citing frequent system downtimes that interrupted workflows and delayed service delivery. Users reported that IFMIS downtime during critical budget approval, procurement, and payment processing periods led to backlogs, frustration, and inefficiencies within departmental operations.

Complex navigation interfaces further undermined effectiveness, as users struggled to locate functions quickly, increasing task execution times and potential for errors. The absence of integrated help features or intuitive design compounded these challenges, highlighting the need for user-centred interface redesigns to improve transaction processing effectiveness.

4.2.2. Efficiency

The system's efficiency was evaluated based on task completion times relative to established operational benchmarks. Results showed that average task completion times exceeded targeted benchmarks by 32%, indicating notable inefficiencies in IFMIS operations. Users attributed these delays to complex multi-step processes within the system, requiring repetitive data entry, form navigation, and cross-referencing.

Furthermore, system response times were described as slow, particularly during peak usage hours, further diminishing efficiency. These inefficiencies undermine the core objective of IFMIS – to streamline financial processes and enhance productivity within public sector financial management.

4.2.3. Learnability

Regarding learnability, users reported considerable difficulty in mastering system functionalities. The unintuitive design of IFMIS interfaces meant that new users took extended periods to achieve proficiency, often relying heavily on colleagues or informal troubleshooting rather than structured training. Many respondents indicated that formal training sessions, when available, focused on procedural compliance rather than practical, hands-on navigation of the system, further limiting effective skill acquisition.

This lack of learnability affects operational performance, as users remain dependent on limited technical support, increasing risks of transaction errors and workflow delays.

4.2.4. Error Tolerance and Satisfaction

Finally, the evaluation of error tolerance and user satisfaction highlighted pervasive challenges. High error rates were reported across transactions, particularly in data entry and navigation processes, with inadequate error recovery features exacerbating these problems. For example, error prompts often lacked clear instructions on corrective actions, leading to repeated mistakes or incomplete transactions.

Consequently, 47% of users reported frequent transaction reversals, requiring re-entry of data and approvals, increasing workload and reducing confidence in the system. Overall, these experiences contributed to low user satisfaction, with users expressing frustration over the system’s complexity, inefficiency, and error-proneness.

4.3. Organizational Policies and Green IT Best Practices

The study also investigated institutional frameworks guiding energy efficiency in IFMIS operations. Results revealed limited awareness among users regarding existing energy-saving policies, with majority unable to identify any formal organizational guidelines promoting green computing practices. This lack of awareness was compounded by the absence of documented institutional green computing frameworks across departments, indicating systemic policy implementation gaps.

Interviews with ICT officers confirmed that while some devices came pre-installed with basic power-saving settings, no structured policies mandated or monitored their application. Consequently, energy-saving features such as automated sleep modes, scheduled shutdowns, and low-power configurations remained underutilized. These findings underscore the urgent need for public institutions to develop and enforce comprehensive Green IT policies to institutionalize

energy-efficient computing practices, reduce operational costs, and contribute to national climate change mitigation efforts.

4.4. Development of the Green IFMIS Framework

This study aimed to address the dual challenges of high energy consumption and poor usability within Kenya's IFMIS implementation by developing an integrated framework that promotes both environmental sustainability and system performance. Guided by factor analysis and Principal Component Analysis (PCA) of empirical data, four key framework dimensions were identified for integration into IFMIS design, deployment, and management.

4.4.1. Framework Constructs

Factor analysis results revealed that the proposed Green IFMIS Framework should encompass the following interrelated dimensions:

Energy-efficient hardware and software design

The analysis underscored that a significant proportion of IFMIS energy consumption arises from device inefficiencies and suboptimal configurations. Respondents reported that over 60% of devices lacked Energy Star certification, and experimental measurements indicated average device consumption of 85 watts per user session, exceeding recommended thresholds for sustainable office computing.

The framework thus prioritizes the procurement and deployment of Energy Star certified hardware including desktops, laptops, and monitors that consume less power while maintaining processing performance. Additionally, it advocates for software design optimization through streamlined code, efficient algorithms, and minimal resource use to reduce processor demands during IFMIS operations. Incorporating power management settings, such as automatic sleep modes, screen dimming, and hard disk hibernation protocols, is integral to achieving systemic energy savings without affecting user productivity.

- User-centred interface development

Usability evaluation revealed pervasive challenges across effectiveness, efficiency, learnability, error tolerance, and user satisfaction dimensions. Specifically, 58% of respondents reported IFMIS as ineffective due to frequent downtimes and unintuitive navigation structures, while task completion times exceeded benchmarks by 32%, reflecting low efficiency. Users also highlighted poor learnability, leading to high cognitive load and frequent errors.

To address these deficiencies, the framework integrates user-centred design (UCD) principles, guided by ISO 9241-11 and ISO 2500 usability standards. This involves redesigning IFMIS interfaces to ensure clear information architecture, logical task flows, minimal required clicks, intuitive visual cues, and error prevention mechanisms. Enhancing interface responsiveness, accessibility features, and multi-device compatibility are recommended to improve overall user satisfaction and operational effectiveness.

Organizational Green IT policies

Analysis of organizational policies indicated limited awareness and absence of enforced Green IT standards across sampled departments. The framework therefore proposes the development and institutionalization of comprehensive Green IT policies within public financial management entities. These policies should encompass guidelines for sustainable ICT procurement, device use standards, maintenance practices, and disposal protocols to minimize environmental footprints. Policies must also embed performance monitoring indicators to evaluate adherence and guide periodic improvements aligned with global sustainability benchmarks.

Capacity building

Finally, factor analysis emphasized that sustainable IFMIS implementation requires targeted capacity building for system users and ICT managers. The framework recommends continuous training programmes focusing on energy-conscious computing practices, interface navigation skills, and troubleshooting techniques. Training should be embedded into induction programmes, professional development plans, and ICT policy dissemination sessions to ensure widespread and consistent adoption of green and user-centred practices.

4.5. Framework Validation

To evaluate its relevance and applicability, the developed Green IFMIS Framework underwent validation through expert review involving ICT managers, system developers, and public financial management experts. Using a structured validation tool, experts assessed each framework dimension's clarity, feasibility, and potential impact on IFMIS sustainability and performance. The validation process yielded a mean acceptance score of 4.3 out of 5, indicating high relevance, practicality, and anticipated positive influence on improving energy efficiency and system usability when adopted within Kenya's public sector institutions.

Experts particularly commended the integrated approach combining technical (hardware and software optimization) and organizational (policy and capacity building) components, noting that such holistic frameworks are essential for sustainable digital transformation in public finance management.

5. Discussion

The study's findings reinforce existing literature on the environmental implications of ICT operations. Nordman and Lanzisera (2011) highlight that computing devices contribute significantly to global electricity demand, an observation mirrored in this study's finding that IFMIS devices consume an average of 85 watts per session, translating to substantial operational costs and greenhouse gas emissions. Grubert et al. (2020) similarly emphasize that sustainable ICT practices are critical in mitigating climate change impacts.

Usability evaluation findings resonate with Ouko (2016) and Quesenbery (2004), who identified that poor interface designs, inadequate training, and frequent system downtimes lead to reduced user effectiveness and satisfaction. The low usability ratings found in this study demonstrate that despite IFMIS' transformative role in public financial management, its potential is undermined by design and operational inefficiencies that can be addressed through structured usability engineering.

The proposed Green IFMIS Framework effectively integrates these dual concerns, aligning with Dedrick's (2010) Green IS principles that advocate for embedding sustainability into IS design and management. By combining energy-efficient hardware and software strategies with user-centred interface improvements, organizational Green IT policies, and continuous capacity building, the framework extends existing Green IS models by contextualizing them for public sector financial systems in developing countries.

Furthermore, the framework's validation by experts underscores its practical applicability, with reviewers noting its potential to achieve cost savings, reduce carbon footprints, and enhance user performance – critical outcomes for Kenya's public sector digitization agenda and global sustainable development commitments.

6. Conclusion

The implementation of Integrated Financial Management Information Systems (IFMIS) in Kenya has undeniably transformed public financial management by automating budgeting, procurement, accounting, and reporting processes. These advancements have enhanced transparency, accountability, and fiscal discipline across government departments, aligning with national public finance reforms and international best practices. However, this study has revealed that despite these achievements, IFMIS remains constrained by two critical challenges: high energy consumption and pervasive usability deficiencies.

The high energy consumption is largely attributed to heavy reliance on ICT infrastructure with minimal integration of energy-efficient computing practices. The widespread use of non-Energy Star certified devices, suboptimal power management settings, and outdated hardware components contribute to elevated operational costs and significant greenhouse gas emissions, undermining Kenya's commitment to environmental sustainability and climate change mitigation goals.

Similarly, the usability evaluation exposed major deficiencies in IFMIS design and implementation. Users reported low system effectiveness due to frequent downtimes and complex navigational structures, low efficiency indicated by extended task completion times, poor learnability caused by unintuitive interfaces, high error rates, and overall dissatisfaction with system performance. These usability issues impede the seamless execution of financial transactions, reduce productivity, and compromise the user experience, thereby limiting IFMIS' potential to fully deliver on its intended objectives within Kenya's public finance management framework.

In response to these interlinked challenges, this study developed the Green IFMIS Framework, an integrated model embedding energy efficiency and user-centred design principles into IFMIS development, implementation, and management. The framework offers a practical solution by proposing structured dimensions encompassing energy-efficient hardware and software design, user-centred interface development based on international usability standards, formulation of Green IT policies, and capacity building for sustainable system use. Validation by experts indicated its high relevance, applicability, and potential to enhance operational sustainability and user experience within Kenya's public sector.

Recommendations

Drawing from the findings and framework development process, the following recommendations are proposed to enhance the sustainability and effectiveness of IFMIS in Kenya:

- Adoption of Energy Star Certified Devices
    - The government, through the National Treasury and ICT procurement authorities, should prioritize the acquisition of Energy Star certified devices in future IFMIS infrastructure upgrades. Energy Star certified hardware consumes significantly less power without compromising processing capacity, thus reducing operational energy costs and lowering carbon footprints in line with Kenya's green economy strategies.
- Redesign of System Interfaces Based on ISO Usability Standards
    - The IFMIS user interfaces should be redesigned to align with internationally recognized usability standards such as ISO 9241-11 and ISO 25000 series. Redesign efforts should focus on enhancing effectiveness by simplifying complex processes, improving efficiency through intuitive layouts and navigation, and strengthening learnability with clear icons, labels, and task flows. Integrating user feedback in iterative redesigns will ensure the system meets user needs and reduces error rates.
- Development and Enforcement of Green IT Policies
    - It is imperative for the National Treasury, in collaboration with the Ministry of ICT, to develop comprehensive Green IT policies governing sustainable ICT procurement, use, and disposal within IFMIS and related systems. These policies should mandate energy efficiency standards for ICT equipment, institutionalize power management protocols, and establish clear guidelines for e-waste management to promote environmental conservation across public sector digital operations.
- Implementation of Targeted User Training Programmes
    - Continuous, targeted training programmes should be developed and implemented to enhance IFMIS users' system proficiency, promote energy-conscious computing behaviour, and familiarize them with newly redesigned interfaces. Training should cover system functionalities, energy-saving practices (e.g. optimal screen brightness, shutdown protocols), and troubleshooting techniques to improve efficiency, reduce operational errors, and optimize system performance.
- Piloting of the Green IFMIS Framework in Selected Counties
    - Before nationwide adoption, the Green IFMIS Framework should be piloted in selected counties representing diverse operational contexts. Piloting will enable evaluation of its scalability, operational impact, user acceptance, and sustainability outcomes. Lessons from pilot studies should inform framework refinement prior to full-scale rollout, ensuring maximum effectiveness and adaptability across Kenya's public sector institutions.

Contributions

This study makes significant contributions to knowledge and practice in the field of sustainable public sector information systems. It is among the first empirical studies in Kenya to comprehensively evaluate IFMIS energy consumption and usability challenges while proposing an integrated framework addressing both dimensions. The Green IFMIS Framework developed and validated herein offers practical insights for policymakers, system developers, and ICT managers seeking to enhance public finance management systems' operational sustainability, cost-effectiveness, and user experience.

For researchers, the study expands literature on Green IS by contextualizing energy-efficient and usability-enhancing design principles within public sector financial management systems in developing countries. It demonstrates the applicability of theoretical models such as Energy Cost Theory, ISO usability standards, and design science research in addressing real-world IS implementation challenges.

Future research

Future research should focus on longitudinal studies assessing the framework's long-term impact on operational cost savings, system performance, and environmental sustainability once implemented. Further studies could also explore user behavioral adaptations to Green IFMIS interventions and comparative analyses of framework applicability in other developing countries with similar public financial management contexts. Expanding the framework to incorporate emerging green computing technologies such as cloud-based virtualization, thin client computing, and AI-driven energy optimization could further enhance IFMIS sustainability and effectiveness in Kenya and beyond.

Compliance with ethical standards

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No conflict of interest to be disclosed.

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