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# LEVERAGING TECHNOLOGY TO ENHANCE RISK MANAGEMENT IN MORTGAGE-FINANCED PROJECTS IN KENYA: A THEMATIC FRAMEWORK APPROACH

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## ABSTRACT

Mortgage-financed construction projects (MFCPs) in Kenya are central to the country's housing delivery agenda, yet they remain vulnerable to diverse risks that compromise performance. This study investigates how technology can be leveraged to improve risk management in MFCPs, focusing on six dominant risk categories: market, financial, planning, construction, legal and regulatory, and environmental. A survey research design was adopted, targeting 1,063 mortgage-financed projects initiated during the 2021/2022 financial year. From a sample of 171 projects, data were collected from 122 respondents using structured questionnaires administered to site agents and clerks of works. Quantitative data were analyzed using descriptive statistics, while qualitative insights were subjected to thematic analysis. The findings reveal that construction risks, particularly contractor inefficiencies and material cost escalation, are most pronounced, followed by financial and planning risks. Developers emphasized that these risks are interconnected, often compounding one another to undermine project outcomes. Thematic analysis identified seven technology-enabled mitigation pillars: project management software and digital platforms, Building Information Modeling (BIM) and digital twins, Artificial Intelligence (AI) and predictive analytics, Internet of Things (IoT) and smart sensors, blockchain and smart contracts, Geographic Information Systems (GIS) and satellite monitoring, and communication and collaboration tools. Each of these technologies directly addresses multiple risk categories, offering integrated solutions that enhance transparency, predictive capacity, and stakeholder coordination. The study concludes that embedding these

technologies across the project lifecycle can significantly improve resilience and sustainability in Kenya's mortgage-financed housing sector. By adopting digital innovations, stakeholders can reduce uncertainty, strengthen accountability, and enhance the performance of MFCPs. This study advances construction risk management theory by developing a thematic framework that integrates emerging digital technologies into the management of mortgage-financed construction projects, thereby reframing technology not as a support tool but as a proactive mechanism for risk mitigation and project resilience.

**KEYWORDS:** Artificial Intelligence, Building Information Modelling, Digital Innovation, Technology Adoption, Risk Management.

## 1.0 INTRODUCTION

Globally, the construction industry is undergoing a digital transformation, with technology increasingly leveraged to manage risks in complex projects. Tools such as Building Information Modeling (BIM), Artificial Intelligence (AI), Internet of Things (IoT), and blockchain are reshaping how risks are identified, assessed, and mitigated (Hwang et al., 2020; Pan et al., 2018). These technologies enable predictive analytics, real-time monitoring, and enhanced transparency, reducing uncertainties related to cost, schedule, and quality. The integration of digital platforms into construction risk management reflects a broader trend toward data-driven decision-making, aligning with global sustainability and efficiency goals (World Bank, 2023).

Across Africa, rapid urbanization and a housing deficit exceeding 51 million units have intensified the need for innovative approaches to project delivery (UN-Habitat, 2020). Mortgage financing is increasingly promoted as a mechanism to bridge this gap, yet projects remain vulnerable to systemic risks such as financing delays, regulatory bottlenecks, and construction inefficiencies (Muigai, Simon, Munala, & Maina, 2025). Technology adoption in construction across the continent remains uneven, constrained by limited infrastructure, skills, and investment. However, emerging evidence suggests that digital tools, such as GIS for site analysis, mobile platforms for stakeholder communication, and BIM for design integration, can significantly improve risk management in housing projects (Centre for Affordable Housing Finance in Africa, 2023).

In Kenya, MFCPs are central to the Affordable Housing Programme, which seeks to address a housing deficit of approximately 2 million units (Kenya National Bureau of Statistics, 2025). Despite their importance, MFCPs face persistent risks including cost overruns, project delays, contractor inefficiencies, and financing challenges (Muigai, Simon, Munala, & Kiambigi, 2025). Developers and financiers increasingly recognize the potential of technology to mitigate these risks. Project management software, BIM, AI-driven predictive analytics, IoT sensors, blockchain-enabled smart contracts, and GIS tools have been identified as transformative enablers of risk management (Tarek et al., 2022). Yet, empirical evidence on how these technologies can be systematically integrated into Kenya's MFCPs remains limited.

Although technology has demonstrated significant potential in global construction risk management, its application in Kenya's mortgage-financed housing sector is still nascent. Existing studies have focused on identifying risks but have not adequately explored how digital innovations can be leveraged to mitigate them. This gap constrains the ability of developers, financiers, and policymakers to design risk-informed strategies that harness technology for improved project outcomes. While global and regional literature emphasizes the transformative role of technology in construction, there is limited empirical evidence on its application in MFCPs in Kenya. Most studies treat technology as a support tool rather than a proactive mechanism for risk mitigation. This lack of contextualized analysis limits the sector's ability to adopt digital solutions effectively. This study seeks to address the identified gap by:

1) Identifying the dominant risks associated with MFCPs in Kenya.
2) Exploring technological innovations that can be leveraged to mitigate these risks.
3) Synthesizing thematic insights into a framework for technology-enabled risk management tailored to Kenya's MFCPs.
4) Providing actionable recommendations for developers, financiers, and policymakers to enhance the performance of MFCPs.

## 2.0 THEORY

### 2.1 Systems Theory

Systems theory provides a holistic lens for understanding construction projects as complex, interdependent systems where risks emerge from the dynamic interaction of subsystems such as finance, regulation, environment, and technology. In the context of MFCPs, systems theory emphasizes that risks cannot be managed in isolation; rather, they must be addressed within the broader network of relationships among stakeholders, processes, and external conditions (Von Bertalanffy, 1972). For example, a financing delay may trigger schedule overruns, which in turn exacerbate contractor inefficiencies and quality risks. By applying systems theory, this study conceptualizes MFCPs as open systems where technology adoption serves as a stabilizing mechanism, enhancing resilience through improved coordination, transparency, and predictive capacity.

### 2.2 Risk Management Theory

Risk management theory provides structured processes such as risk identification, assessment, mitigation, and monitoring, that guide the systematic handling of uncertainties in construction projects (El-Sayegh, 2008). Within MFCPs, risks span financial, planning, construction, legal, and environmental domains, each with distinct impacts on cost, time, and quality. Risk management theory underscores the importance of proactive strategies, emphasizing that risks should be anticipated and mitigated before they materialize. This study extends risk management theory by integrating digital innovations such as BIM, AI, IoT, and blockchain into traditional frameworks, thereby reframing technology as a proactive enabler of risk mitigation rather than a passive support tool.

### 2.3 Technology Adoption Models

To explain how technology adoption strengthens risk management, this study draws on the Technology Acceptance Model (TAM) and the Technology–Organization–Environment (TOE) framework. TAM posits that perceived usefulness and ease of use are the primary drivers of technology adoption (Davis, 1989). In MFCPs, stakeholders are more likely to adopt BIM or AI when these tools demonstrably improve efficiency and are user-friendly. The TOE framework extends this by situating adoption within three dimensions: technological readiness, organizational capacity, and environmental pressures (Tornatzky & Ostrowiecki, 1994). For MFCPs, adoption is shaped not only by the inherent capabilities of technologies but also by organizational resources (skills, leadership, culture) and external factors (regulatory frameworks, housing demand, and market competition).

This study emphasizes that the effective adoption of risk management technologies requires alignment among stakeholder perceptions, organizational readiness, and external factors by integrating the TAM with the TOE framework. The study offers a multi-faceted theoretical framework by integrating systems theory, risk management theory, the TAM, and the TOE framework. It perceives technology not solely as a supportive instrument but as an active component integrated within project systems to foresee, alleviate, and control hazards. This theoretical synthesis enhances comprehension of how digital technologies can revolutionize risk management procedures in Kenya's mortgage-financed housing market.

## 3.0 METHODOLOGY

### 3.1 Research Design

A research design establishes a framework for data gathering and analysis. This study adopts the survey research design described by Bryman (2012) and Creswell and Plano Clark (2017). Bryman (2012) describes a survey as one that studies multiple cases at a single point in time by measuring quantifiable data with the aim of identifying patterns of association. The advantage of data quantification is that it provides a consistent benchmark to the researcher and, at the same time, makes it possible to understand relationships between variables.

### 3.2 Sampling Methods and Sample Size

The unit of analysis was the construction project, while the unit of observation was either the site agent or the clerk of works found on site. Inferences made were on all mortgage-financed construction projects, given that the sample size was selected probabilistically as outlined in the next section.

In this study, the population included all construction projects financed through mortgages throughout the country. This study focuses on the 1,063 mortgages initiated during the 2021/2022 financial year, as per the annual banking report by the Central Bank of Kenya (2023). The sample size was calculated based on the following formulae from Cochran (1977) and Bartlett et al. (2001).

$$n_o = \frac{t^2 \times s^2}{e^2}$$

Where: -

- $n_0$= required return sample size
- $t$ = alpha level value (0.01 = 2.576 for sample size of 120 or more; the alpha level of .01 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error.) 2.576 is the z-score for a 99% confidence interval.
- $s$ = estimated standard deviation in population for 7-point scale (1.167; estimate of variance deviation for 7-point scale calculated by using 7 [inclusive range of scale] divided by 6 [number of standard deviations that include almost all (approximately 98%) of the possible values in the range])
- $e$ = acceptable level of error for the mean being estimated (0.21; number of points on primary scale × acceptable margin of error; points on primary scale = 7; acceptable margin of error = .03 [error researcher is willing to accept])

Therefore;

$$n_o = \frac{2.576^2 \times 1.167^2}{0.21^2} = 205$$

However, since this sample size exceeds 5% of the population (1,063×5%=53), the following (Cochran, 1977) correction formula was used to estimate the final sample size.

$$n_f = \frac{n_0}{1 + \frac{n_0}{population}} = \frac{205}{1 + \frac{205}{1063}} = 171\ projects$$

Where;

- $n_f$ = final sample size
- $n_0$ = original sample size
- Population = target population

This study employed simple random sampling to select the sample size from the population. Kothari (2004) refers to this sampling method as chance sampling or probability sampling, as every item in the population has an equal likelihood of selection, and each potential sample from a finite universe possesses an identical probability of being selected. An ideal sample fulfills the criteria of efficiency, representativeness, reliability, and adaptability.

### 3.3 Data Collection

Upon approval of the research proposal by the university, the researcher sought permission from the National Commission for Science and Technology and Innovation (NACOSTI) to collect field data. According to Creswell (2003), structured interviews and questionnaires are the two most common research methods associated with survey research design. The latter was adopted in this study as the method of collecting data. The measured indicators were derived from previous literature and refined so that they were not only appropriate for the respondents but also generated enough data for hypothesis testing. Risk probability and impact were measured using a seven-point Likert scale, ranging from “extremely low” (1) to “extremely high” (7). Impact was assessed across cost, time, and quality dimensions, with means converted into Relative Importance Index (RII) values following Tarek et al. (2022). This scaling approach ensured comparability across diverse risks and facilitated the calculation of composite risk scores.

### 3.4 Data Analysis

This study employed both descriptive statistics and thematic analysis to capture the multidimensional nature of risks in MFCPs. Descriptive statistics, analysed using SPSS software, provided quantifiable insights into the prevalence and severity of risks, offering a structured benchmark for comparison across categories. Thematic analysis, on the other hand, allowed for deeper exploration of practitioners' perspectives, uncovering detailed strategies and contextual factors that numbers alone could not reveal (Braun & Clarke, 2006). The combination ensures methodological triangulation, enhancing validity by integrating objective measures with subjective experiences.

The integration strategy followed a convergent parallel design (Creswell & Plano Clark, 2018). Quantitative results identified dominant risks and their relative impact, while qualitative findings revealed how technology could mitigate these risks. The two strands were merged at the interpretation stage: for example, construction risks ranked highest quantitatively, and BIM/IoT emerged qualitatively as key mitigation tools. This convergence allowed the study to propose a thematic framework where technological pillars directly align with empirically measured risk categories.

### 3.5 Validity and Reliability

Expert evaluations were performed to ensure the face and content validity of the questionnaire. Five experts, comprising three academic thesis supervisors and two industry professionals, collectively possessing 112 years of expertise, provided recommendations for enhancing the data gathering instrument. A pilot test was conducted with a sample of the target population (n=10) to identify any underlying issues. Minor changes were implemented in accordance with recommendations from the experts and participants of the pilot research.

### 3.6 Potential Limitations

While survey research provides breadth, it is limited in depth. Respondents may interpret questions differently, leading to measurement bias. Self-reported data can also be influenced by social desirability or recall errors. Furthermore, surveys capture perceptions at a single point in time, potentially overlooking evolving risks or long-term effects. These limitations were mitigated through expert validation of instruments and triangulation with thematic analysis, but they remain important considerations.

## 4.0 RESULTS

A total of 171 questionnaires were distributed based on the calculated sample size. The questionnaires were administered online through Google Forms. 123 questionnaires were returned. This translated to a response rate of 71.9%. Based on the 70% threshold set by Fincham (2008), the response rate achieved for this study was considered adequate.

### 4.1 Background Information

Five elements of background information were evaluated in the data collection instrument. The factors included: level of education, professional experience, project type, project value, and project duration. Their findings are delineated in the subsequent sections.

#### 4.1.1 Level of Education

Figure 1 illustrates that 52.5% (n=64) of respondents possessed a Bachelor's degree, whilst 36.1% (n=44) held a Master's degree. Collectively, these two categories include 108 of the 122 respondents (nearly 89%). This indicates that the industry predominantly consists of highly educated professionals. This may be due to the preference of most financial institutions to grant mortgages to salaried persons, who are typically educated professionals. 5.7% (n=7) possessed a Diploma, whilst merely 3.3% (n=4) held a PhD. The limited quantity of Doctorates was anticipated, considering that only a minor fraction (perhaps solely those in academia) of professionals progress beyond a master's degree. The group with the lowest representation consisted of post-secondary certification holders, accounting for 2.4% (n=3).

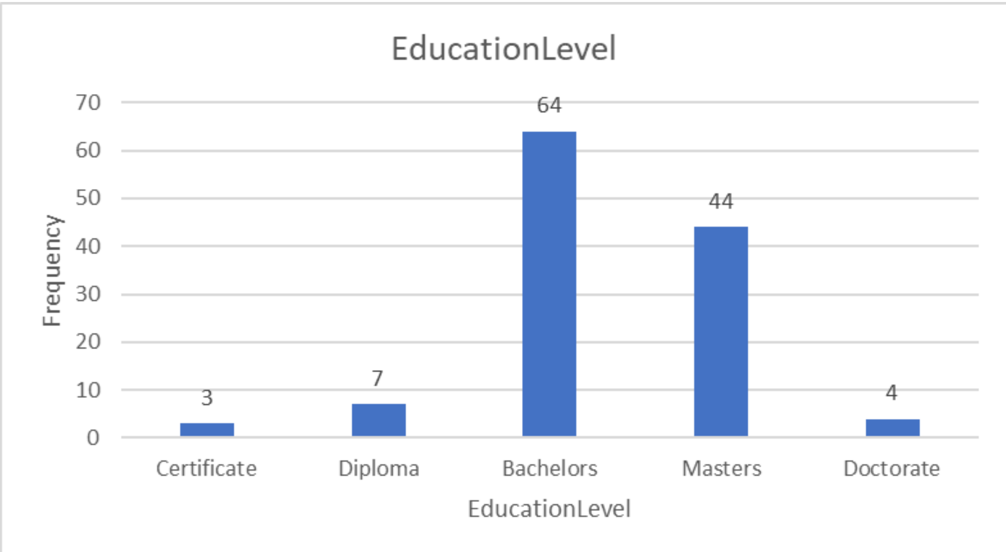


**Figure 1: Level of Education.**

The findings reveal that Kenya's mortgage-financed construction sector is dominated by highly educated developers, with Bachelor's and Master's degrees being the norm. This likely enhances professionalism but may also create barriers for those with lower academic qualifications. The financial institutions appear to value highly educated professionals.

#### 4.1.2 Professional Background

Considering the anticipated varied backgrounds of the respondents (developers), the inquiry regarding their professional background was articulated in an open-ended format. The findings are illustrated as a word cloud in Figure 2. A considerable percentage of responders possess backgrounds in construction-related fields. These encompassed Construction Management, Civil Engineering, Quantity Surveying, Structural Engineering, Architecture, and Mechanical Engineering, among others. Several developers with backgrounds in business and banking. This is anticipated as bank officials are well-acquainted with the diverse mortgage financing alternatives present in the market. The spectrum of occupations was very extensive.


**Figure 2: Professional Background.**

### 4.1.3 Type of Projects

The respondents were requested to specify the type of project they were presently undertaking, which was financed by a mortgage. Figure 3 illustrates that houses were predominantly funded by mortgages, accounting for 68.3% (n=82) of the total. Mixed-use development was followed at a distance by 13.3% (n=16) and commercial buildings at 11.7% (n=14). Office buildings and industrial facilities constituted the least mortgage-financed categories of development projects, each representing 3.3% (n=4).

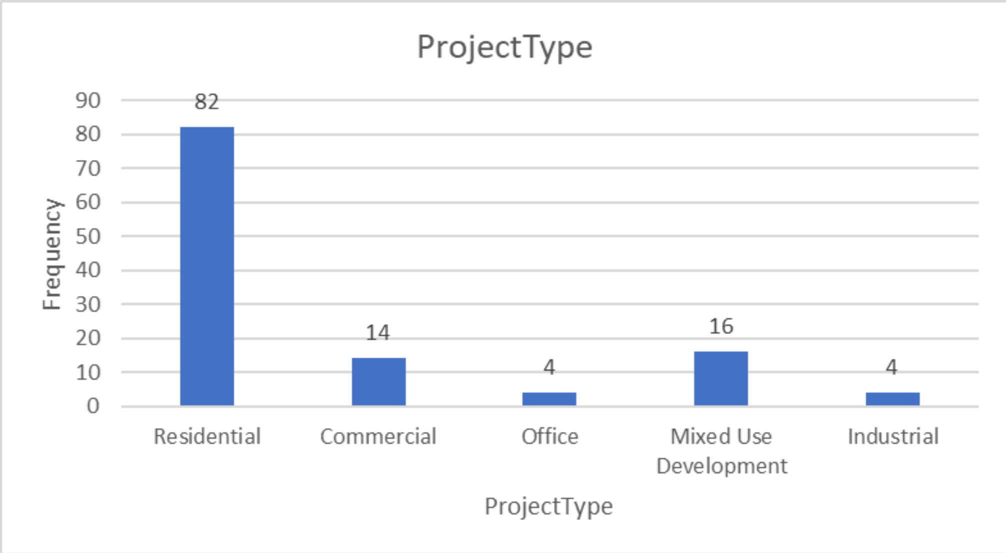


**Figure 3: Type of Project.**

The results revealed that residential projects overwhelmingly dominate the mortgage-financed construction sector in Kenya, with commercial, office, mixed-use developments, and industrial projects making up a much smaller share. The overwhelming dominance of residential projects likely reflects Kenya's ongoing demand for housing, driven by population growth, urbanization, and government initiatives such as affordable housing programs. Mortgage products and incentives may be more accessible or attractive for residential developments compared to other sectors. The lower numbers for commercial, office, and industrial projects may a number of things, (i) mortgage financing is less commonly used or less available for non-residential developments, (ii) these sectors might rely more on alternative financing structures (e.g., corporate loans, equity investment), and (iii) there may be greater perceived risk or longer payback periods for non-residential projects, making them less attractive for mortgage-backed funding. This is because such projects are more capital-intensive compared to residential projects.

The presence of 16 MUD projects (13.3%) suggests a growing trend towards integrated developments that combine living, working, and leisure spaces. This aligns with global urbanization trends and can enhance project viability by diversifying revenue streams and meeting multiple market needs. This is fundamental in ensuring that completed projects are capable of repaying the loan obligations.

### 4.1.4 Project Value

The participants were requested to specify the value of the construction project they were presently undertaking. Figure 4 displays interesting results in which the extremes had the highest frequencies. The results presupposed an inverted bell curve. The predominant building projects (n=62, 51.2%) had a value of "up to 20 million" Kenyan shillings, followed by those valued at "above 120 million" Kenyan shillings (n=32, 26.4%). Projects valued at KShs. 81 – 100 million exhibited a frequency of 9.1% (n=11), whereas those valued at KShs. 21 to 40 million exhibited a frequency of 8.3% (n=10). Projects valued at KShs. 41 to 60 million. Both the 61 – 80 age group and the 81 – 100 age group ranked bottom, both with a frequency of 2.5% (n=3).

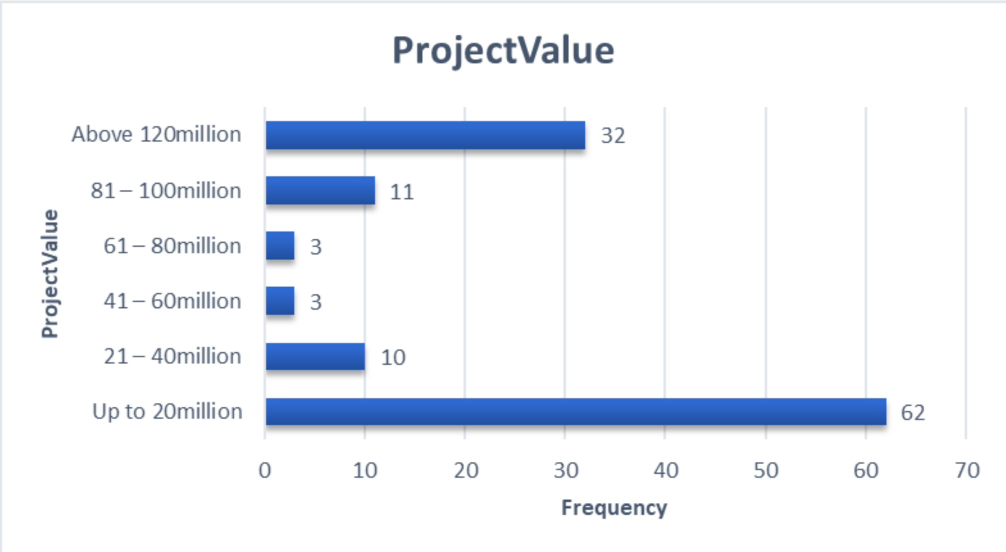


**Figure 4: Project Value.**

### 4.1.5 Project Duration

The project's duration was quantified in weeks. This was conducted at intervals of 12 weeks. The results depicted in Figure 5 demonstrated an even distribution among all groups. Projects lasting "over 72 weeks" were the most prevalent, accounting for 24.8% (n=30). Projects lasting "61-72 weeks" exhibited the lowest representation, with 5.0% (n=6). Projects with a duration of "less than 12 weeks" occurred at a frequency of 9.1% (n=11).

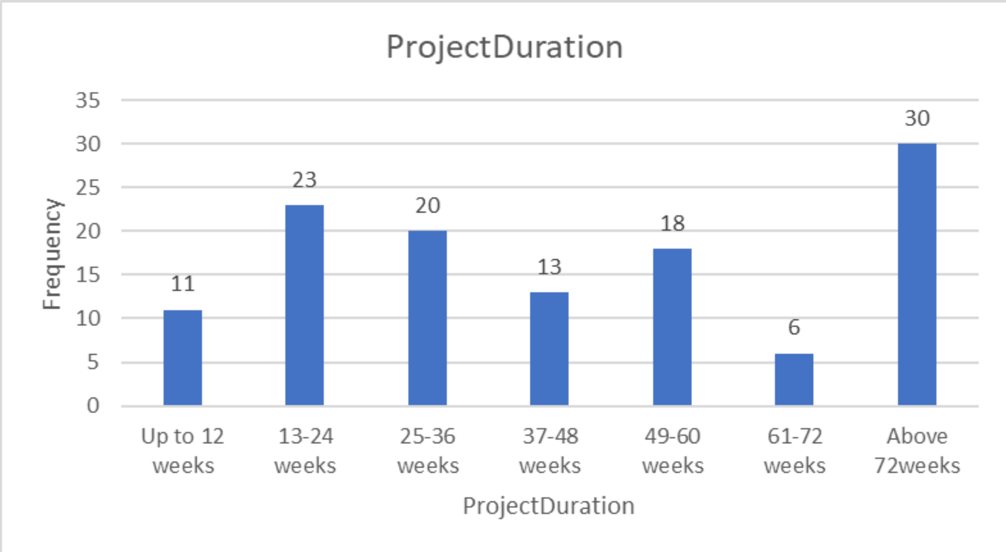


**Figure 5: Project Duration.**

The highest number of projects (24.8%) reported durations of above 72 weeks, indicating that a significant portion of mortgage-financed developments in Kenya are long-term, complex projects, likely to be large-scale or multi-phase developments. This finding complements the earlier findings on project values, where a substantial number of projects also had high values, suggesting that large investments correlate with extended construction timelines.

### 4.2 Risks Associated with MFCPs

This section sought to establish the risks associated with MFCPs. Six types of risks were considered. A seven-point Likert scale ranging from "extremely low" to "extremely high" was adopted for both risk probability and risk impact. The means were converted to RII values by dividing by the highest possible score on the Likert scale (7) as advocated for by Tarek et al. (2022). The overall risk impact was calculated by obtaining the means of the three types of risk impact evaluated. The risk level was then calculated by multiplying the risk probability and the overall risk impact, and converted to a percentage.

A total of 41 risks were evaluated and summarised in six categories, namely market risks, financial risks, planning risks, construction risks, legal and regulatory risks, and environmental risks as presented in Table 1.

**Table 1: Risks Associated with MFCPs.**

| | Risks | P | Ic | It | Iq | I | R | Rank |
|---|---|---|---|---|---|---|---|---|
| a) | Market risks | 0.63 | 0.65 | 0.47 | 0.48 | 0.53 | 35% | 4 |
| b) | Financial risks | 0.66 | 0.75 | 0.58 | 0.52 | 0.62 | 41% | 2 |
| c) | Planning risks | 0.62 | 0.60 | 0.85 | 0.55 | 0.67 | 41% | 2 |

| | Risks | P | Ic | It | Iq | I | R | Rank |
|---|---|---|---|---|---|---|---|---|
| d) | Construction risks | 0.54 | 0.81 | 0.79 | 0.71 | 0.77 | 42% | 1 |
| e) | Legal and regulatory risks | 0.45 | 0.60 | 0.64 | 0.48 | 0.57 | 26% | 5 |
| f) | Environmental risks | 0.41 | 0.60 | 0.55 | 0.46 | 0.54 | 22% | 6 |
| P=Risk Probability, Ic=Impact on Cost, It=Impact on Time, Iq=Impact on Quality, I=Overall Impact (Mean; Ic, It & Iq), R=Risk Score=P*I | | | | | | | | |

Source: (Author, 2025)

### 4.3 Leveraging Technology in Risk Management of MFCPs

Respondents were asked to suggest how technology could be leveraged when managing risks associated with MFCPs. Their insights, drawn from practical experience, were thematically analyzed using the six-phase approach proposed by Braun and Clarke (2006). A word cloud was generated to visualize the most frequently cited concepts (see Figure 6), revealing dominant terms such as project management software, BIM, AI, IoT, blockchain, digital platforms, predictive analytics, and real-time monitoring.


**Figure 6: Word cloud on Leveraging Technology to Improve Risk Management in MFCPs.**

The analysis yielded seven overarching themes, each reflecting practical strategies and orientations toward the use of technology in risk management.

### 4.3.1 Project Management Software and Digital Platforms

The most recurrent theme was the use of project management software such as MS Project, Primavera, and Procore to track project progress, timelines, and budgets. Developers emphasized that such tools provide centralized dashboards for monitoring risks and ensuring accountability. Two respondents noted:

*"By using project management software like MS Project to track project implementation."*

*"Installing project management software and risk analysis systems helps monitor overruns in terms of time and cost against the project programme in real time."*

### 4.3.2 Building Information Modeling (BIM) and Digital Twins

Respondents highlighted BIM as a transformative tool for integrated risk assessment, enabling visualization of design, cost, and scheduling risks before construction begins. BIM was seen as critical for clash detection, scenario analysis, and enhanced stakeholder collaboration. Two respondents noted:

*"Building Information Modeling (BIM) provides a 3D digital representation of a project, integrating timelines and budgets to identify potential risks."*

*"Virtual simulation of the construction project using BIM identifies areas of conflict, ensures precise BoQ, material schedules, and contract period accuracy."*

BIM directly addresses identified risks by ensuring design precision and reducing risks of defects or delays.

### 4.3.3 Artificial Intelligence (AI) and Predictive Analytics

Developers emphasized the role of AI and machine learning in predictive risk modeling, analyzing historical data to forecast potential cost overruns, delays, or contractor defaults. Two respondents noted:

*"Predictive analytics can forecast potential risks such as cost overruns, delays, or issues with subcontractors."*

*"Technology reduces human errors; it predicts and suggests mitigation before risks arise while offering real-time, large data analytics."*

AI-driven predictive analytics provides a proactive mechanism to anticipate such risks and design mitigation strategies.

### 4.3.4 Internet of Things (IoT) and Smart Sensors

Respondents highlighted the use of IoT devices and smart sensors for real-time site monitoring, environmental tracking, and equipment performance assessment. Two respondents noted:

*"IoT devices can monitor environmental factors such as weather, vibrations, and air quality, helping to identify risks like structural instability or safety hazards."*

*"Real-time monitoring through drones and sensors can detect deviations or risks early."*

IoT technologies directly address these risks by providing continuous environmental data.

**4.3.5 Blockchain and Smart Contracts**

Respondents emphasized the potential of blockchain technology to enhance transparency in financial transactions, contracts, and supply chain processes. Smart contracts were seen as tools to automate payments and enforce compliance. Two respondents noted:

*"Storing contracts, permits, and payment records on a blockchain can reduce the risk of fraud or disputes."*

*"Smart contracts automate contract execution and payments based on milestones, ensuring accountability and minimizing disputes."*

Blockchain strengthens contract management by ensuring secure, transparent, and automated enforcement.

**4.3.6 Geographic Information Systems (GIS) and Satellite Monitoring**

Respondents highlighted the use of GIS and satellite imaging for site analysis, location-based risk assessment, and monitoring project progress. Two respondents noted:

*"GIS can assess risks related to the project location, such as flood zones, seismic activity, or proximity to resources."*

*"Satellite imaging for ongoing projects helps track progress and identify risks in real time."*

GIS and satellite monitoring provide spatial intelligence to support regulatory compliance and environmental risk assessment.

**4.3.7 Communication and Collaboration Tools**

Finally, respondents emphasized the role of cloud-based communication platforms (e.g., Microsoft Teams, Slack, WhatsApp) in enhancing stakeholder collaboration and reducing misunderstandings. Two respondents noted:

*"Creating a platform where ideas from various stakeholders can be shared for fast-tracking of projects."*

*"Frequent visits, uploading of project reports to shared forums, improved communication through use of technology such as WhatsApp."*

Technology-enabled collaboration ensures transparency, accountability, and timely reporting of risks.

### 4.3.8 Summary of the Thematic Analysis

The thematic analysis reveals that developers perceive technology as a multi-dimensional enabler of risk identification and assessment in MFCPs. Project management software, BIM, AI, IoT, blockchain, GIS, and communication platforms collectively enhance monitoring, predictive analytics, transparency, and collaboration. The recurring emphasis on real-time monitoring and predictive analytics suggests that developers view technology not merely as a support tool but as a transformative mechanism for proactive risk management.

## 5.0 DISCUSSION OF FINDINGS

### 5.1 Comparative Interpretation of Risk Categories

The dominance of construction risks aligns with global findings that inefficiencies in contractor performance and material cost escalation are common drivers of project failure (Mbaya, 2023; Zou & Sunindijo, 2015). Financial and planning risks, ranking equally high, reflect Kenya's mortgage financing environment, where disbursement delays and bureaucratic bottlenecks often undermine project timelines (CBK, 2023; HF Group, 2022). Market risks, though moderate, remain significant given Kenya's volatile housing demand and price fluctuations. Legal/regulatory and environmental risks, while ranked lower, should not be overlooked, as regulatory compliance and climate resilience are increasingly critical in sustainable housing delivery (Abdullah et al., 2025).

### 5.2 A Thematic Framework for Leveraging Technology in Risk Management of MFCPs

The proposed framework in Figure 7 organizes seven technological pillars around their capacity to mitigate the six dominant risks affecting mortgage-financed construction projects (MFCPs) in Kenya. Each pillar addresses multiple risk categories, offering a layered, proactive approach to project resilience.

**Pillar 1-Project Management Software and Digital Platforms:** Tools such as MS Project, Primavera, and Procore enable centralized tracking of budgets, schedules, and milestones (Prasad, 2025). These platforms mitigate financial risks by flagging cash flow delays and supporting phased disbursement models. They also address planning risks by improving visibility into permit timelines and stakeholder coordination. By integrating dashboards and alerts, they enhance managerial oversight and reduce the likelihood of missed deadlines or cost overruns.

**Pillar 2-Building Information Modelling (BIM) and Digital Twins:** BIM provides a 3D digital representation of the project, integrating design, cost, and scheduling data (Datta et al., 2023). It mitigates construction risks by enabling clash detection, precise material quantification, and simulation of construction phases. BIM also supports environmental risk management by modelling sustainability metrics and simulating climate scenarios (Elsheikh et al., 2025). Digital twins extend BIM's utility by enabling real-time monitoring of built assets, improving lifecycle risk management (Elsheikh et al., 2025).

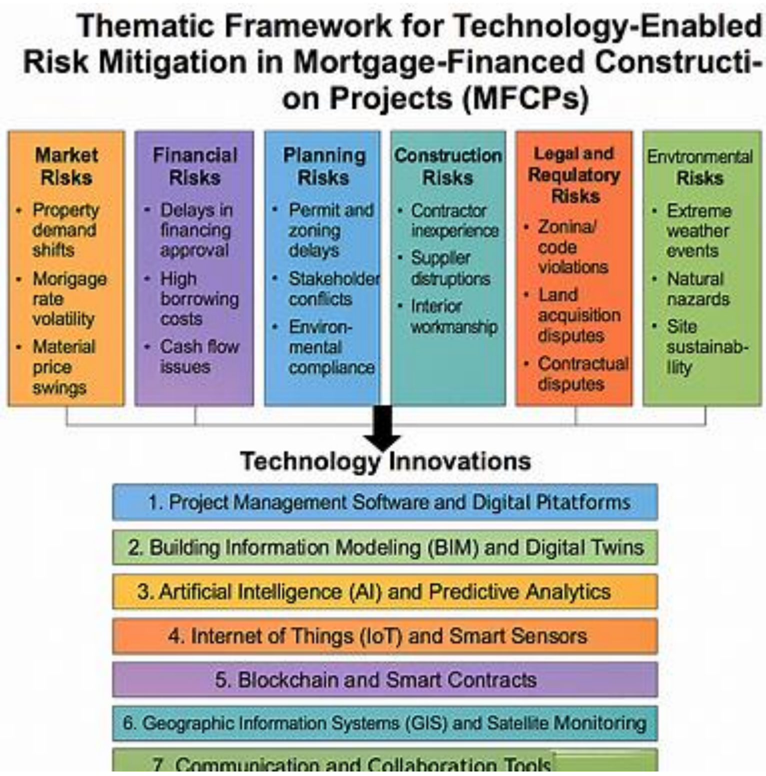


**Figure 7: A Thematic Framework for Leveraging Technology in Risk Management of MFCPs**.

**Pillar 3-Artificial Intelligence (AI) and Predictive Analytics:** AI algorithms analyze historical project data to forecast risks such as cost overruns, delays, and contractor defaults. Predictive analytics help mitigate market risks by modeling demand trends and price fluctuations (Nyqvist et al., 2026). They also support financial risk management by identifying patterns in loan disbursement delays and budget deviations (Vilibić et al., 2026). AI enhances decision-making by offering early warnings and scenario-based planning (Pejić et al., 2023).

**Pillar 4-Internet of Things (IoT) and Smart Sensors:** IoT devices and sensors provide real-time data on environmental conditions, equipment performance, and site safety. These technologies mitigate environmental risks by detecting extreme weather, structural instability, or hazardous conditions (Khodabakhshian et al., 2023). They also address construction risks by monitoring material usage, worker activity, and equipment health. IoT enhances responsiveness and reduces downtime through automated alerts and remote diagnostics (Zhang et al., 2025).

**Pillar 5-Blockchain and Smart Contracts:** Blockchain ensures secure, transparent storage of contracts, permits, and financial records. Smart contracts automate payments based on verified milestones, reducing financial delays and disputes (Pham et al., 2025). These technologies mitigate legal and regulatory risks by enforcing compliance and reducing fraud. They also support market risk management by enhancing trust in transactions and reducing speculative behavior (Nada & Othman, 2025).

**Pillar 6-Geographic Information Systems (GIS) and Satellite Monitoring:** GIS tools assess site suitability, zoning constraints, and environmental vulnerabilities (Wahba et al., 2025). Satellite imagery supports real-time progress tracking and spatial risk analysis. These technologies mitigate planning risks by streamlining permit approvals and ensuring compliance with land use regulations. They also address environmental risks by identifying flood zones, seismic activity, and ecological sensitivities (Abdelouhed et al., 2022).

**Pillar 7-Communication and Collaboration Tools:** Cloud-based platforms such as Microsoft Teams, Slack, and WhatsApp facilitate real-time communication among stakeholders. These tools mitigate planning and managerial risks by improving coordination, reducing misunderstandings, and accelerating decision-making (Nawaz et al., 2019). They also support regulatory compliance by enabling timely reporting and documentation sharing (Prasad, 2025).

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

This study examined how technology can be leveraged to improve risk management in mortgage-financed construction projects (MFCPs) in Kenya. The findings revealed that MFCPs are exposed to six dominant categories of risk: market, financial, planning, construction, legal and regulatory, and environmental. These risks often interact, compounding vulnerabilities and undermining project performance across cost, schedule, quality, and compliance dimensions.

The thematic analysis demonstrated that developers and financiers increasingly view technology not as a peripheral support tool but as a transformative enabler of proactive risk management. Seven technological pillars were identified as central to this transformation: project management software and digital platforms, Building Information Modeling (BIM) and digital twins, Artificial Intelligence (AI) and predictive analytics, Internet of Things (IoT) and smart sensors, blockchain and smart contracts, Geographic Information Systems (GIS) and satellite monitoring, and communication and collaboration tools. Each of these technologies directly addresses multiple risk categories, offering integrated solutions that enhance transparency, predictive capacity, and stakeholder coordination.

The study concludes that embedding these technologies across the project lifecycle can significantly improve resilience and sustainability in Kenya's mortgage-financed housing sector. By adopting digital innovations, developers can reduce construction inefficiencies, financiers can strengthen accountability in financial flows, regulators can streamline compliance, and policymakers can foster an enabling environment for affordable housing delivery. Ultimately, technology-enabled risk management provides a replicable model for emerging economies, bridging global best practices with local housing priorities and advancing Kenya's Affordable Housing Programme.

## 6.2 Recommendations

Building on the conclusions, the following recommendations are proposed to strengthen technology-enabled risk management in mortgage-financed construction projects (MFCPs) in Kenya:

### 6.2.1 For Developers

- **Integrate Digital Platforms into Project Governance:** Adopt project management software to centralize monitoring of budgets, schedules, and risks, ensuring accountability across all phases of construction.
- **Leverage BIM and Digital Twins:** Use BIM for clash detection, precise material quantification, and sustainability modeling, while employing digital twins for real-time monitoring of built assets.
- **Adopt IoT for Site Monitoring:** Deploy smart sensors and drones to track environmental conditions, equipment performance, and safety compliance, reducing disruptions and enhancing quality control.

### 6.2.2 For Financiers

- **Utilize Blockchain for Transparency:** Implement blockchain and smart contracts to automate payments, secure financial records, and reduce fraud or disputes in mortgage financing.

- **Support Predictive Analytics:** Encourage the use of AI-driven predictive models to forecast financial risks such as loan defaults, cash flow delays, and market volatility, thereby improving credit risk assessment.
- **Invest in Digital Risk Tools:** Provide financing incentives for developers who adopt advanced risk management technologies, aligning financial support with innovation.

### 6.2.3 For Regulators and Policymakers

- **Streamline Approvals with GIS:** Integrate GIS and satellite monitoring into regulatory processes to accelerate permit approvals and ensure compliance with zoning and environmental standards.
- **Promote Digital Collaboration:** Encourage the use of cloud-based communication platforms for transparent reporting and stakeholder coordination, reducing bureaucratic inefficiencies.
- **Create Enabling Policy Frameworks:** Develop national guidelines that recognize technology as a core component of risk management in housing delivery, incentivizing adoption through tax breaks or subsidies.

### 6.2.4 Cross-Sectoral Recommendation

- **Embed Technology Across the Lifecycle:** Stakeholders should adopt the seven technological pillars holistically, ensuring that risk management is proactive, data-driven, and embedded from design to post-completion.

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