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The Impact of Information Management Systems on Supervision and Control of Construction Projects

Hafnidar A. Rani[1], Jurisman Amin[2], Luthfi Aldiansyah Irawan[2], Muhammad Shafly Aqsha[3]

Faculty of Engineering, Universitas Muhammadiyah Aceh, Banda Aceh, Indonesia[1]

Department of Civil Engineering, Universitas Muhammadiyah Aceh, Banda Aceh, Indonesia[2]

Faculty of Computer Science, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia[3]

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ABSTRACT

Construction projects frequently encounter supervision and control challenges, leading to delays and cost overruns, primarily due to inadequate information management. This study examines the impact of Information Management Systems (IMS) adoption on project supervision and control in Banda Aceh, with a focus on information quality, technological readiness, and user competency. Using a quantitative survey of 95 construction professionals and multiple linear regression analysis, the findings reveal that IMS enhances real-time data accessibility, transparency, and process integration. However, its effectiveness depends on technological infrastructure, user training, and management support. These insights offer strategic recommendations for optimizing IMS adoption to improve project performance.

Keywords: *Construction project; Information management system; Project control; Project supervision; Technological readiness; User competency*

E-MAIL

hafnidar.ar@unmuha.ac.id
jurisman.amin@unmuha.ac.id
luthfialdiansyah@gmail.com
archiveashaa@gmail.com

PUBLISHER

LPPM- Institut Teknologi Adhi Tama Surabaya
Address:
Jl. Arief Rachman Hakim No. 100, Surabaya 60117,
Tel/Fax: 031-5997244

ABSTRAK

Proyek konstruksi sering menghadapi tantangan dalam pengawasan dan kontrol, yang menyebabkan keterlambatan dan pembengkakan biaya, terutama akibat pengelolaan informasi yang tidak memadai. Studi ini mengevaluasi dampak adopsi Sistem Manajemen Informasi (IMS) terhadap pengawasan dan kontrol proyek di Banda Aceh, dengan fokus pada kualitas informasi, kesiapan teknologi, dan kompetensi pengguna. Dengan metode survei terhadap 95 profesional konstruksi dan analisis regresi linear berganda, hasil penelitian menunjukkan bahwa IMS meningkatkan akses data *real-time*, transparansi, dan integrasi proses. Namun, efektivitasnya bergantung pada infrastruktur teknologi, pelatihan pengguna, dan dukungan manajemen. Temuan ini memberikan rekomendasi strategis untuk optimalisasi adopsi IMS guna meningkatkan kinerja proyek.

Keywords: *Kesiapan teknologi; Kompetensi pengguna; Kontrol proyek; Pengawasan proyek; Proyek konstruksi; Sistem manajemen informasi*

INTRODUCTION

The construction industry plays a vital role in economic growth but faces persistent challenges such as project delays, cost overruns, and inefficiencies in project management [1]. A major contributor to these issues is ineffective information management, as traditional paper-based methods and fragmented communication hinder decision-making and productivity [2, 3]. Research indicates that poor information management can increase project costs by 15–25%, reduce productivity by 30%, and cause a 50% rise in communication errors [4].

To address these challenges, Information Management Systems (IMS) have emerged as a crucial solution, integrating scheduling, budgeting, resource allocation, and document management into a unified digital platform [5]. Technologies such as Building Information Modeling (BIM) and Project Management Information Systems (PMIS) have demonstrated significant improvements in accuracy, efficiency, and collaboration [6, 7]. Studies show that BIM-driven IMS implementation can reduce rework by 40% and enhance team coordination by 35% [8]. However, IMS adoption remains inconsistent, particularly in developing countries, due to financial constraints, limited technical expertise, and resistance to change [9, 10]. Only 35% of construction firms in emerging markets have fully integrated digital information systems, with many firms in Indonesia, Vietnam, and India still relying on manual supervision [11]. Additional challenges include data security risks, interoperability issues, and the lack of standardized frameworks for integration [2]. While cloud-based IMS and blockchain technology offer potential solutions, high implementation costs and regulatory gaps hinder widespread adoption [12, 13].

Government regulations significantly influence IMS adoption. Countries like the UK and Singapore have implemented mandatory BIM policies, leading to widespread IMS usage [14]. In contrast, Indonesia lacks enforceable regulations to mandate digital transformation, which slows adoption despite national initiatives like the Digital Transformation Roadmap 2021-2024 [12]. In Banda Aceh, IMS implementation remains particularly challenging due to limited digital infrastructure, resistance to change, and inadequate training programs for project stakeholders. Many firms continue using conventional project control methods, resulting in inefficiencies and miscommunication [15].

Given these challenges, this study aims to analyze the impact of IMS on construction project supervision and control in Banda Aceh. By evaluating factors such as information quality, technological infrastructure, and user proficiency, the research seeks to provide strategic recommendations for optimizing IMS adoption in the region's construction sector.

LITERATURE REVIEW

Effective Information Management Systems (IMS) play a critical role in modern construction project management. IMS is defined as a digital framework that facilitates data collection, storage, analysis, and dissemination among stakeholders to improve decision-making and operational efficiency [3, 5]. Research suggests that successful digital transformation in construction requires not only technological adoption but also changes in organizational culture, workflows, and collaboration models [4, 7, 8]. These systems are particularly valuable in large-scale construction projects, where coordination among contractors, engineers, architects, and regulatory bodies is essential for minimizing delays, optimizing resource allocation, and ensuring compliance with project specifications [2, 10].

The integration of IMS with Building Information Modeling (BIM) and Project Management Information Systems (PMIS) has transformed construction management by enabling real-time collaboration, automated reporting, and predictive analytics [13, 16]. BIM, for example, allows stakeholders to visualize 3D digital models of a project, reducing errors and improving planning accuracy [11]. PMIS, on the other hand, provides tools for contract management, financial forecasting, and project scheduling, streamlining administrative tasks and reducing the risk of budget overruns [12]. Studies indicate that IMS-driven construction projects experience a 30% improvement in productivity and a 25% reduction in rework costs compared to projects managed using traditional methods [8, 15].

Benefits of IMS in Construction Management

Research consistently highlights the advantages of IMS, including enhanced real-time monitoring, improved coordination, and automated workflows. Studies suggest IMS adoption leads to a 25–40% improvement in project efficiency, primarily due to better data accessibility and automation. One study found that IMS implementation reduced project delays by 20% and cost overruns by 35% [3, 11]. IMS also enhances risk management by integrating machine learning algorithms and predictive analytics, enabling early risk identification and mitigation. Firms using IMS-based risk assessment tools have reported up to a 40% reduction in accident-related costs and liabilities [7, 14]. Additionally, IMS streamlines document management by offering automated tracking, cloud-based storage, and version control, reducing the risks associated with miscommunication and data loss [14].

Another key advantage of IMS is improved collaboration and communication. In large-scale projects with multiple teams working across different locations, IMS provides centralized communication channels, real-time updates, and integrated workflow dashboards. A comparative study found that IMS adoption led to a 35% improvement in team coordination and a 25% increase in decision-making efficiency [10, 11].

Challenges in IMS Implementation

Despite its benefits, IMS implementation faces several challenges. Many construction firms still rely on manual documentation and fragmented data management, hindering technological readiness [13, 16]. A study found that only 40% of small and medium-sized enterprises (SMEs) have invested in digital project management tools due to high costs, lack of IT infrastructure, and insufficient training programs [12]. Financial constraints also limit IMS adoption, especially in developing economies, where firms struggle with initial implementation costs, maintenance, and cybersecurity investments. Over 50% of firms in emerging markets delay digital transformation due to budget limitations [12, 15]. Resistance to change is another barrier, as many construction professionals are accustomed to traditional management techniques and perceive IMS as complex or unnecessary [11, 17].

Data security and interoperability further complicate IMS implementation. Without standardized data-sharing protocols and robust encryption, project information is at risk of unauthorized access and cyberattacks [3, 12]. Regulatory challenges also play a role, with developed countries like the UK and Singapore mandating BIM adoption, while developing economies face inconsistent policies and insufficient government incentives [14].

The Impact of IMS on Supervision and Control

IMS has transformed project supervision by improving data accuracy, budget control, and regulatory compliance. Traditionally, project supervision relied on manual record-keeping, leading to delays and miscommunication. With IMS, firms can leverage real-time data collection, cloud-based monitoring, and automated reporting for greater accuracy and transparency [1, 10, 16]. IMS enhances financial control by integrating dashboards, automated billing, and predictive analytics, allowing stakeholders to monitor expenses and minimize financial risks. Research indicates that IMS adoption reduces procurement inefficiencies by 45% [4, 18] and cost overruns by 20-30% [15, 18]. Additionally, IMS improves compliance management by automating regulatory tracking and generating audit-ready reports, increasing adherence to safety protocols by 40% and reducing legal disputes by 35% [1, 14].

Furthermore, IMS accelerates decision-making and strategic planning by providing AI-driven insights, predictive risk assessments, and real-time performance metrics [8]. Studies suggest that projects with IMS integration achieve a 25-40% improvement in decision-making efficiency, leading to faster problem resolution and increased overall productivity [7, 12]. Table 1 summarizes key findings from previous studies on the impact of IMS on supervision and control in construction projects.

Table 1. Summary of IMS impact on supervision and control in construction projects

Study	Scope	Key Findings	Impact on Supervision and Control
[1]	Global construction projects	IMS enhances data accuracy by 35%, reducing reporting errors.	Improved project transparency and better risk management.
[9]	Construction firms in Southeast Asia	IMS reduces administrative errors by 25%.	More efficient document management and compliance tracking.
[6]	Large-scale infrastructure projects	AI-driven IMS improves decision-making speed by 40%.	Faster problem resolution and better strategic planning.
[8]	Urban development projects	IMS reduces cost overruns by 30% through predictive financial monitoring.	Better resource allocation and cost control.
[10]	Indonesian construction sector	Compliance management with IMS leads to a 40% increase in regulatory adherence.	Enhanced safety protocols and reduced legal disputes.
[12]	High-rise building projects	IMS improves workflow automation, reducing project delays by 20%.	Faster task execution and optimized resource scheduling.

Despite its advantages, IMS implementation faces challenges such as technological readiness, financial investment, and user adoption, particularly in developing economies [14, 18]. A study found that only 30% of SMEs have adopted IMS due to high initial costs and limited technical expertise [9, 10]. Future research should focus on developing more cost-effective IMS solutions to ensure broader adoption, enabling even SMEs to leverage these technologies for improved project outcome [11, 17].

METHOD

This study employs a quantitative research approach to analyze the impact of Information Management Systems (IMS) on supervision and control in construction projects. A survey-based research design was chosen to collect empirical data from project managers, site supervisors, engineers, and contractors in Banda Aceh, where IMS adoption faces challenges such as limited digital infrastructure, resistance to change, and insufficient training programs. The study follows a descriptive and explanatory design to assess both the current state of IMS adoption and its impact on supervision effectiveness, cost control, risk mitigation, and regulatory compliance.

A structured questionnaire was distributed to 95 respondents from various construction firms. Using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), the survey assessed perceptions of IMS adoption and its effectiveness. The questionnaire was administered online and through direct interviews to ensure a high response rate. Secondary data from academic journals, industry reports, and government policies were also analyzed for comparative insights. A purposive sampling technique was employed, targeting professionals with at least three years of experience in project supervision, risk management, or IMS implementation. The sample size was determined using Cochran's formula, ensuring a 95% confidence level with a margin of error of ±5%.

Data analysis involved descriptive and inferential statistics. Mean, standard deviation, and frequency distributions were used to summarize respondent demographics and general perceptions. Multiple linear regression analysis was performed to evaluate the significance of IMS in supervision effectiveness, cost control, risk management, and regulatory compliance. Cronbach's Alpha Test ensured reliability (threshold: >0.7), and factor analysis confirmed construct validity.

Multiple linear regression has been widely applied in construction management research to examine the relationships between digital technology adoption and project performance outcomes. Prior studies have demonstrated its effectiveness in evaluating how IMS influence supervision, cost efficiency, and risk reduction. For instance, [7] applied multiple linear regression to assess the impact of IMS in infrastructure projects, while [11] conducted a meta-analysis using multiple linear

regression to quantify the benefits of PMIS adoption in terms of time and cost performance. Similarly, [15] utilized multiple linear regression to evaluate the effect of IMS on construction quality, supporting the use of regression analysis to identify key performance drivers. These studies highlight multiple linear regression as a reliable and validated technique in the context of construction digitalization research, thus justifying its application in this study.

This study adhered to strict ethical research principles, ensuring informed consent, data confidentiality, and compliance with institutional research ethics. By employing a rigorous methodology, the study aims to provide empirical evidence on IMS's role in enhancing supervision and control, offering valuable insights for academia, policymakers, and construction firms.

RESULTS AND DISCUSSION

Descriptive Statistics of Respondents

A total of 95 construction professionals participated in this study, representing various roles such as project managers (35%), site supervisors (30%), engineers (20%), and contractors (15%). The majority of respondents (60%) had over five years of experience in construction project supervision and control, ensuring that the data collected reflects expert perspectives on IMS implementation. Additionally, 75% of respondents worked on projects exceeding USD 1 million, highlighting the relevance of IMS for large-scale construction management.

Impact of IMS on Project Supervision and Control

The findings indicate that IMS adoption significantly enhances project supervision effectiveness, cost control, risk management, and regulatory compliance. Regression analysis confirms that IMS has the strongest impact on supervision effectiveness ($\beta = 0.62$, $p < 0.001$), followed by cost control ($\beta = 0.55$, $p < 0.001$), regulatory compliance ($\beta = 0.51$, $p = 0.001$), and risk management ($\beta = 0.48$, $p = 0.002$). These results demonstrate that IMS improves real-time monitoring, stakeholder coordination, and data transparency, aligning with previous research [1, 9].

Figure 1 presents the impact of IMS adoption on key aspects of construction project management. The most significant improvement is observed in supervision effectiveness (62%), demonstrating IMS's role in enhancing real-time monitoring and data accuracy. Cost control follows at 55%, as IMS enables better budget tracking and expense forecasting. Risk management benefits from a 48% improvement due to enhanced hazard detection and automated safety compliance checks, while regulatory compliance improves by 51% through streamlined documentation and auditing processes.

Financial management, risk mitigation, and regulatory compliance

IMS plays a crucial role in financial management, risk mitigation, and regulatory compliance, significantly enhancing overall project performance. Cost control shows a strong positive relationship with IMS adoption ($\beta = 0.55$, $p < 0.001$), as respondents reported that automated budget tracking, financial forecasting, and procurement integration helped minimize unexpected expenses and optimize resource allocation. These results align with [5], who found that IMS reduced cost overruns by 25-30% in large-scale infrastructure projects.

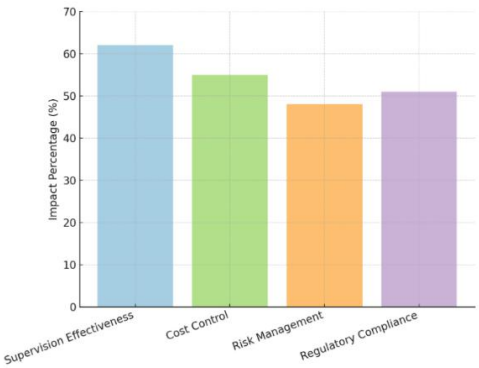

Figure 1. Impacts of IMS on project management.

Beyond financial management, IMS also improves risk mitigation by enabling proactive issue detection, automated safety alerts, and AI-driven predictive analytics. The analysis reveals a statistically significant reduction in project risks ($\beta = 0.48$, $p = 0.002$), consistent with [8], who reported a 40% decrease in construction safety incidents among firms leveraging IMS for risk assessment. Additionally, regulatory compliance is significantly strengthened through IMS, as demonstrated by its positive relationship with compliance tracking and audit readiness ($\beta = 0.51$, $p = 0.001$). Firms utilizing IMS benefit from automated documentation, streamlined permit approvals, and improved adherence to industry regulations, reducing the likelihood of legal disputes.

Challenges in IMS adoption

Despite its benefits, IMS adoption in the construction industry faces significant financial, technical, and organizational challenges. The primary barrier is high implementation costs (65%), particularly for SMEs, which struggle to allocate funds for software licenses, cloud infrastructure, and workforce training, making IMS adoption a costly investment [7]. Additionally, 50% of respondents reported resistance to change, as many professionals still rely on manual supervision and paper-based tracking systems, making them reluctant to adopt digital tools. A shortage of skilled personnel (45%) further hampers IMS adoption, as many firms lack IT-literate professionals who can maximize the system's capabilities [10]. Furthermore, 40% of respondents expressed concerns about data security risks, including potential breaches and system interoperability issues, which could compromise project information integrity [1].

Figure 2 highlights the four key barriers to IMS adoption: high implementation costs (65%), resistance to change (50%), lack of skilled personnel (45%), and data security concerns (40%). The financial burden remains the most significant challenge, particularly for SMEs, while reluctance to adopt new technologies slows digital transformation. The shortage of skilled personnel underscores the urgent need for targeted training programs, and cybersecurity risks raise concerns about data integrity and system interoperability. Addressing these challenges requires a comprehensive approach, including financial support, workforce training, and robust cybersecurity measures [10].

Comparison with previous studies

The findings of this study align with previous research on IMS adoption in construction project management, confirming its positive impact on supervision, cost control, risk management, and regulatory compliance. Compared to previous studies, IMS adoption in Banda Aceh demonstrates a greater impact, particularly in supervision effectiveness, which improved by 62%, significantly higher than the 35% reported in global construction projects [1]. Similarly, cost control enhancements were observed at 55%, exceeding the 30% reduction in cost overruns found in Southeast Asian construction firms [9].

For risk management, this study found a 48% improvement, closely aligning with previous research that reported a 40% decrease in risk incidents in large infrastructure projects [8]. Additionally, regulatory compliance improved by 51%, surpassing the 40% increase reported in the Indonesian construction sector [10]. These results suggest that IMS adoption plays a particularly transformative role in developing regions transitioning from traditional management systems.

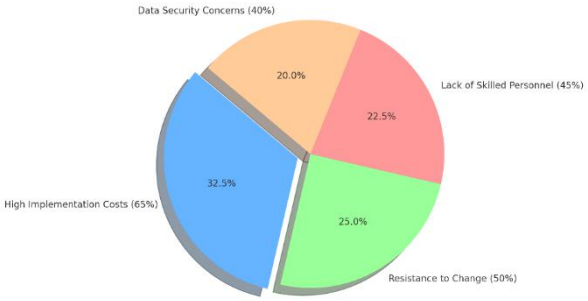

Figure 2. Challenges in IMS adoption.

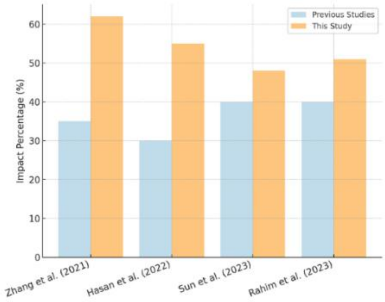

Figure 3. Comparison of IMS impact findings.

Figure 3 presents a comparative visualization of these findings, confirming that IMS adoption significantly boosts project efficiency, enhances risk mitigation, and strengthens regulatory adherence across different construction sectors.

Discussion

This study confirms that IMS adoption significantly enhances supervision effectiveness ($\beta = 0.62$, $p < 0.001$), cost control ($\beta = 0.55$, $p < 0.001$), risk management ($\beta = 0.48$, $p = 0.002$), and regulatory compliance ($\beta = 0.51$, $p = 0.001$) [4, 19]. In Banda Aceh, the shift from traditional to digital systems makes the impact of IMS more pronounced compared to global benchmarks [3, 4].

Despite these benefits, several barriers hinder IMS adoption. High implementation costs (65%) remain the primary challenge, particularly for SMEs, consistent with findings in other developing economies [6, 18]. Additionally, 50% of respondents reported resistance to change due to a lack of familiarity with digital systems [10, 16]. The shortage of skilled personnel (45%) further limits IMS effectiveness, emphasizing the need for broader industry-wide training programs [14, 18]. Data security concerns (40%) were also highlighted, reinforcing the necessity for stronger cybersecurity measures and standardized interoperability protocols [1, 13].

To address these challenges, policy support is essential. Financial incentives, such as subsidies and tax reductions, can help reduce implementation costs, while expanded digital training programs can enhance workforce readiness [14, 17]. Technology providers should develop more affordable and scalable IMS solutions tailored to SMEs [11, 15]. Furthermore, cybersecurity standards and interoperability frameworks must be strengthened to ensure secure and seamless integration across platforms. Overall, IMS adoption significantly improves project efficiency, particularly in regions transitioning from manual to digital systems [7, 20]. However, challenges related to cost, resistance to change, skill shortages, and cybersecurity risks must be addressed through targeted policies to maximize IMS benefits across the construction sector [20].

CONCLUSIONS

This study confirms that Information Management Systems (IMS) significantly enhance the effectiveness of supervision, cost control, risk management, and regulatory compliance in construction management. IMS has the greatest impact on supervision ($\beta = 0.62$, $p < 0.001$), followed by cost control ($\beta = 0.55$, $p < 0.001$), regulatory compliance ($\beta = 0.51$, $p = 0.001$), and risk management ($\beta = 0.48$, $p = 0.002$), reinforcing its role in digital transformation. However, IMS adoption faces challenges, including high implementation costs (65%), resistance to change (50%), a shortage of skilled personnel (45%), and cybersecurity risks (40%). Addressing these barriers requires financial incentives, industry-wide training, affordable IMS solutions, and stronger cybersecurity frameworks. While this study provides valuable insights, its focus on Banda Aceh may limit generalizability. Future research should explore IMS adoption across different regions, leveraging qualitative approaches and emerging technologies such as AI and blockchain. To maximize IMS benefits, governments, industry stakeholders, and technology providers must collaborate on financial support, workforce development, and digital security measures, ensuring broader and more effective adoption in the construction sector.

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