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**Integrating Artificial Intelligence and Building Information Modeling to
Enhance Hotel Development Performance in Saudi Arabia: A Proposed
National Framework**

Prepared by:

MOHAMAD MOSADAK ALSAEED

Academic No: 253001110

Supervised by:

Dr. Alfaisal Abdelhameed Mohamed

Dr. Fayez Ali Jrad

Year:2026

DECLARATION

I declare that this dissertation entitled:

"Integrating Artificial Intelligence and Building Information Modeling to Enhance Hotel Development Performance in Saudi Arabia: A Proposed National Framework" is my original work and that no part of this has been submitted to this or any other university for any other award or qualification. I certify that the information and published material have been fully acknowledged and cited in the text of this dissertation as specified in the University's regulations. Any help provided in the preparation of this dissertation has been duly acknowledged. I recognize that academic offences including plagiarism, fraud, and any misrepresentation, can be punished under the University's regulations on Academic Misconduct.

Student Name: Mehmet Saitoğlu

Student ID: 253001110

Signature: 

Date: 17-7-2026

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Abstract:

The rapid adoption of Building Information Modeling (**BIM**) and the Artificial Intelligence (**AI**) are transforming the Architecture, Engineering, Construction, and Operations (AECO) industry by enabling new approaches to project delivery and intelligent digital decision – making , While ample research was devoted to studying the utilization of AI and BIM individually, little has been investigated into how these two emerging technologies work together to improve processes across the hotel development life-cycle , especially in the Saudi environment. Accordingly, this study aims at examining the impacts of AI, BIM and AI-BIM integration on hotel development performance (**HDP**) and develop a Saudi AI-BIM framework to support digital transformation for the industry in line with the ambitions of the Saudi **Vision 2030**.

A quantitative research design with a positivist philosophical stance and deductive approach was adopted. Structured questionnaires were the primary instrument for collecting data from professionals working in hotel development projects in Saudi Arabia. A total of **137** valid questionnaires was analyzed using IBM SPSS Statistics software to investigate the proposed research hypotheses with descriptive, reliability, Pearson correlation and multiple regression analysis techniques. The findings indicate that AI, BIM, and AI-BIM integration positively impacts the **HDP**, but it is significantly noticed that AI-BIM integration enhances the **HDP** to the highest levels, demonstrating that, integrating AI with BIM – generated digital information offers significant improvement than implementing either technology independently, will offer highest results compared to their stand-alone utilization.

The study also identified that several factors have to be addressed before the widespread integration of AI-BIM: data interoperability, quality of information, the organization's readiness, and availability of skilled workers. This study contributes to the existing body of knowledge by providing empirical evidence for the integration of AI and BIM in hotel development projects in Saudi Arabia, by presenting actionable recommendations for developers, consultants, contractors, hotel operators and government stakeholders to adopt practices of integrated AI-BIM and by formulating a national framework that enables AI-BIM implementation through the entire Hotel development Life Cycle in Saudi Arabia.

Keywords: Artificial Intelligence, Building Information Modeling, AI–BIM Integration, Hotel Development, Hotel Development Performance, Saudi Arabia.

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List of Abbreviations by Domain:

1. Architecture, Engineering, Construction & Digital Construction (AECO)

- **AECO:** Architecture, Engineering, Construction and Operations
- **BIM:** Building Information Modeling
- **AEC/FM:** Architecture, Engineering, Construction and Facility Management
- **MEP:** Mechanical, Electrical, and Plumbing / Building Services Engineering
- **CAD:** Computer-Aided Design
- **CDE:** Common Data Environment
- **IFC:** Industry Foundation Classes (Open data exchange format)
- **IDS:** Information Delivery Specification
- **COBie:** Construction Operations Building Information Exchange
- **AIM:** Asset Information Model
- **BMS:** Building Management Systems
- **HVAC:** Heating, Ventilation, and Air Conditioning
- **NCR:** Non-Conformance Reports

2. Artificial Intelligence, Tech & Data Science

- **AI:** Artificial Intelligence
- **ML:** Machine Learning
- **DL:** Deep Learning
- **NLP:** Natural Language Processing
- **CV:** Computer Vision
- **Gen AI:** Generative Artificial Intelligence
- **IoT:** Internet of Things
- **GIS:** Geographic Information System
- **ANN:** Artificial Neural Network
- **SVM:** Support Vector Machine
- **RF:** Random Forest
- **DNN:** Deep Neural Network
- **CBR:** Case-Based Reasoning

3. Hospitality, Lodging & Operations Management

- **FF&E:** Furniture, Fixtures, and Equipment
- **O&M:** Operations and Maintenance
- **SLA:** Service Level Agreements
- **OCC:** Occupancy Rate
- **ADR:** Average Daily Rate
- **RevPAR:** Revenue per Available Room
- **GOPPAR:** Gross Operating Profit per Available Room
- **BPM:** Business Process Management
- **RPA:** Robotic Process Automation
- **VUCA:** Volatility, Uncertainty, Complexity, and Ambiguity
- **PMI:** Project Management Institute

- **ISO:** International Organization for Standardization

5. Finance, Investment & Economics

- **ROI:** Return on Investment
- **NPV:** Net Present Value
- **IRR:** Internal Rate of Return
- **DCF:** Discounted Cash Flow
- **EVM:** Earned Value Management
- **CPI:** Cost Performance Index
- **SPI:** Schedule Performance Index
- **OECD:** Organization for Economic Co-operation and Development

6. Study-Specific Variables & Research Methodology

- **HDP:** Hotel Development Performance (The dependent variable of the study)
- **RO:** Research Objectives (Represented as RO1 to RO6 in the text)
- **RQ:** Research Questions (Represented as RQ1 to RQ6 in the text)
- **H:** Hypotheses (e.g., Main hypothesis H1, and sub-hypotheses H1a, H1b, etc.)

CHAPTER ONE - INTRODUCTION

1.1. Introduction

One of the biggest digital transformations in the history of the Architecture, Engineering, Construction and Operations (AECO) industry is currently underway.

Digital technologies are evolving at an unparalleled pace, project complexity is rising, sustainability expectations are increasing and stakeholder expectations are growing, forcing a paradigm shift in how projects are planned, designed, delivered, operated and maintained. Common challenges in traditional project management remain, such as fragmentary project information, poor interdisciplinary coordination, delays in schedule, cost overruns, inefficient team communication, and difficulties in information management across the many stages of the project lifecycle.

As a result, organizations are now motivated towards enabling digital transformation as a strategic solution to improve project performance and achieve sustainable value creation (Project Management Institute [PMI], 2025).

Artificial Intelligence (AI) and Building Information Modeling (BIM) in particular stand out among the emerging digital technologies that have emerged as key enablers of innovation in the construction industry.

Machine learning, predictive analytics, intelligent decision support, automated data analysis, risk forecasting, and schedule optimization are key methods that Artificial Intelligence supports project management with.

Simultaneously, Building Information Modeling gives us integrated digital environment which improves communication and collaboration between multiple disciplines, data management, coordination of designs, construction planning, and life cycle asset performance. Recent research has indicated that using ai-aided buildings in conjunction with building information modeling (BIM) greatly enhances planning, design, construction, operations, and decision-making in buildings via applied intelligence of project information through the building lifecycle (Datta et al., 2024; Du et al., 2024).

Instead of being perceived as isolated technologies, AI and BIM are now increasingly considered as two conjoined parts of Construction 4.0. The integration of AI / ML into project management enables project teams to analyze large amounts of project data, predict project risks, automate repetitive tasks, optimize resource allocation, and enhance collaboration

between project stakeholders. Hence, the integration of AI and BIM has gained significant attention as an avenue for enhancing project performance, decreasing uncertainties, and facilitating data-driven decision-making throughout the entire lifecycle of construction projects from their conceptualization to their completion (Rangasamy & Yang, 2024).

Hotel investment projects are some of the most complicated projects within the construction industry since they require ongoing collaboration between developers, investors, architects, engineers, consultants, contractors, hotel operators, suppliers, facility managers. Unlike more conventional developments, hotel projects must still balance architectural quality, operational efficiency, sustainability goals, guest experience, investment expectations, and long-term asset performance.

Thus, the project management, information system integration and goal-oriented decision-making from feasibility studies to design, construction, commissioning, operation and facility management is vital for successful hotel development. According to Kim et al. Artificial Intelligence is now impacting the hospitality sector to a large extent by improving operational efficiency, enhancing customer experience, and building high-risk business strategies (2025).

Hotel developments now play a strategic role in the Saudi Vision 2030 agenda to diversify the national economy with measures to boost tourism, raise levels of private-sector participation in the economy, and the increase foreign and domestic regional investment. The tourism sector in the Kingdom has been one of the fastest growing sectors since the release of Vision 2030.

It has a national tourism strategy, aiming to significantly increase the contribution of tourism to 10% of the Gross Domestic Product and create ~1.6 million jobs by 2030 (Organization for Economic Co-operation and Development [OECD], 2024).

In order to meet these national goals, Saudi Arabia is rolling out mega projects all over the country like NEOM, The Red Sea, AMAALA, Qiddiya, Diriyah Gate and Rua Al Madinah. While these projects promise to significantly enhance hotel room capacity and attract overseas tourism, this may require sophisticated digital technologies astutely capable of additionally augmenting project delivery, operational readiness and lifecycle asset management.

In a related context, the Ministry of Tourism announced that over 50 international hospitality brands continue to accelerate their investments in Saudi Arabia, pushing the kingdom to become one of the fastest growing tourism investment markets in the world.

However, in the face of these impressive achievements, hotel development projects in Saudi Arabia continue to be plagued by a wide spectrum of challenges such as schedule delays, cost overruns, design coordination conflicts, fragmented project information, procurement uncertainties, construction rework and limited integration across project phases.

While BIM has been increasingly implemented for design coordination and information management, and AI capabilities are more routinely being used in project analytics and decision support, there have been limited examples of integrated implementation throughout the hotel development lifecycle.

Additionally, while previous studies have mostly examined Artificial Intelligence and Building Information Modeling in isolation, there is still a lack of empirical research on the interaction effect of the two technologies on hotel development performance in the Saudi context (Datta et al, 2024; Du et al, 2024).

Hence, the aim of this research is to examine the effect of Implementation of Artificial Intelligence and Building Information Modeling on hotel development performance in Saudi Arabia. The study in particular looks at the AIBIM application theory aspect to improve the project plan, multi-disciplinary, coordinates management, cost performance, schedule performance, project risk, project quality, and stakeholder satisfaction.

Grounded in its empirical findings, the research proposes a National AI–BIM Framework to facilitate and guide the digital transformation of hotel development projects, offering actionable recommendations for government, developers, consultants, contractors, hotel operators, and facility managers.

The significance of this study is that by exploring a key research gap related to Saudi Arabia's context, it extends the limited literature on digital transformation from a hotel development perspective, and further supports the strategic goals of Saudi Vision 2030.

1.2. Background of the Study:

Hotel development is truly one of the most complex kinds of real estate development as it is a hybrid of a construction project, a hospitality business, and a long-term investment asset all at once. In the case of residential or commercial developments, the conclusion of this project is typically the delivery of a physical building, whereas for a new healthcare service, the physical building is the commencement of a life cycle of operations that can last decades. So, hotel development is assessed not only on the classic project performance measures of time, cost and quality, but also on operational readiness, guest satisfaction, maintainability, lifecycle performance, sustainability and long-term asset value.

Such multidisciplinary nature needs integration between development, design, construction, operation, facility management, and asset management throughout the project lifecycle (Fayadh, 2025).

Have a strong participation by international hotel operators throughout the process of development, a feature that distinguishes with developments in other sectors. National operators, however, have a hand in laying down what needs to be assembled long before a build goes up, unlike many other real-estate verticals.

They define broad standards for architectural design, engineering systems, interior design, furniture, fixtures and equipment (FF&E), operational workflows, sustainability requirements, fire and life safety systems, IT infrastructure, pre-opening procedures, and facility management. These standards serve the purpose of maintaining operational uniformity, brand fidelity, guest replenishment and sustainable business performance within diverse continental brands (Fayadh, 2025).

Best-in-class international operators like Marriott International, Hilton, IHG Hotels & Resorts, and Accor all take a similar approach to the development process providing structured technical development programmers and lifecycle support to hotel owners from the onset of the project and throughout the course of operations.

Due to operators enforcing highly standardized development requirements all across the world, hotel developments by nature produce highly structured, repeatable, and information-rich datasets. Pre-fabricated rubrics for guest rooms, bathrooms, public areas, mechanical and electrical systems, operational procedure standards, maintenance regime, and asset registrations are devised and replicated across projects.

Thus, the hotel development is an information-rich setting, wherein extensive multidisciplinary data is generated over various stages, from feasibility studies, planning, design, procurement, construction, commissioning, operation, facility management, refurbishment and asset management. Such a level of standardization creates an incredible window to digitalize information, to leverage Organizational learning and continuously use knowledge based on prior hotel developments (Fayadh, 2025).

Hotel developments are growing larger — and more complex to operate — and access to information has become one of the most precious resources in the project. The design in the delivery method determined through decisions made in feasibility studies; design decisions drive procurement strategy; procurement drives construction performance; construction quality determines operational readiness (time-to-occupancy), maintenance efficiency (O&M), lifecycle costs, and long-term investment performance.

As a result, continuity of information across the entire project lifecycle is now considered on par with managing physical construction activities. Yet, project information is often dispersed across disciplines, software products, organizations, and project stages, with the consequent duplication of work, inconsistency of information, time-consuming decisions, limited collaboration, and poor knowledge transfer between project participants (Project Management Institute [PMI], 2025).

This, along with international standards regulating digital information management, has also increased awareness of the significance of information continuity. The ISO 19650 standard defines a method of systematic creation, management, exchange, and reuse of project information throughout the lifecycle of built assets to support data-driven decision making, collaboration and operational performance (ISO 19650-1, 2018). Similarly, building SMART international advocates the principles of Open BIM and Industry Foundation Classes (IFC) as the means to facilitating the consistent, interoperable and lifecycle-based information transfer between all the stakeholders within the project process.

These international initiatives collectively recognize that the effectiveness of project delivery more and more relies on the quality, availability, and persistence of digital information at a whole over isolated project documents.

In this context, digital technologies are key enablers for lifecycle information management in complex construction projects. Building Information Modelling (BIM) gives you a

cohesive digital environment for developing, organizing, and managing multi-disciplinary project information over the asset lifecycle.

On the other hand, Artificial Intelligence (AI), facilitates advanced analytical skills, such as predictive modelling, machine learning, automated decision support, optimization, pattern recognition and intelligent data analysis. Recent research views AI and BIM, not as stand-alone technologies, but rather as complementary candidates within Construction 4.0, capable of converting structured project information into actionable knowledge, which leads to planning, multidisciplinary coordination, construction performance, operational availability, facility management, and strategic asset management (Datta et al., 2024; Du et al., 2024; Valdebenito & Forcael, 2025).

These advances notwithstanding, industry practice today is relatively patchy. Most of the time we have two separate processes that a hotel project would have: BIM mostly engages in design coordination, documentation and clash detection, while AI applications are separately incorporated into the project in support of a single process (e.g., week, cost, quality and risk forecasting). As a result, all the information produced through the hotel development lifecycle has been separated into different, non-cohesive digital environments, restricting collaboration, stalling information continuity, and stopping project stakeholders from maximizing the power of integrated digital workflows.

Similar observations are noted in many of the most recent studies investigating the state of digital transformation research in the domain of construction project management, concluding that despite potential benefits, the integration of AI and BIM remains only at an initial stage of adoption (Attia, 2025; Datta et al., 2024).

In addition, while international hotel operators have developed extensive technical and operational standards that govern hotel development, the academic literature has only offered a limited guide as to how such standards could be facilitated through systematic AI–BIM integration throughout the entire hotel development lifecycle.

While existing studies have examined either Artificial Intelligence, Building Information Modeling, digital construction, or smart buildings separately, making this the first few empirical studies on combining AI, Building Information Modeling, digital construction, or smart buildings for implementation in hotel development projects. In light of this, it becomes more apparent in Saudi Arabia given that hotel developments are mandated to meet

international operator expectations, align with national strategies, bolster digital initiatives, be operationally viable and optimize long-term asset performance.

In line with this, there is still a lack of knowledge with regards the systematic adoption of AI and BIM within hotel development projects, combined with no clear implementation strategy that responds to the characteristics of the Saudi hospitality context.

1.3. Problem Statement:

Though the Architecture, Engineering, Construction and Operations (AECO) industry is undergoing deep digital transformation, project organizations remain challenging in establishing integrated information management throughout the lifecycle of construction projects. While different digital technologies have enhanced certain functions in individual project areas, project information is presumably still isolated between disciplines, project phases, and software environments.

Such fragmentation hinders multidisciplinary collaboration, decision-making, information reliability, and project performance. New evidence suggests that lack of systematic integration between digital technologies, as opposed to lack of access to individual digital technologies, poses a main barrier to the effective uptake of the digital construction in the research community (Alves et al., 2025).

The nature of hotel development projects makes these challenges particularly apparent due to their multi-disciplinary nature and long operational lifecycle. Various stages including planning, design, procurement (the process of securing necessary resources), construction, commissioning, operation, facility management, and even asset management happen repeatedly during development, while at the same time having to meet the technical and operational requirements mandated by global hotel operators.

As a result, even problems in information integration across these interrelated steps lead to suboptimal project efficiency, diminished operational readiness, increased lifecycle costs, and reduced long-term asset performance (Fayadh, 2025).

Despite that Building Information Modeling (BIM) has already established itself as a promising approach to the digital management of design strategies, these remain implemented virtually exclusively for design coordination and documentation. Artificial Intelligence (AI), on the other hand, is being applied in a fragmented manner, e.g., in cost estimation, schedule prediction, quality inspection, and risk analysis.

Nonetheless, these technologies from supply chain are seldom applied as an integrated digital ecosystem to manage information flow continuously throughout the entire project lifecycle. This eLearning is part of the latest research and engagement activity on the systemic integration of AI and BIM Findings from two recent systematic reviews show that, although AI can improve project delivery and lifecycle decision-making, organizational integration between AI and BIM remains limited (Alves et al., 2025).

The problem is particularly significant in Saudi Arabia, a country in the middle of rapid digital transformation in a construction industry that plays a critical role for a hospitality market that is growing faster than nearly anywhere else in the world.

While the use of BIM has increase throughout the Saudi construction sector, empirical evidence indicates that the adoption and appropriate implementation is still hampered by organizational, technical and human-resource barriers (Alshibani et al., 2024). The implications of these issues increase dramatically for hotel developments where international operator standards, lifecycle information management, and operational readiness are critical to project success.

From an academic perspective, the majority of the previous research considered Artificial Intelligence, Building Information Modeling and digital transformation as single research areas instead of being combined.

Though the application of the recent studies that have started to highlight AI–BIM integration in the broader AECO industry, to the specific folds of hotel development projects still lacks empirical evidence. Moreover, scant literature addresses the integration of AI and BIM specifically in the context of the Saudi hospitality industry or how this combines to support hotel development in its entire lifecycle, while meeting international operator standards and local industry requirements (Alves et al., 2025; Fayadh, 2025).

Accordingly, a significant research gap exists regarding the systematic integration of Artificial Intelligence and Building Information Modeling to enhance hotel development performance through lifecycle information management in the Saudi Arabian hospitality sector.

1.4 Aim of the Study:

The primary aim of this research is to evaluate the impact of integrating Artificial Intelligence (AI) and Building Information Modeling (BIM) on improving the performance of hotel development projects in Saudi Arabia.

In particular, the research aims to investigate the impact of integrating AI and BIM on project performance across the hotel development lifecycle, encompassing project planning, multi-disciplinary coordination, cost management, schedule performance, risk management, operational readiness, facility management, and asset performance over the project lifecycle.

Following the empirical results, the study also seeks to create a Proposed National AI–BIM Framework to facilitate and promote the integration of Artificial Intelligence and Building Information Modeling throughout the entire hotel development lifecycle within the country.

This article proposes a framework that creates practical, evidence-based recommendations to guide developers, consultants, contractors, hotel operators, facility managers, investors, and government authorities in bringing digital transformation into hotel development projects, improving hotel development project performance, and fulfilling the strategic objectives of Saudi Vision 2030.

1.5 Research Objectives

To achieve the aim of this study, the following research objectives are proposed:

RO1. To assess the current level of Artificial Intelligence (AI) and Building Information Modeling (BIM) adoption in hotel development projects in Saudi Arabia.

RO2. To investigate the current level of integration between Artificial Intelligence (AI) and Building Information Modeling (BIM) throughout the hotel development lifecycle.

RO3. To evaluate the impact of AI–BIM integration on hotel development project performance throughout the project lifecycle, including project planning, multidisciplinary coordination, cost management, schedule performance, project quality, risk management, operational readiness, facility management, and long-term asset performance.

RO4. To evaluate the impact of AI–BIM integration on the business and investment performance of hotel development projects, including operational efficiency, lifecycle value, return on investment (ROI), investment performance, sustainability, and long-term asset value.

RO5. To identify the critical success factors and implementation barriers affecting the systematic adoption and integration of Artificial Intelligence and Building Information Modeling in hotel development projects in Saudi Arabia.

RO6. To develop a **Proposed National AI–BIM Framework** that supports the systematic integration of Artificial Intelligence and Building Information Modeling throughout the hotel development lifecycle while aligning project delivery, operational requirements, business objectives, and the strategic goals of Saudi Vision 2030.

1.6 Research Questions:

This study seeks to answer the following research questions:

RQ1. What is the current level of Artificial Intelligence (AI) and Building Information Modeling (BIM) adoption in hotel development projects in Saudi Arabia?

RQ2. What is the current level of integration between Artificial Intelligence (AI) and Building Information Modeling (BIM) throughout the hotel development lifecycle?

RQ3. How does AI–BIM integration influence hotel development project performance, including project planning, multidisciplinary coordination, cost management, schedule performance, project quality, risk management, operational readiness, facility management, and long-term asset performance?

RQ4. How does AI–BIM integration influence the business and investment performance of hotel development projects, including operational efficiency, lifecycle value, return on investment (ROI), sustainability, and long-term asset value?

RQ5. What are the critical success factors and implementation barriers affecting the systematic adoption and integration of Artificial Intelligence and Building Information Modeling in hotel development projects in Saudi Arabia?

RQ6. What are the key components of a Proposed National AI–BIM Framework that supports the systematic integration of Artificial Intelligence and Building Information Modeling throughout the hotel development lifecycle while aligning project delivery, operational requirements, business objectives, and the strategic goals of Saudi Vision 2030?

1.7 Research Hypotheses:

Based on the research objectives, research questions, and the conceptual framework presented in this study, the following hypotheses are proposed:

Main Hypothesis

H1: Artificial Intelligence (AI), Building Information Modeling (BIM), and AI–BIM Integration have a statistically significant positive effect on Hotel Development Performance (HDP) in Saudi Arabia.

Sub-Hypotheses

H1a: Artificial Intelligence (AI) has a statistically significant positive effect on Hotel Development Performance (HDP).

H1b: Building Information Modeling (BIM) has a statistically significant positive effect on Hotel Development Performance (HDP).

H1c: AI–BIM Integration has a statistically significant positive effect on Hotel Development Performance (HDP).

1.8 Significance of the Study

1.8.1 Academic Significance

This study contributes to the existing literature in several important ways. It closes one of the major research gaps in the literature by studying the better adoption of Artificial Intelligence (AI) and Building Information Modeling (BIM) in hotel development projects, a particular field that has not received empirical attention before.

Previous studies have mainly investigated AI, BIM and Digital Transformation as separate research areas with limited work addressing their systemic integration across the hotel development process in Saudi Arabia.

Second, the research contributes to the existing literature by analyzing hotel development performance from a project management as well as a business and investment perspective.

This study includes not only the project delivery indicators of conventional construction research (i.e. time, cost, quality), but also operational readiness, lifecycle information management, facility management, investment performance, ROI/NPV, sustainability and long-term asset value.

This wider view gives us a fuller view of hotel development performance through the life cycle of a project.

Finally, the theoretical contribution of this study is the Proposed National AI–BIM Framework, which consolidates principles that expand project management, digital transformation, Building Information Modelling, Artificial Intelligence, hotel development, and lifecycle information management into a coherent implementation framework. This framework provides a foundation for further study in academic research, comparative studies, and the development of theory around digital transformation in construction and hospitality.

1.8.2 Practical Significance

On the practical side, the results of this research are expected to deliver valuable contributions to various stakeholders in hotel development projects.

The study provides evidence-based recommendations for practitioners—developing, consulting, contracting, hotel operating, facilitating, project managing and investing—by illustrating the use of AI–BIM integration as a means to enhance project planning, multidisciplinary coordination, cost management, schedule performance, risk management, operational readiness, facility management, and long-term asset performance.

It also aims to help owners, investors, and asset managers provide transparency of business benefits by demonstrating how AI and BIM integration can improve operational efficiency, lifecycle value, investment performance, ROI, sustainability, and ultimate (long-term) asset value. As a result, they can enhance investment decisions, reduce lifecycle costs, improve operational performance, and increase hotel development project competitiveness.

In addition, the draft National AI–BIM Framework is designed as a practical implementation resource of how organizations can incorporate Artificial Intelligence and Building Information Modeling into their digital transformation efforts.

Implementing a framework gives the project a structure, allowing for consistent execution across the hotel development lifecycle, while also enhancing collaboration, information management, and performance.

1.8.3 Policy and National Significance

In addition, this research has implications for Saudi policymakers and government authorities in charge of digital transformation, construction, tourism, and hospitality development.

It is expected that the national AI–BIM framework will provide an evidence-based reference that facilitates the establishment of national guidelines, implementation strategies, and

industry best practices to maximize the adoption and operationalization of AI and BIM for hotel development projects.

In addition, it supports Saudi Arabia's ambition of having a national digital transformation agenda, as well as lifecycle information management, project delivery efficiency, operational performance and innovation across the hospitality sector.

The proposed National AI–BIM Framework directly contributes to the objectives outlined in Saudi Vision 2030, particularly in the areas of economic diversification, tourism development, digital transformation, sustainable infrastructure, and the global competitiveness of the Saudi hospitality industry.

Apart from its immediate applicability, we hope this framework will serve future national standards, digital governance policies, and implementation roadmaps that would guide the systematic adoption of AI and BIM across the Saudi hospitality sector. By doing so, the study may contribute to the local hospitality industry capability to gain advantage on both the basis of indicative and empirical data for the performance of individual projects and the strategic digital transformations for sustainable development of the long-term perspectives within the Kingdom.

1.9 Scope of the Study

This study investigates the integration of Artificial Intelligence (AI) and Building Information Modeling (BIM) and its impact on the performance of hotel development projects in the Kingdom of Saudi Arabia.

The research is limited to hotel development because hotel development challenges are representative of one of the most complicated forms of real estate development. Projects are with international hotel operators subject to global brand standards requiring multidisciplinary coordination, long asset life cycles, and integration of project delivery with operational readiness, facility management, and asset management over the long term. Thus, the results of this study are specific to the Saudi hospitality market and should not ideally be generalized to other forms of property developments, including but not limited to residential, commercial, healthcare, or industrial.

The proposed research investigates the complete lifecycle of hotel development from feasibility to procurement, commissioning, operation and facility and asset management with the application of the AI–BIM integration. By approaching the topic from distinct

perspectives to measure the effects of the interplay between AI and BIM on hotel development performance, this paper examines both project management performance as well as business performance. Features of the system from a project management perspective include: planning, multidisciplinary coordination, cost management, schedule performance, quality improvement, and risk management, while features of the business perspective include: operational readiness, facility management, investment performance, total return on investment (ROI), sustainability, stakeholder satisfaction, total facility performance over time.

The empirical research employs cross-sectional quantitative research using a structured rating-type questionnaire administered to professionals engaged in hotel development projects throughout Saudi Arabia (i.e., including developers, consultants, contractors, hotel operators, project and facility managers). The data collected are analyzed using relevant statistical techniques to examine the hypothesized research hypotheses and empirically establish the Proposed National AI-BIM Framework.

This study was restricted to the first level of application – the strategic and managerial implementation of AI–BIM integration for hotel development in this research. The study therefore does not cover topics related to software development, (artificial intelligence algorithms, programming techniques, system architecture and design, cyber and physical security, or other technical aspects of digital technologies. Instead, it examines how integrating artificial intelligence (AI) and building information modeling (BIM) will bring an innovation in project delivery, operational performance, business outcomes, and lifecycle information management to achieve improved performance of hotel development projects within the Saudi hospitality sector.

1.10 Limitations of the Study

This study has several limitations that should be considered when interpreting its findings. Of this study that need to be noted when discussing the results of this study.

First, the study is restricted to the Kingdom of Saudi Arabia. Even though Saudi Arabia is one of the fastest-growing hospitality markets and an appropriate context to study the impact of AI–BIM integration for hotel development, these findings may not be generalizable to hotel development projects in other countries due to diverse regulatory environments, market conditions, levels of digital maturity, as well as hotel development practices.

Second, the study is limited to hotel development projects only. These sectors vary in project types, stakeholder structure, operational requirements, and strategies applied to optimize the asset management process in other parts of real estate. Therefore, results should be discussed only with respect to hotel development context.

Third, this study adopts a cross-sectional quantitative research design. relying on survey-based data analyzed using a structured questionnaire during the same span of time. This means the results represent respondents' perspectives at the point in time the data was collected, they do not capture natural evolution in organizational practices or project performance and technology adoption over time.

Fourth, the research uses project performance indicators from professionals' perception, not a direct measure of project performance indicators. Perception-based data may be impacted by individual experience, organizational practices, and professional judgement, although all respondents had substantial experience with hotel development projects.

Finally, the research is limited to the strategic and managerial use of Artificial intelligence and Building Information Modeling. This research leaves out the technical aspects like software development, artificial intelligence algorithms, programming techniques, system architecture, interoperability protocols, cybersecurity, and software engineering implementation. Rather, the study focuses on how artificial intelligence and Building Information Modelling can optimize project delivery, operational performance, business outcomes and lifecycle information management of hotel development projects.

In spite of these limitations, the study provides some empirical evidence into AI–BIM integration in hotel development projects in the Saudi hospitality sector, and represents a practical base in constructing the Proposed National AI–BIM Framework.

1.11 Definition of Key Terms:

1.11.1 Artificial Intelligence in Hotel Development

Hotel Development AI refers to the application of intelligent computational systems that enables in project and business decision-making across the lifecycle of hotel development. AI enables project teams to analyze project data, automate complex processes and predict the outcome of their projects – enhancing organizational risk management and overall business performance (Egwim et al., 2024; Chen et al., 2025).

In this study, Artificial Intelligence refers to AI-driven technologies integrated with Building Information Modeling (BIM) to enhance hotel development performance across the entire project lifecycle.

1.11.2 of Building Information Modeling (BIM) in Hotel Development:

In hotel development, Building Information Modeling (BIM) is a collaborative information management process; leveraging the generation and exchange of data to establish reliable information throughout all parts of authoring, collaborating, managing and delivering projects across their lifecycle.

BIM establishes a common digital environment for enhancing multidisciplinary teams in several aspects, strengthening information quality and coordination of various project Stakeholders involved throughout the planning-intended design-process (PID), procurement, construction / commissioning as well facility management and asset-management phases (Revolti et al., 2024; Zhang et al., 2024) In this study, Building Information Modelling (BIM) describes an integrated digital information environment that can support the lifecycle of hotel development projects and enhance project as well as business performance through integration with Artificial Intelligence

1.11.3 AI–BIM Integration in Hotel Development:

AI–BIM integration in hotel development, that is, the strategic integration of Artificial Intelligence (AI) and Building Information Modeling (BIM) to develop an intelligent digital environment that supports data-driven project and business decision making in hotel projects across their lifecycle.

The integration of AI capabilities with BIM-based information enhances multidisciplinary collaboration, efficient project planning and delivery, support for operational readiness and overall performance of hotel development (Li et al., 2024; Datta et al., 2024). In this study AI- BIM Integration in this study indicates the integration of Artificial Intelligence and Building Information Modeling as per the high-level principles and strategies for hotel development performance purpose over project lifecycle

1.11.4 Hotel Development Lifecycle:

Hotel Development Lifecycle – A sequence of interconnected phases that a hotel project goes through (feasibility, planning, design, procurement, construction, commissioning, operation, facility management, and long-term asset management). Unlike traditional construction

projects, hotel development involves a continuous integration between project delivery and operational readiness, brand standards, lifecycle information management and business objectives, which is necessary for sustainable project and business outcomes across the asset lifecycle (Noordzy & Whitfield, 2021; Wang & Chen, 2023).

For this research, the hotel development lifecycle serves as the contextual framework for assessing AI–BIM integration to enhance hotel development performance throughout the project lifecycle.

1.11.5 Hotel Development Performance

Hotel development performance refers to the extent to which a hotel development project delivers on its project delivery objectives and long-term business objectives throughout the asset lifecycle. It encompasses project management performance (time, cost, quality and coordination), as well business performance (operational efficiency, investment performance, return on investment (ROI), sustainability, and stakeholder satisfaction (Kim et al., 2025; Sampaio et al., 2025).

Hotel development performance (HDP) — the dependent variable in the study — is captured by financial performance, project delivery time, project quality, cost performance return on investment (ROI), and stakeholder satisfaction.

1.11.6 Proposed National AI–BIM Framework:

The Proposed National AI–BIM Framework is evidence–based implementation framework developed based on the findings of this research to Support the strategic implementation of AI – BIM integration across hotel development projects in Saudi Arabia.

The framework is designed to provide structured guidance to support government agencies, developers, consultants, contractors, hotel operators, facility managers, and investors to improve project delivery, business performance, lifecycle information management, and sustainable value creation (Alves et al., 2025; Valdebenito & Forcael, 2025).

The Proposed National AI–BIM Framework presented in this study is the main research output, which is a practical implementation framework integrated throughout the hotel development lifecycle using AI and BIM for the Saudi hospitality sector.

CHAPTER TWO - LITERATURE REVIEW

2.1 INTRODUCTION:

This chapter provides a review of the relevant theoretical and empirical literature pertaining to the integration of AI and BIM in the context of hotel development. This chapter aims to establish the theoretical foundation for the study by discussing the concept, principles, applications and advancements in the current development and application of Artificial Intelligence (AI), Building Information Modeling (BIM) and their combination in the hotel development process.

The chapter will begin by discussing the development and uses of AI in business administration, real estate development and hotel development. This is followed by the study of Building Information Modeling (BIM) its principles, its capabilities and its application within the process of hotel development. Building upon these theoretical foundations, the chapter then examines the integration of AI and BIM across all the major stages of hotel development lifecycle, that includes: feasibility study, integrated design, cost estimation, project construction management, operation and maintenance management, and assets lifecycle management,

Finally, the chapter discuss the principal challenges for AI and BIM integration for the construction and establishment of the theoretical basis for the conceptual framework provided in this thesis.

2.2 Artificial Intelligence in Business, Real Estate Development and Hotel Development:

2.2.1 Concept and Evolution of Artificial Intelligence:

Artificial Intelligence (AI) is widely recognized as one of the most transformative technological developments of the twenty-first century, although AI is one of the most prominent fields encompasses intelligent software applications, smart systems or ultra-automation, however its scientific foundations extend beyond conventional software applications of the modern era. AI is broadly interdisciplinary, drawing together ideas from computer science, mathematics, statistics, cognitive science, neuroscience, linguistics, engineering, among other disciplines; aimed at developing computational systems capable of performing tasks that would normally require human intelligence.

Such tasks involve reasoning, learning, knowledge representation, problem-solving, perception, language understanding, planning and adaptation. For this reason, AI is not just thought of as a software technology, but rather as a comprehensive scientific discipline that concerns building intelligent computational agents able to observe the world around them, process the information they receive, learn from experience and improve their performance over time (Russell & Norvig, 2021; Kühl et al., 2022).

There is no universally accepted definition of Artificial Intelligence mainly due to the dynamic nature of the idea, which has evolved with the complexity of computational science over the past decades. AI has been defined in various ways, and its meaning has shifted throughout the years — early definitions focused on simulating human reasoning and symbolic problem solving, while modern perspectives define AI as intelligent systems that can learn from data, make inferences, and autonomously adapt to a changing environment. In this context, the recent literature increasingly characterizes AI as a set of computational techniques by which machines, which can perceive, reason, learn, predict and generate outputs that support complex cognitive functions.

This broader perspective is indicative of a stepwise evolution over time, from traditional, rule-based computation, toward adaptive, data-driven intelligent systems, capable of operating under uncertainty, and continuously improving through interaction with data and their surrounding environment (Jiang et al., 2022; Kühl et al., 2022).

The formal recognition of Artificial Intelligence as an academic discipline is usually dated to the Dartmouth Summer Research Project on Artificial Intelligence, held at Dartmouth College in Hanover, New Hampshire, from 30 June to 30 August 1956, during which John McCarthy coined the term "artificial intelligence" and argued that "every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it".

This major event kicked off a formal scientific exploration of intelligent machines and laid the foundation for contemporary AI research. For the next few decades, researchers focused mostly on symbolic reasoning, logic-based systems and heuristic search methods. The early approaches considered the notion of having intelligent behavior in a machine by directly writing down human knowledge in form of computational rules that will solve precisely defined problems.

This is a paradigm that is often called Symbolic AI, or Good Old-Fashioned Artificial Intelligence (GOFAI), and was the dominant form of AI until the mid-1980s, which produced large numbers of expert systems across scientific and industrial fields (Russell & Norvig, 2021; Jiang et al., 2022).

The first major practical successes of Artificial Intelligence were represented by expert systems, these rule-based systems excelled in specific application domains, and by encoding the knowledge of domain experts into logical rules. However, they largely relied on hand-built [knowledge-bases] that were costly to create and maintain, lacked scalability, and adaptability to changing environments.

In addition, the symbolic AI was unable to handle data that was uncertain, incomplete, high-dimensional, or highly complex data, hence it could not be used in real-world problems characterized by ambiguity, uncertainty, and dynamic conditions. Such technical shortcomings, in conjunction with hardware availability and technological hype cycles and expectations of what AI can achieve led to years of reduced investment and low levels of research activity dubbed as the "AI winters" (Russell & Norvig, 2021; Jiang et al., 2022).

The revival of Artificial Intelligence in the late 1990s and the early twenty-first century represented a new era in AI research. Instead of mostly relying on hand-coded knowledge, researchers increasingly began applying statistical approaches that could learn directly from data through training and testing processes.

Several key factors drove this transition, including substantial improvements in computation in terms of both speed and cost; the near-ubiquitous availability of fast graphical processing units (GPUs); the explosive growth of cloud computing, to support computationally intensive workloads; gigantic increases in the digitization of data. These advancements, along with the spectacular growth of data availability, collectively enabled computational models and tools that identified complex patterns within large-scale datasets, improving prediction, learning efficiency, and generalization. As a result, AI research gradually moved on from knowledge engineering to data-driven learning, laying the scientific foundation for contemporary intelligent systems (Ahmed et al., 2023; Baratchi et al., 2024).

This transformation fundamentally reshaped both AI research and its practical applications. Instead of trying to simulate human logic, modern AI is increasingly statistical modelling, which tries to derive patterns directly from data rather than through pre-defined logical rules. The versatility, scalability and adaptability of intelligent systems have greatly improved with

this data-oriented paradigm, enabling AI systems to operate effectively in dynamic and uncertain environments, dynamic environments characterized by uncertainty and complexity. These paradigm shifts, therefore, prompted a transition for Artificial Intelligence from being a well-defined area of research studies to a broader scientific framework, a comprehensive scientific framework covering multiple computational paradigms with expanding capability and applications capability (Kühl et al., 2022; Ahmed et al., 2023).

Advances in Artificial Intelligence research over the past decade have been substantial not only due to impressive increases in computational hardware but also due to ongoing breakthroughs in learning algorithms and model architectures. This has allowed AI systems to process a wide variety of data types., such as numerical data, natural language, images, videos, audio, and multimodal datasets. As a result, Artificial Intelligence is considered not just a single technology but now an integrated ecosystem of interconnected technologies.

The primary technological pillars underpinning modern AI systems include: Machine Learning (ML) Deep Learning (DL) Natural Language Processing (NLP) Computer Vision (CV) Generative Artificial Intelligence (Gen AI) Predictive Analytics Understanding these technologies is essential for explaining how Artificial Intelligence has achieved its current capabilities and its widespread adoption across diverse domains, Understanding the characteristics and historical development of these technologies is essential for explaining the current capabilities of Artificial Intelligence and provides the theoretical foundation for the subsequent sections of this chapter.(Ahmed et al., 2023; Baratchi et al., 2024; Maslej et al., 2025).

Over the past decade, Artificial Intelligence has undergone unprecedented technological advancement has resulting in an integrated technological framework composed of several interconnected computational paradigms that exist together. Instead of a single technology, modern AI integrates several complementary techniques, each developed for a different category of analytical, perceptual and cognitive tasks.

These technologies are founded on distinct computational principles and learning mechanisms but together they form intelligent systems to process increasingly complex forms of information. Therefore, understanding the technological architecture of modern AI is essential for interpreting its evolving character and its wider application in a sci-entail and industrial context (Kühl et al., 2022; Baratchi et al., 2024).

Machine Learning (ML) has become the dominant paradigm that has turned Artificial Intelligence from rule-based inference into data-based learning. Rather than relying on explicitly programmed rules, machine learning algorithms automatically discover patterns and relationships in the available data to make predictions or classifications. This iterative learning process allows computational models to continuously improve their performance as new data become available.

As a result, the principal learning paradigms include many modern AI applications are supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning. Additionally, automated machine learning (AutoML), which requires limited human intervention for algorithm selection, feature engineering and parameter optimization, has significantly simplified the process for model development and further accelerated the deployment of AI across a wide range of scientific and industrial domains (Baratchi et al., 2024).

Deep Learning (DL) has emerged as one of the most significant breakthroughs in the evolution of AI and is a superior type of machine learning based on multi-layer artificial neural networks. In contrast to traditional machine learning algorithms, which often rely on hand-engineered features, deep learning architectures learn hierarchical representations directly from the raw data.

These architectures have significantly improved performance on complex tasks involving images, speech, language, video, and sensor data. Recent review papers suggest that deep learning is widely recognized as one of the keys enabling technologies of modern Artificial Intelligence (Ahmed et al., 2023) with applications in many scientific and engineering fields due to continuous improvements in neural network architectures, optimization methods, transfer learning, and computational hardware.

Natural Language Processing (NLP) represents another major technological pillar of modern Artificial Intelligence — the ability of computers to understand, interpret and generate human language. Early NLP systems relied primarily on rule-based methods and statistical language models, they were little more than rules combined with a statistics-based model of the language, however recent advances have been driven by transformer-based architectures and foundation models that can learn contextual representations of language from massive text corpora. This has dramatically improved machine translation, question answering, summarization, conversational agents, document analysis, and information retrieval.

Importantly, the emergence of Large Language Models (LLMs) has greatly increased the capacity of AI systems to perform a wide range of language-related tasks within a unified computational architecture, representing a major milestone in modern AI research (Kumar, 2024).

Alongside these developments, the field of Computer Vision (CV)—enable machines to perceive and interpret visual information and understand information contained in images, videos, and three-dimensional environments—has also been transformed. Recent improvements in convolutional neural networks, vision transformers and multimodal learning have significantly improved the performance of AI systems on visual recognition, object detection, image segmentation, three-dimensional reconstruction, and scene interpretation. As a result, Computer vision has matured as a well-established research domain supporting intelligent automation across multiple industries that require accurate visual analysis of data (Ahmed et al., 2023).

One of the most transformative developments in the recent evolution of Artificial Intelligence has been the emergence of Generative Artificial Intelligence (Generative AI). Generative AI is a type of AI that generates new content while traditional AI classes primarily focus on analysis, classification, or prediction of existing information. Generative AI learns the statistical distributions from training data to produce new content.

AI systems are now capable of generating high-quality content, such as coherent text, realistic images, computer code, audio, video and other digital artefacts at an unprecedented level of quality and realism due to recent advances in transformer architectures, diffusion models, generative adversarial networks, and foundation models. Such developments have largely opened up the scientific promise of Artificial Intelligence and spawned novel research pursuits about creativity, human–AI collaboration, model transparency, explainability, and responsible AI development (Kumar, 2024; Balasubramaniam, 2024).

In general, the history of Artificial Intelligence reflects a gradual transition from symbolic reasoning and hand-engineered expert systems to adaptive, data-driven, and increasingly autonomous computational models that learn from a wide variety of information. Hence, Contemporary AI is best characterized as a rapidly-changing technological ecosystem rather than a monolithic computational technique, evolving through advances in algorithms, computing infrastructure, and availability of data. This technological advancement therefore lays the scientific groundwork for comprehending the ways through which Artificial

Intelligence has since evolved beyond its computational precursors to support increasingly sophisticated applications in the management of business matters, project management, real estate development and hotel development, which are hereafter scrutinized in the next sections of this chapter.

2.2.2 Artificial Intelligence as a Strategic Business Capability:

Artificial Intelligence (AI) has evolved significantly from a computational technology designed to automate repetitive tasks and understand patterns, previously integrated mainly into operational processes into a strategic organizational capability —enabling Value creation, organizational innovation, and sustainable competitive approach. The rise of machine learning, deep learning, natural language processing, computer vision and predictive analytics has moved AI well beyond the automation of operations, allowing organizations to process vast amounts of structured and unstructured data, producing insights on what actions to take and informing more complex management decision-making.

As a result, AI is increasingly being recognized as a fundamental organizational resource that enhances strategic planning, organizational learning, knowledge management and business transformation in data-driven contexts (Dwivedi et al., 2023; Wamba et al., 2021).

The Strategic role of AI is strongly related to the digital transformation journey of contemporary organizations. Rather than functioning as a standalone technology, AI is increasingly integrated with digital platforms, cloud computing, big data analytics, and Internet of Things (IoT) technologies to create intelligent business ecosystems which could perhaps enhance organizational agility, operational efficiency, and innovation capability.

The studies suggest that organizations which strategically adopt AI enjoy better business performance, driven by better decision making, improved allocation of resources, faster innovation processes, and better responses to changing market conditions. Consequently, AI is widely recognized as one of the primary facilitators of digital transformation and sustainable competitive advantage (Verhoef et al. 2021; Dwivedi et al. 2023).

Another important dimension of AI as a strategic capability is in BI and DSS. Traditional business intelligence systems generally relied primarily on descriptive analysis of historic data, while AI-enabled business intelligence includes predictive and prescriptive analytics—enabling organizations to predict future trends, detect future opportunities and risks, identify and leverage potential strategic initiatives, and support decision-making with the aforementioned data-driven accuracy.

AI-enabled decision support systems combine advanced analytics with machine learning algorithms to provide recommendations in real time, allowing managers to make quicker, more accurate, and data-driven decisions in uncertain environments. As a result, AI converts business intelligence from a reporting capability into a continuous organizational learning and competitive advantage strategic capability (Ransbotham et al., 2021; Dwivedi et al., 2023).

Although the strategic potential of AI is widely recognized, literature consistently stresses that AI in isolation does not create competitive advantage. Successful adoption of AI requires complementary organizational capabilities such as high-quality data, digital infrastructure, governance, and leadership commitment, employee competencies employees and organizational readiness for implementation of this change. As a result, researchers argue that AI should not be regarded AI merely as a technological tool, but as an organizational capability that creates value when aligned with the business strategy, organizational processes, and humans.

This perspective further emphasizes the importance of AI as a vital pillar for digital transformation in many other sectors including real estate development and hospitality in the following sections (Verhoef et al. 2021; Wamba et al. 2021).

2.2.3 AI Applications in Business Management:

AI has gradually matured into an enabling capability integrated with business management to support more intelligent, adaptive, and evidence-based managerial practices. Instead of isolated automation tasks, AI applications in business management work across analytical, operational, and strategic domains. Evidence-based and process-driven, today's AI systems help organizations handle massive amounts of structured and unstructured data, discover latent trends, predict outcomes, recommend alternative actions, and automate manual business processes.

This has transformed AI from a specific technical task into a more general management function that extends the organizations' abilities to gather information, orchestrate resources, manage risk, and navigate uncertainty. Accordingly, AI capabilities in business management can be broadly categorized into six interconnected capabilities: intelligent decision support, prediction, strategic planning, knowledge management and risk analytics and business process automation (Dwivedi et al., 2023; Baabdullah, 2024; Ghosh, 2024).

2.2.3.1 Intelligent Decision Support:

Intelligent decision support is one of the most urgent applications of AI in the business management area. Conventional decision support methods relied mostly on uniform databases, prebuilt analytical models and descriptive reporting.

Even though the systems assisted in improving information access, they were not very efficient in handling cases involving uncertainty, incomplete data and changing business conditions. Conversely, with the inclusion of machine learning, natural language processing, optimization algorithms, and Explainable AI, decision support systems facilitated by AI generate recommendations to serve operational, tactical, or strategic decisions, going beyond static reporting. They assess a larger number of alternatives, identify relationships that are not easily identified by traditional analysis, and base decisions on more complete evidence (Cao et al., 2024; De Leoni et al., 2024)

The real power of AI-enabled decision support is in bridging computational analysis with human managerial judgment. While AI has the ability to analyze vast amounts of data and execute various what-if scenarios to create sound recommendations, managerial decisions cannot uniquely be distilled into linear algorithmic responses involving ethical considerations, stakeholder needs, organizational culture, and contextual knowledge. Accordingly, the importance of AI for the decision-making process should not be interpreted as a substitutive aspect of managers, but as an additive view of managerial cognitions. Studies on how strategic decisions play out hint that while AI should help in the search, representation and evaluation of strategic alternatives, interpreting and owning the final decision would still rest with humans (Csaszar et al., 2024; De Leoni et al., 2024) This is particularly critical under complex business situations, where the quality of decision-making is contingent on both accurate analysis and qualitative contextual judgment.

2.2.3.2 Predictive Analytics:

Another major application of AI in business management is predictive analytics. It is built on the ability to process historical data, using statistical modelling, machine learning, deep learning and pattern recognition algorithms to identify relationships in large datasets and predict future events with a higher level of accuracy.

Predictive analytics allows an organization to predict customer demand, predict consumer behavior, forecast financial performance, study market trends, optimize resource allocation,

spot operational anomalies, and identify potential risks before they materialize and turn into a bigger risk. In contrast to predictive analytics, which focuses on providing perspectives on the past and merely explaining what has happened (descriptive analytics), analytics that provide insights into the future and give cues for possible managerial actions provide management with foresighted perspectives (Chatterjee et al., 2024; Gao et al., 2024; Muth et al., 2025).

From a managerial perspective, its primary value lies in reducing uncertainty and supporting proactive decision-making. By identifying weak signals, exposing new patterns, and continuously learning from newly available data, AI-based predictive models can enable organizations to move away from reactive management toward anticipatory and evidence-based management.

They enable a broad spectrum of strategic and operational decisions, including sales forecasting, investment planning, market opportunity assessment, innovation management, supply chain optimization, workforce planning, and enterprise risk management. Recent empirical investigations show that machine learning and deep learning approaches are well-suited for forecasting firm performance to bolster a firm's competitive advantage when powered by high-quality enterprise data and capable analytical frameworks (Gangwani & Zhu, 2023; Gao et al., 2024; Chatterjee et al., 2024).

However, the success of predictive analytics is determined by a number of organizational and technical factors such as data governance, data quality, feature selection, model validation, algorithm transparency, and the contextualization of the analytical outcomes.

Thus, predictive analytics needs to be viewed as a tool for intelligent decision-support rather than a mechanism for producing accurate forecasts; even when predictive analytics capabilities directly improve managerial judgment, strategic planning, and organizational reactions to dynamic and uncertain business environments (Muth et al., 2025; Gangwani & Zhu, 2024; Chatterjee et al., 2024).

2.2.3.3 Strategic Planning

(AI) has emerged as an essential organizational capability for supporting strategic planning in modern organizations. Historically, organizations traditionally developed their long-term strategies based on managerial experience, market intelligence, financial analysis, environmental scanning, and historical performance analysis. While these approaches are

still relevant, they are rarely enough to cope with the volatility, uncertainty, complexity and ambiguity (VUCA) that characterize contemporary business environments.

AI enhance strategic planning due to: combining different internal and external data sources, continuously monitoring environmental changes, spotting the new market opportunities and threats, simulating alternative strategic scenarios, and enabling the more systematic analysis of strategic alternatives (Biloslavo et al., 2024; Kurpiela & Teuteberg, 2024).

At the managerial level, AI aids strategic planning by enhancing strategic intelligence, expediting information processing, and enabling data-driven strategic decisions. With AI-powered analytical features, managers can not only evaluate multiple strategic alternatives to identify potential business outcomes, allocate resources economically, and improve organizational adaptability in a volatile market environment.

Rather than replacing strategic leadership, AI enhances managerial capabilities with deeper analytical insight enabling informed strategic discussions. As such, organizations can enhance the quality, speed and stability of strategic planning while relying on human judgement, ethical obligation and organizational accountability at the core of final strategic decisions (Hutzschenreuter & Lämmermann, 2025; Kurpiela & Teuteberg, 2024; Biloslavo et al., 2024).

2.2.3.4 Knowledge Management:

Another important application of Artificial Intelligence (AI) in business management is knowledge management. Current organizations are constantly producing large amounts of both explicit and tacit knowledge through business documents, operational systems, customer interactions, project records, organizational communication, and digital platforms.

Traditional knowledge management systems relied on manual documentation, document management and keyword-based retrieval mechanisms to capture, curate and disseminate organizational knowledge.

While these endeavors have facilitated organizational learning for centuries, they often suffer from fragmented knowledge bases, outdated information, low accessibility, and challenges in extracting actionable insights from overwhelming amounts of unstructured data (Taherdoost & Madanchian, 2023; Alavi et al., 2024).

Artificial Intelligence takes the traditional knowledge management functionalities mentioned above to the next level by facilitating automation of knowledge acquisition, intelligent classification, semantic search, information retrieval, knowledge summarization, expertise identification, and knowledge discovery.

These advancements in natural language processing (NLP), machine learning, and generative AI capabilities enable organizations to convert unstructured data into actionable organizational knowledge, speed up knowledge sharing, enhance organizational learning and enable managers to make evidence-based decisions.

Studies suggest that AI is more valuable to organizations as a complement to rather than a substitute for human expertise and as part of an appropriate governance framework that ensures transparency, accountability, and quality of knowledge (Alavi et al., 2024; IEEE Engineering Management Review, 2025).

However, AI-enabled knowledge management is also faced with a series of important managerial challenges including credibility of information, credibility of sources, data privacy, intellectual property issues, algorithmic bias, and lack of organizational control over knowledge assets.

So, knowledge generated with the help of AI should not be accepted at the face value. Instead, organizations need to validate AI-generated outputs with more trusted information sources, interpret them within the organizational context and integrate them with human expertise to enable reliable knowledge growth and managerial decision-making (IEEE Engineering Management Review, 2025; Alavi et al., 2024).

2.2.3.5 Business Process Automation:

Business process automation represents one of the most prominent and transformative applications of Artificial Intelligence in business management. Legacy automation has traditionally been limited to repetitive, rule-based tasks such as data entry, transaction processing, and workflow routing.

In contrast AI-enabled automation moves beyond conventional rule-based systems by enabling systems to recognize and classify information, understand content, answer natural language questions, identify anomalies, and dynamically adapt workflows based on the shifting dynamics of the operation. As a result, business process automation has transitioned from the very basic task automation to smart process management with automation combined

with self-learning, reasoning, and adaptive-decision making capabilities (Rosemann et al., 2024; Fettke & Di Francescomarino, 2025).

AI plays an essential role in BPM, bringing improvements to the entire lifecycle of business processes – from process discovery, modelling, mining, execution, monitoring, redesign, and continuous improvement. Rather than simply replacing human labour, AI plays an even more critical role in complementing intelligent process orchestration, offering organizations the ability to orchestrate complex workflows with the power of machine learning, natural language processing, computer vision, and generative AI.

Process mining and RPA work together by providing visibility to improve process efficiency, thereby reducing input/output errors in the operations and manual processing delays in the service delivery, and to respond to changing business environments effectively, while further leveraging organizational agility and digital transformation capabilities (Rosemann et al., 2024; Kampik et al., 2025).

This is aligned with recent studies of contemporary BPM research, which believe that AI contributes value with a balanced combination of automation and augmentation. Automation enhances organizational productivity by reducing tedious manual work through increased process consistency; augmentation enhances managerial function through analyzing processes, handling exceptions, decision-making and continuous learning.

Rather than replacing managers, AI increasingly serves as an intelligent assistant that enhances decision quality while enabling employees to focus on higher-value strategic and analytical tasks (Fettke & Di Francescomarino, 2025; Kampik et al., 2025).

Furthermore, empirical findings suggest that organizations derive sustainable business value from AI only when AI capabilities are embedded into higher-order BPM capabilities (i.e., process governance, organizational learning, process innovation, and decision-making performance).

AI investments alone rarely generate substantial organizational benefits unless they are accompanied by effective management practices and business process redesign.

Hence Business Process Management acts as the distinct organizational capability that converts AI technologies into practical benefits such as operational performance, organizational effectiveness, innovation capability, and competitive advantage, for example (Zebec & Indihar Štemberger, 2024).

While these opportunities exist, responsible governance is needed to ensure that AI-enabled business process automation respects transparency, accountability, data privacy, fairness, and regulatory compliance.

Recent research advocates embedding responsible AI practices throughout the business process lifecycle so that intelligent automation achieves efficiencies while preserving stakeholder trust and organizational legitimacy.

Consequently, the future of business process automation does not rest in task automation per se but rather in the creation of intelligent, adaptable, and reliable business processes that learn continuously, optimize performance sustainably, and enable organizations to transform (Pisoni & Moloney, 2024).

Together, these AI applications should not be treated as independent technologies, but rather be viewed as a suite of complementary managerial capabilities that collectively enhance organizational performance.

Intelligent decision support, predictive analytics, knowledge management, risk analytics, and business process automation together empower managerial decision-making, operational efficiency, and organizational agility by converting data into actionable knowledge.

The preceding discussion provides the theoretical foundation for this research, presents the business management background for AI and then gets into how they are useful for project management and sector-specific areas.

Within hotel development, these capabilities are integrated into hotel development are the feasibility analysis, investment decisions, project planning, design coordination, risk forecasting, operational readiness, and lifecycle performance optimization supported with AI through project management, real estate development, and hotel delivery processes.

Thus, the following section focuses on the intersection of AI in project management that serves as the conceptual link between business management and real estate and hotel development.

2.2.4 Artificial Intelligence Applications in Real Estate Development:

2.2.4.1 Artificial Intelligence as a Strategic Enabler for Real Estate:

Development The real estate development industry is witnessing a significant and rapid digital revolution. Digital transformation is driven by rapid advancement of technologies such as Artificial Intelligence (AI), big data analytics, cloud computing, the Internet of Things (IoT) and other digital technologies.

Traditionally, real estate development is characterized by management intuition, informal knowledge, fragmented information systems and reliance on experience. In today's development market, decision-making has become increasingly data-driven requiring integrated information to improve investment outcomes, operational efficiency and strategic competitiveness.

Indeed, increased uncertainty and complexity in real estate markets, rising demands of customers, and environmental regulations make innovation a strategic concern for developers (Wang, 2023; Al-Haimi et al., 2025).

In this era of digital disruption, AI has evolved beyond improving operational efficiency and automating routine tasks, to a strategic capacity of organizations to add value at every level of the real estate development process. In fact, AI systems can analyze information from financial, technical, operational and market sources; AI thus facilitates better assessment of project viability, resources allocation and investment selection as well as more data-supported and logical planning.

Moreover, leveraging AI enables companies to better respond to the unpredictable nature of the market, enhance organizational agility respond to dynamic challenges in real estate development market (Wang, 2023; Al-Haimi et al., 2025).

Thus, regarding its contribution to organizational value creation and innovation from a strategic perspective, AI can lead to a sustainable competitive advantage by providing better quality and speed of decision making.

Specifically, AI's prediction capabilities and decision support systems may support real estate developers in identifying high-value investment opportunities, evaluating investment decisions, making decisions about portfolio optimization and better planning for capital allocation. Accordingly, AI needs to be treated not as a future technology but rather as a strategic enabler for real estate organizations.

2.2.4.2 AI for Development Feasibility and Investment Decision-Making:

Successful real estate development begins with feasibility assessment and investment decision-making, which establishes if the project is feasible to be financed, attractive to the market and can create long-term sustainable value.

Decisions that occur at the beginning stages of the development cycle – such as site selection, market evaluation, demand prediction, financial assessment, and investment assessment – impact project performance and return on investment throughout the entire lifespan of the asset. Traditionally, development decisions have been based on the use of historic data, feasibility studies from experts, financial models and experience of professionals.

However, increased market fluctuations, economic uncertainty, changing customer demands and rapid digital adoption have added considerable complexity to real estate development decisions, emphasizing a need for better and data-driven decision analysis (Pollestad & Oust, 2025; Kandipati, 2025).

AI provides a powerful decision support capability that enables developers to analyze, interpret and combine a vast array of demographic, financial, environmental, market, and geospatial data to support investment decisions. Instead of a traditional approach based on feasibility analysis, periodic market studies, and static assumptions, AI uses various structured and unstructured data sources to process information in real-time to detect hidden correlations, to forecast market behavior, and to assess different investment opportunities, thereby transforming the process of development feasibility from a retrospective/experience-based approach to a prospective/dynamic data-based one (Kandipati, 2025; Jamarani et al., 2024) .

Site Selection One of the earliest AI-driven use cases in development feasibility is site selection. Proper selection of a development site is one of the most significant strategic choices constructability, access, market demand, property value and future investment yield. Typically, traditional methods involve manual site evaluation and expert judgement and are hence prone to personal bias and limitations.

However, AI leverages combinations of GIS, machine learning techniques, geospatial analytics, remote sensing, mobility data, demographics, land use, and existing infrastructure to analyze hundreds of parameters concurrently and identify suitable sites to maximize development potential and de-risk long-term investment (Al-Rimawi & Nadler, 2025; Wang et al., 2025).

Market intelligence Apart from spatial analysis, AI substantially enhances market intelligence by enabling constant market conditions review and updates rather than merely relying on a feasibility report done once in a while. Modern AI solutions market continuously analyze market conditions in light of changing economic trends, real estate trends (property sales, rental value trends), buyer sentiments, changing trends online for property listed for sales, changing trends in population and macro-economic conditions. AI algorithms with ML use and derive relationship amongst these disparate factors to come out with market intelligence.

In this respect the developers are able to get a perspective about market, competitors, their strategy for pricing, target market segments, and demand before they can commit a huge chunk of money. This improves strategic planning and market intelligence leading to better decision-making. (Kandipati, 2025; Guo & Liu, 2024).

The use of predictive forecasting to assess demand for residential, commercial, hospitality or mixed-use developments – another valuable role that AI can play in the feasibility phase is a key tool for decision-making and for building a project to meet actual market need, not some arbitrary forecast from past trends or historical data, at the time capital is allocated to a project.

With changes in the economy, population dynamics, trends in tourism, and shifting tastes in consumers; accurately forecasting future demand has never been harder. Predictive AI addresses these challenges, combining historical data along with real-time market data in conjunction with a series of market assumptions to predict rates of occupancy, absorption rates, rental performance, and sales velocity as well as future customer demand. Machine learning models continue to adapt with the more market data they have, providing significantly more accurate and real-time projections than the models often relied on in traditional feasibility forecasts (Muth et al., 2025; Pollestad & Oust, 2025).

Following to market research and demand forecasting, AI further increases the reliability and quality of the feasibility study for the development through incorporating the technical, financial, environmental, and market data in sophisticated models. In contrast with traditional feasibility studies that are often made up of static assumptions and deterministic financial models, AI enables the developers to conduct dynamic feasibility analysis due to its ability to update data in real time, use predictive models, and run simulations of various scenarios.

The AI can also analyze numerous development scenarios in parallel to simulate financial viability of those scenarios given specific market conditions and determine the variables impacting viability the most. As such, developers can now look beyond static feasibility assessments (Lim, 2025; Kandipati, 2025).

Further, investment appraisal can also be facilitated by AI-driven decision-support systems which enables the appraisers to gauge the profitability of a particular development for a variety of economic and financial situations. Traditional investment appraisal methods typically rely on NPV, IRR, DCF, and sensitivity analyses.

Unlike conventional models that evaluate a limited number of scenarios AI is able to learn continuously from evolving market trends and identify complex patterns across multiple economic conditions. AI evaluates thousands of potential market scenarios instead of relying on limited number of predefined variables. This enables developers and investors to predict investment performance with more precision, thus also helping make more reliable investment decisions on which real estate alternative to proceed with (Pollestad & Oust, 2025; Lalum et al., 2025).

Similarly, Financial forecasting has also been significantly enhanced by AI. Forecasting financial outcomes such as revenues, development costs, financing needs, cash flow and return on investments is necessary to ascertain the financial viability and resilience of developments in the long-run.

AI forecasting algorithms are continuously trained using historic project data coupled with current information about economic trends, inflation, interest rates, construction cost index, real-estate markets to generate more accurate financial forecasts than traditional statistical methods and these provide proactive measures in anticipating the financial deviations during the planning phase (Jamarani et al., 2024; Muth et al., 2025).

AI also plays a significant role in portfolio optimization. Investment portfolios seek to optimize the allocation of limited capital across diverse project opportunities. Instead of analyzing projects individually, an investment portfolio considers multiple factors, including expected project returns, project risks, geographical diversity of investment opportunities, market diversification across different markets, available capital constraints, and market economic volatility to identify optimal portfolio allocations.

Machine learning provides an organization with a better understanding of portfolio outcomes while helping investors optimize portfolios based on investor's risk tolerance. It leads to enhanced strategic capital allocation and more resilient investment portfolios capable of adapting to market dynamics changes (Mertzanis, 2025; Lalum et al., 2025).

Ultimately, the application of AI is changing how we approach investment decisions and development feasibility – transitioning it from a fragmented and subjective experience-based discipline into an interconnected, forward looking, and adaptive analytical framework. AI supports developers in enhancing the quality of investment opportunities, lowering uncertainty, optimizing capital investment decisions and bolstering the long-term viability and performance of projects. It leverages intelligent site selection, market and demographic analysis, demand prediction, dynamic feasibility assessment, investment evaluation, cash flow forecasting and portfolio management to establish a solid robust strategic foundation.

for subsequent adoption across other stages of the project development lifecycle, including planning, design integration, construction, and ultimately an integrated AI-BIM workflow.

2.2.5 AI in Hospitality Business and Hotel Development

2.2.5.1 AI in Hospitality Business:

A major digital transformation is happening in hospitality because of growing customer expectations, the pressures of fierce market competition and the speedy advancement of technology. Where some other real estate sectors remain property-focused, Hotels offer service, and sustained success relies on effective operational processes, high quality guest experience, as well as physical assets and financial performance.

This makes the adoption of AI, a technology with strategic advantages to enable organizations to boost business results through an evidence-based strategy and intelligent operations (Kim et al., 2025; Gonalves et al., 2024).

From an operational data perspective, hotels produce large amounts of operating data from reservation systems, property management systems, customer relationship management systems, online travel agents and guest reviews in the operation process of hotels in modern era. Artificial intelligence provides hotel operators with a way to analyze these complex and varied operating data to identify guest behavior patterns, predict the direction of the market, obtain business intelligence that provides support for better business management (Henriques & Nobre Pereira, 2024; Mohammed & Guillet, 2026).

In addition to streamlining operations, AI is enabling hotels to implement customer-centric strategies by offering service personalization, intelligent revenue optimization, targeted marketing, and dynamic guest experiences.

These solutions help hotel businesses enhance their competitiveness, optimize service levels and achieve sustained business success within an ever-changing industry (Gonalves et al., 2024; Haynes & Egan, 2024).

Thus, it follows that the function of AI technology has expanded from being a tool for operations to becoming a strategic enabler that can support hotel developers, hotel owners, hotel operators and hotel management companies throughout the entire lifecycle of the hotel development process. Therefore, the subsequent paragraphs explore the major uses of AI in hotel development including, but not limited to: the positioning of the hotel market, selecting the correct brand and operator, creating a framework for the revenue stream, enabling the operational preparedness and enhancing long-term value creation (Kim et al., 2025; Henriques & Nobre Pereira, 2024).

2.2.5.2 AI for Hotel Market Positioning:

Successful hotel development extends beyond selecting a good site and market viability studies; the project must establish a distinct market positioning to set it apart from competitors in an ever-growing and challenging market.

In this respect, hotel market positioning can be described as the process by which hotel market developers and operators determine and create a distinctive value proposition and market identify associated with their brand within a specific location – their target audience, offering, quality of service, pricing, positioning as against rivals and so on.

Since, in general, traveler perceptions, attitudes, behavior, travel choices and competitive interactions change over time, market positioning has become increasingly sophisticated and reliant on large volumes of data, which is now made accessible through artificial intelligence (AI) (Gonalves et al., 2024; Dogru et al., 2024).

Hotel market positioning supported by AI differs substantially from traditional approaches. As such, artificial intelligence continuously analyses data from online travel agents, booking sites, reviews from customers, social media, online searches, and travel demand for specific destinations.

This type of mixed information identifies emerging trends in consumer interests, traveling styles, and gaps in competitors which traditional market surveys do not manage to identify. As a result, hotel businesses align their products and services with actual consumer demand (Henriques & Nobre Pereira, 2024; Mariani et al., 2024).

AI also enhances customer segmentation through the identification of more complex customer behavior profiles in the different groups of travelers, with machine learning (ML) algorithms classifying customers based on travel purpose, reservation behavior, travel patterns, payment performance, service preferences, or degree of loyalty; enabling hotel operators to better determine targeted market positioning strategies that suit specific user types, such as luxury travelers, families, business travelers, or longer-term stays, in order to increase competitiveness and satisfaction (Gonçalves et al., 2024; Dogru et al., 2024).

Another important application of AI is the continuous monitoring of competitors can be continuously monitored rather than relying on periodic market assessment.

Competitors' pricing, online reputation, customer reviews, advertising and promotional strategies can all be monitored and analyzed through AI-driven analytical systems which allows hotel managers to identify competitors' strength and weakness and maintain their relative advantage.

This enables hotel managers to respond proactively to market changes by responding with dynamic strategic adjustments to maintain competitive differentiation and strengthen their market position (Mohammed & Guillet, 2025; Haynes & Egan, 2024).

In essence, AI transitions the market positioning process from a static marketing process to dynamic ongoing capability, informed by a never-before available view of market, and customer data.

Using techniques such as AI-driven segmentation, destination and competitor insights and customer behavior intelligence, the application of AI can allow hotel developers and operators to enhance competitive positioning, whilst delivering better value to the customer and investor alike. Following the market positioning exercise, AI's contribution to hotel development extends further into the processes of brand matching and operator selection, whereby strategic market position and market demands translate to a desired hotel brand and operating partner (Dogru et al., 2024; Henriques & Nobre Pereira, 2024).

2.2.5.3 AI for Hotel Brand and Operator Selection:

One of the most significant strategic decisions in hotel development is the selection of most appropriate hotel brand and management operator. The choice directly influences market position, service quality, operational efficiency, financial success, and long-term value of the property.

Well-established international hotel firms, such as Marriott International, Hilton, IHG Hotels & Resorts, Accor, and Hyatt Hotels Corporation offer a diverse array of brand selections covering diverse hospitality market segments, target customer groups and service standards. Therefore, developers must take into consideration not only the familiarity and perception of each brand, but also the suitability of such brand in connection with the development strategy of the project, destination characteristics and ultimate investment objectives (Kim, 2024; Dev, 2025).

AI application enhances the efficiency of this complex decision – making process, by integrating other sources of data such as market data, customer data, competitor benchmarking data or operational performance data in advanced AI – driven models. Instead of basing decisions solely on experience or on consultants' recommendations, AI allows developers to evaluate multiple hotel brands on different performance criteria such as customer loyalty, market share, brand image, brand strengths or past performance identify the best hotel brand that aligns with project's concept, target market and strategic objectives (Kim et al., 2025; Kim, 2024).

AI also assists in the selection of hotel operators through the analysis of alternative hotel ownership and operating structures and their impact on hotel's operating performance.

Recent empirical studies indicate that hotel guest satisfaction and service quality vary depending on the form of hotel operation (chain-managed hotels, third-party managed hotels, and owner-operated hotels) depending on hotel's market segment and market placement. Based on such analysis, developers can make a comparison and benchmark the potential hotel operators objectively and select the right partners who deliver operational excellence for long-term value (Kim et al., 2024; Kim et al., 2025).

Essentially, the overall, AI-assisted framework for evaluating hotel brands and operators transforms a highly subjective decision-making process from a judgment-making exercise to

a disciplined analytical framework integrating both business acumen and hospitality experience.

Assessing alternative branding options, management strengths, and the alignment between the brand and market conditions all at once helps owners find brand partners that support their strategic objectives of building a differentiated competitive position, superior operational efficiency, and sustainable asset value over the life of the property (Kim et al., 2025; Dev, 2025).

2.2.5.4 AI for Revenue Management and Demand Optimization:

Today, revenue management is recognized as arguably the most significant commercial role in hotels, since hospitality inventory (unoccupied hotel rooms) is perishable and extremely sensitive to supply and demand in the marketplace. Unsold hotel rooms will never be sold, as a physical product can be sold at any point during its lifetime.

Therefore, correct pricing and accurate demand forecasting represent crucial factors influencing the commercial success of hotels. The modern hotels' marketplaces are dynamic with changing patterns of travel, a growing network of online booking channels, increased competition on price and ever more sophisticated and volatile consumer demands.

The traditional revenue management strategies based on historical data on bookings and human intuition were less capable to deal with the complexity and pace of such changing environments. AI has transformed revenue management by enabling intelligent prediction, autonomous learning, and constant analysis of real-time market data (Gao, 2025; Ampountolas & Bai, 2025).

One of AI's most significant contributions in the context of hotel revenue management is its ability to greatly increase the accuracy of demand forecasting. It's no exaggeration to claim that forecasting is at the core of the revenue management discipline.

This form of forecasting underlies decisions regarding room pricing, inventory management, staff forecasting, purchasing needs, and distribution channel decisions (Henriques & Nobre Pereira, 2024).

Machine learning, and specifically deep learning technologies, can create predictive models that ingest huge quantities of diverse data – historic reservation, pricing, cancellations,

searches from engines, weather patterns, event schedules (local to global), flight movements, macroeconomic indicators, and digital consumer activity.

These data sources extend beyond the historical booking data traditionally used in statistical forecasting models. Rather than simply making extrapolations, AI models learn on new data and make dynamically updated forecasts that reflect changing market circumstances (Ampountolas & Bai, 2025).

improved forecasting accuracy enables more informed decisions around pricing, inventory allocation, and operational resourcing. In turn, the hotel's Occupancy Rate (OCC), Average Daily Rate (ADR), Revenue per Available Room (RevPAR), and Gross Operating Profit per Available Room (GOPPAR) are all improved as they represent core measures of success in revenue management (Remy et al., 2019).

The net effect of AI is thus to increase accuracy in predicting demand and to equip hotels with the ability to quickly adapt to a fast-changing market landscape, thus capturing opportunities and improving profitability (Ampountolas & Bai, 2025).

Improved forecasts allow hotels to implement more advanced dynamic pricing and revenue optimization as an AI-driven Revenue Management System constantly monitors expected demand, booking lead time, consumer willingness to pay, available room capacity, competitive set prices, significant market events, distribution channel performance and then generates a live recommended room rate.

Rather than having generic rule-based seasonal pricing in place, the intelligent pricing algorithms dynamically adjust hotel rates in real-time in line with the prevailing market, ensuring optimal occupancy alongside improved Average Daily Rate (ADR), RevPAR and total revenue generation.

A number of empirical studies in recent times have demonstrated adaptive AI-based pricing models outperform traditional rule-based because the models can identify complex nonlinear relationship between demand and price and adapt quickly to changing market environments (Streviniotis et al. 2024; Gao, 2025).

2.2.5.5 AI for Operational Readiness:

Operational readiness is a pivotal stage during hotel development, which represents the transformation from project delivery to commercial operations. Far beyond simple physical completion, operational readiness is a measure of a company's capacity to deliver its services effectively, cost efficiently and consistently beginning the day of its launch.

Operational readiness involves readiness of processes, human capital, digital technologies, governance systems, operational coordination, and delivery mechanisms that ensure alignment and coordination of all hotel operations with service level agreements (SLAs) and service standards and expectations of guest experiences.

In effect, operational readiness has shifted from a project-transfer focused function into an organizational competence that underpins a hotel's service excellence, operational robustness, guest satisfaction, and, by extension, long-term organizational performance (Chang et al. 2026).

The traditional approach of hotel operational readiness has traditionally relied on manual coordination, extensive check lists, multidisciplinary team meetings and relying on operational project teams and hotel operator's past experience.

The increased complexity of hotel development, digital disruption of the hospitality industry and the changing demands of customers have exposed to the limitations of traditional operational readiness practices Artificial intelligence (AI) as emerged as an intelligent agent enabler that enhances an organization's readiness by improving decision-making, knowledge management, operational coordination and the monitoring of activities during the pre-opening stage.

AI -enabled solution can integrate the scattered operational data from different sources, pinpoint the areas of readiness gaps, support workforce management and development programs, enable team collaboration, and provide predictive capabilities to enhance the accuracy of pre-opening plans and mitigation of operational risks prior to hotel opening, by turning scattered data into intelligent knowledge (Chang et al., 2026; Dwivedi et al., 2024).

2.2.6 AI in Construction Project Management:

2.2.6.1 AI for Project Planning and Scheduling:

Planning and scheduling are important processes in construction project management as they determine the order of operations, the distribution of project resources, and the identification of project milestones among others.

Planning quality determines project performance, especially in terms of the time taken for completion, project costs, and productivity. However, modern construction projects have become very complicated due to the increased scale of projects, fragmented supply chains, multidisciplinary team composition, varying needs of clients, and unpredictable conditions at construction sites among other factors.

These factors make the use of traditional planning approaches ineffective since they mainly depend on deterministic scheduling procedures and the knowledge of project managers (Chen et al., 2025; Nenni et al., 2025).

Artificial intelligence (AI) is a new technology that can help overcome several limitations faced during construction planning. Contrary to the conventional scheduling software that is only concerned with producing static project schedules, AI helps in dynamic planning by examining historical data of projects, working with real-time project data, discovering patterns in construction data, and continuously optimizing planning decision throughout project execution.

Using the analytical abilities and decision-making support capabilities of AI, it is possible for project planners to predict schedule changes, consider different execution methods, and plan more effectively before the delays occur. Several systematic reviews have shown that planning and scheduling are some of the most developed and most widely used applications of AI in construction project management (Adebayo et al., 2025; Razi et al., 2026).

Machine Learning (ML), an artificial intelligence technique used in construction project management, has made it possible for planners to predict more accurately through the use of project data that has been collected over time.

Machine learning algorithms analyze historical information to create a model that predicts project variables, such as activity duration, labor productivity, equipment productivity, procurement, weather, subcontractors' productivity, among others, to create more accurate predictions. Unlike traditional prediction approaches, which depend largely on predefined

assumptions, the machine learning model learns and grows consciously with more project information (Chen et al., 2025; Aladağ et al., 2024).

Another important role played by AI technology is schedule optimization. Project schedulers always have to consider various scheduling options, taking into account factors like limited resources, contract dates, space available for work, and other dynamic factors on-site. As the complexity of the project increases, the problem becomes more difficult.

Optimization methods driven by AI technologies can examine thousands of scheduling possibilities simultaneously and provide optimal execution plans in order to reduce project completion time, reduce idle time, optimize resource usage, and increase project efficiency in general. This way, project managers can choose between various scheduling options, providing a good compromise between time, costs, productivity, and other constraints (Adebayo et al., 2025; Razi et al., 2026).

Due to recent advances in reinforcement learning and predictive analytics, **AI-assisted** planning activities have been significantly enhanced through schedule adaptation during project execution.

Instead of making use of fixed baseline schedules, smart scheduling systems evaluate the real performance of the project, compare it with the planned one, predict possible schedule deviations in the future, and suggest appropriate measures to be taken.

This makes it possible for construction managers to take preventive measures in case of changes in the design, problems with the procurement process, labor issues, unfavorable weather conditions, and other common occurrences in construction projects (Razi et al., 2026; Wuni et al., 2025).

AI helps in collaborative planning through improved communication between the different stakeholders involved in the projects. Modern AI systems are able to analyze a large number of project documents, extract relevant information about schedules, create progress reports, and aid in faster managerial decision making.

More recently, Generative AI has demonstrated considerable potential to have a high potential of helping the project team members with creating initial work breakdown structures, scheduling suggestions, constraints summary, and collaborative discussion during the project planning sessions. As these technologies are still developing, one of the major

concerns of the current research is that the use of AI should not interfere with the expertise of the project manager (Nenni et al., 2025; Wuni et al., 2025).

In conclusion, AI is revolutionizing construction planning and scheduling by shifting from a traditional administrative function to an intelligent and adaptable process. Through the integration of analytical techniques, learning algorithms, optimization tools, and intelligent decision-support capability, AI allows project planners to enhance their planning accuracy, optimize their resource allocation, decrease scheduling uncertainties, and generally improve project performance.

Planning activities provide the necessary base on which other AI applications in construction project management will be applied, especially cost estimating, cost controlling, risk managing, quality controlling, safety management, and project performance monitoring, discussed in the following sections (Chen et al., 2025; Razi et al., 2026; Wuni et al., 2025).

2.2.6.2 AI for Cost Estimation and Cost Control:

The cost estimation process and cost control function have been identified as important elements in the management of construction projects, since they significantly influence issues related to the feasibility of the project, financial planning, budgeting, procurement, and general performance of the project.

Effective cost estimation provides the initial financial plan of the project, whereas successful cost control helps maintain expenditures within the budgets of the project through the entire construction process. Unfortunately, it has become more difficult to provide efficient cost management processes because of issues like complexity of the project, volatile material costs, shortages of qualified labor, logistics problems, design changes, and other reasons. Conventional cost management techniques depend heavily on historical databases, manual quantity take-offs, expert knowledge, and financial reporting.

Consequently, inaccurate cost estimations and ineffective cost control continue to be the leading contributor to cost overrun and reduce project profitability (Gao et al., 2026; Karadimos & Anthopoulos, 2024).

This has prompted the incorporation of Artificial Intelligence (AI) technology as a powerful way of improving construction cost management through the use of advanced technologies. Instead of using estimating methodologies based on past project experience, AI enables construction companies to study vast amounts of historical and current project information

to find complex cost patterns and make data-based financial decisions during all project phases.

Thus, the use of AI has shifted the approach to cost estimation from being an experience-based process to becoming a predictive and data-based activity that can enhance estimation precision, facilitate automated cost tracking, and allow for proactive cost management. Unlike traditional cost estimation methods that focus on expert estimators' knowledge and historical cost data, AI techniques are capable of analyzing the complicated nonlinear interactions among project characteristics, labor productivity, amount of materials needed, equipment usage, project location, procurement environment, and market factors to produce accurate cost estimates.

Several systematic studies show that AI methods such as ANN, SVM, RF, DNN, and CBR have become leading approaches in the area of construction cost estimation due to their superior performance compared to traditional statistical models (prediction accuracy and adaptation capacity).

In addition, the intelligent models keep getting better at forecasting costs as they obtain more project data, thus reducing the uncertainty of estimations and ensuring better financial planning during the early stages of construction projects' development (Gao et al., 2026; Karadimos & Anthopoulos, 2024)

In fact, recent advancements in deep learning have made AI applications more useful by predicting the actual costs of construction rather than only estimating initial budgets. Sophisticated neural network architectures can learn hierarchical relationships between many cost drivers and automatically identify the variables that have the most significant impact on project costs. This enables project stakeholders to have more reliable financial forecasts at the conceptual planning stage, which leads to earlier budget optimization and more effective contingency planning.

Recent empirical studies have demonstrated that deep learning models can enhance prediction accuracy and diminish dependence on subjective expert judgement, notably during the initial planning phases, where project information is incomplete and the level of uncertainty is relatively high (Liu et al., 2025).

Beyond cost estimation, the use of Artificial Intelligence (AI) has become an effective approach to cost control on an ongoing basis throughout project execution. Continuous AI-

based monitoring of planned and actual project expenditures, detection of future cost variances and estimation of cost performance during the rest of the project, as well as suggested mitigation strategies helps project managers to address cost overruns proactively before they become severe.

As an intelligent system for cost control, it provides real time cost-performance-indicators, rather than relying on financial reports only in the course of the project so that managers can continuously control project's budget performance. Recent research about combining the use of Machine Learning with Earn value management (EVM) demonstrates that AI significantly improves the prediction accuracy of CPI, SPI and overall project costs and allows managers to take action to mitigate any potential financial risks in an early stage (Yalçın et al., 2024; Gao et al., 2026).

Artificial Intelligence also assists in strategic cost management, through Supporting cost forecasting, cost optimization, and risk of uncertainty analysis. The predictive AI can assess various financial scenarios, predict future cost trends, identify the potential financial impact of project risks and optimize resource allocation based on different project context. Recent advanced in Natural Language Processing (NLP) functionality for analyzing contract, bid records, variation orders and previous project information documents, the organization can extract the hidden risks in cost and improve the accuracy of cost estimation.

It empowers construction organizations to transition from reactive cost management toward predictive data-driven financial planning (Shrestha et al., 2025; Gao et al., 2026).

Despite these advances, there remain several barriers to the widespread adoption of AI in construction cost management. Existing AI algorithms remain significantly reliant on the quality, availability, and accuracy of historical project data. Variations between project characteristics, region, market dynamics, tender approaches, and procurement models can affect model generalizability.

As much existing research has been validated with historical data as with active projects, the additional real-world validation studies are necessary. Thus, prevailing research continues to identify AI as a support technology which augments rather than supplants the experienced judgements of cost engineers, project managers, and quantity surveyors in their high-stakes decisions (Gao et al., 2026; Razi et al., 2026).

Eventually, AI shifts cost management from retrospective cost accounting to forward-looking, data-centric project controls. AI provides advanced financial analysis by using machine learning (ML), deep learning (DL), and predictive analytics (PA) techniques to refine budget forecasts, support real-time cost management, and provide real-time financial decision-making. This leads to enhanced cost-effectiveness, better financial outcomes and allows construction firms to effectively address cost-related challenges associated with construction projects.

2.2.7 Challenges and Limitations of Artificial Intelligence:

Despite the transformative promise of AI, a number of technological, organizational and ethical issues may stand in the way of actual value delivery. One of the most significant challenges is the availability and quality of data; without timely and reliable input, the accuracy and efficacy of prediction and decision support generated by AI models could be seriously undermined.

Therefore, robust data governance is essential to maintain accurate, complete and continually updated data that support reliable application of AI (Dwivedi et al., 2024).

The readiness of the organization also remains an interesting challenge. A proper implementation of AI implies that a company possesses: a strong digital infrastructure, knowledgeable employees, a sufficient leadership level commitment, and organization willingness to redesigning their current business processes.

Often organizations fail to realize their AI's true potential despite substantial investments in AI technologies without having those complementary resources at hand (Verhoef et al., 2021; Wamba et al., 2021).

In addition, the areas concerning ethics and governance are very important. As organizations increasingly integrate AI into decision-making processes which has given rise to transparency, explainability, accountability, algorithm bias, and data security, and privacy protection concerns. Due to this, good AI governance has become strategic necessity for organizations. (Habbal et al., 2024).

The construction and hospitality sectors are further challenged by having fragmented project information. The distribution of project information across various project participants, technologies and phases limits information interoperability and integration and consequently of the quality of AI-generated outputs. As AI does not generate or manage integrated

information but rather analyses information that exists, its viability depends on the availability of a formalized digital information environment to manage information coherently throughout a project's life cycle (ISO 19650-1, 2018; Valdebenito & Forcael, 2025)

To sum up, while AI can helpfully deliver high levels of analysis and prediction, this depends on reliable digital information, good governance and the readiness of your organization to integrate AI within an integrated digital information environment.

These limitations highlight the importance of BIM when we consider it can provide an integrated digital and collaborative information environment which will allow reliable AI tools to be employed to support the entire process of the development of the hotel.

Thus, the subsequent section will introduce the principles, and capabilities of BIM then discuss it along with AI application as an integrated intelligent digital ecosystem.

To summarize the preceding discussion, we have illustrated that AI is no merely a computational technological product, but rather a strategic capability enabling a host of project lifecycle services, ranging from strategic support in decision-making, prediction, business operations, project execution and hotels management to the real estate development. Nonetheless, the effectiveness of AI fundamentally depends on, the prerequisite always depends on the availability of accurate, structured, and up-to-date project information. Without such a digital data input, AI cannot fully realize its predictive and analytical capabilities.

Accordingly, the discussion now turns to Building information Modeling (BIM) as this provides the collaborative digital information framework which provides a collaborative digital environment for integrating project information, the disciplines work collaboratively with each other, the lifecycle data is manageable Before investigating the integration of BIM and AI to the intelligent digital ecosystem that empowers the hotel development, it is necessary to understand the BIM first.

2.3 Building Information Modeling (BIM) in Hotel Development:

2.3.1 Introduction to Building Information Modeling (BIM):

Building Information Modelling (BIM) is arguably one of the most transformative digital innovations revolutionizing the architecture, engineering, construction and facility management (AEC/FM) sector. It is not simply a three-dimensional (3D) modelling tool, but an information management methodology for producing, exchanging and managing reliable digital information for the whole life cycle of an asset.

By setting up a Common Data Environment (CDE) and adopting a Collaborative Information Management approach, it allows Clients, Designers, Consultants, Contractors, Suppliers, Facility Managers to create, share and keep updated digital project information within an integrated environment.

In doing so, it helps overcome fragmentation, improve communications, support better decisions, and achieve better outcomes for planning, designing, building, operating, managing, maintaining and eventually decommissioning buildings, infrastructure and structures. Accordingly, BIM is recognized as a collaborative information management framework that facilitates integrated project delivery throughout project lifecycle rather than simply a 3D design technology (ISO, 2018; Sacks et al., 2025).

The BIM concept and its capabilities have evolved significantly over the past three decades. In the first instance, digital design was developed to digitize traditional drawings with CAD which produced graphic information and could not convey other object related data in a direct and intelligent manner.

In the late 90's and early 2000's, the concept has become increasingly focused on the object-oriented modeling for which each object element (i.e. Walls, doors, columns, beams, pipes and another building components .) has both geometric and non-geometric information embedded, consequently , BIM evolved from a modeling tool into intelligent information management platform and a tool that can be used in multi-discipline coordination and clash detection, analysis, simulation, quantity, estimating and planning, and also facilities management and sustainability analyses (Sacks et al., 2025; Teulier & Bagieu, 2024).

However, the primary differences between BIM and traditional CAD system lie in the following aspects. Conventional CAD primarily focus on creating a collection of 2D and 3D visual representations of design components where each drawing was constructed separately

and manually coordinated with others whenever design changes are made. BIM applies smart parametric objects within a single digital building model where each component contains graphic, spatial, operational, and other relevant information, which makes any change reflected immediately across all the derived plans, schedule and quantities.

As such, design discrepancy is avoided; discipline integration can be further reinforced, and the quality of the generated design documentation becomes more reliable (Sacks et al., 2025).

In addition, the development of BIM has undergone stages called BIM Maturity Levels which show the evolution of the digital transformation of the construction industry. BIM Level 0 describes the classical 2D drawings where a low degree of information sharing and minimal digital collaboration between teams occurs.

BIM Level 1 refers to managed CAD standard and some degree of information sharing. BIM Level 2 represents the standard now commonly required, where disciplines communicate via federated discipline models contained in a Common Data Environment, while the authoring models remain separate; whereas BIM Level 3 envisages an interoperable digital environment in which the collaboration occurs through the use of common project information shared among all the participants to manage all the life cycle phases of an asset. (ISO, 2018; Sacks et al., 2025).

BIM implementation has traditionally been described using BIM Maturity Levels which describe the increasing levels of digitalization of the Architecture, Engineering, Construction and Facilities management (AEC/FM) industry, progressing from Level 0 to Level 3: Level 0 – the 2D CAD environment of paper drawing or CAD with minimal exchange/collaboration of digital data by any project parties.

BIM Level 1 - Managed CAD standard development with supported structure of information and managed exchange of information and basic collaboration; BIM Level 2 - Discipline-specific authoring models developed which can be used for clash detection/coordination purposes as they are all combined into a federated model within a Common Data Environment (CDE) , Level 3 – represent the envisioned fully integrated digital model approach, supported by full integration between discipline specific authoring tools and the shared project information Model for collaboration, development, and operation (UK BIM Framework, 2022; Sacks et al., 2025).

In conclusion, Building Information Modeling should not be considered solely as a three dimensional (3D) modeling application, but rather as a methodology for integrated digital information management that embraces and enhances the role of people, processes, technology, and common information management standards. By establishing a single source of trustworthy project information during the asset's lifecycle, BIM promotes multidisciplinary cooperation, improves decision quality, increase project productivity, and facilitates the effective asset management throughout the asset lifecycle.

2.3.2 Principles and Foundations of Building Information Modeling:

Building Information Modeling (BIM) is built on an integrated series of principles creating a collective, information-centered way to produce and execute built assets for their entire lifecycle.

BIM principles provide a framework for a fundamentally different process to other traditional digital design approaches, where data structures support decision-making in an open environment involving different professions.

This framework allows for structured information to be created, validated, communicated, and used throughout the life cycle for improved decisions from pre-planning through operation and maintenance stages, to provides the information foundation upon which Digital Twin technologies can later be developed and operated (Teulier & Bagieu, 2024).

Underlying most of the concept, BIM employs a logic of modeling with intelligent and parametric object-based building elements, rather than the construction drawing using the system of disconnected geometrical objects used in most of the CAD applications.

Elements like wall, columns, beams, doors, window, MEP Equipment are intelligent object which contain geometric information and non-geometric attributes like: material, characteristics of usage, cost value, maintenance details, and functional links with the others element. In that they are parametric, once an object is modifying the changes are broadcast to all linked documentation (plan, schedule, quantities table, and other project documentation) reducing the time of coordination effort, minimizing inconsistencies number and improved data integrity (Teulier & Bagieu, 2024).

Another key principle in BIM is Information Management throughout the Lifecycle of the asset. Information generated at the start of the project should remain of value during the construction, commissioning, occupation, operation, renovation and then demolition of the

building. Thus, BIM encourages the maintenance of a dynamic information repository as opposed to standalone information datasets created independently of the project stakeholders.

BIM fosters a lifecycle information perspective whereby reliable information exists at all stages of a project's life where it is required; preventing loss of information between project phases, enabling optimization during asset operations (International Organization for Standardization [ISO], 2018; Kaya & Özener, 2025).

To successfully manage information lifecycle, BIM requires organized digital environment termed as Common Data Environment (CDE). The CDE stores and manages all the approved information related to a project, models, drawings, specifications, schedules, reports, and other communication project communication, reviewed and disseminated using strict controls.

This provides a single source of truth, increases reliability, and maintains version control, trackability of information and minimizes risks of siloed project data. The CDE standardize the processes required for review, authorizing, publishing and archiving of information facilitating transparency and collaboration across the various members of the multidisciplinary team (ISO, 2018; Xiang et al., 2025).

Interoperability forms another fundamental principle of BIM and refers to the efficient exchange of information between different software application without loss of data. As architects, structural engineers, building services engineers, quantity surveyors, and facilities managers may all use different software programs, OpenBIM is often implemented as an open, software-neutral protocol pioneered by buildingSMART International.

In essence, OpenBIM uses IFC as the underlying data standard and to create communication between the different software programs. Most recently, additional standards like IDS have been introduced to increase communication via machine-readable information requirements to deliver data to the highest quality throughout the building process (ISO, 2018; buildingSMART International, 2024; Gao et al., 2025).

Interoperability enables the BIM to support collaborative workflows across multidisciplinary project teams by allowing seamless information exchange between different software platforms.

The new working paradigm does not produce separate, discipline-based documents but provides the environment for all actors (architect, structural engineer, MEP engineer,

contractor, consultant, owner, facilities manager) to interact using coordinated information model in an integrated digital environment. Collaborative workflows result in early detection of potential conflicts, better coordination of the design process, minimized rework, more effective communication and the support of effective multidisciplinary decision-making during all project phases (Chen et al., 2025).

Formally, this process is dictated by the ISO 19650 series, which has emerged as the international benchmark for information management for BIM.

Rather than prescribe specific software tools, ISO 19650 standardizes information delivery processes by setting requirements for definition of information, responsibilities allocation, information production, review of deliverables, approval management and exchange of information at each step of the asset's lifecycle. The standard emphasizes information quality, conformity, responsibility and governance while encouraging standardization in digital operation regardless of project scale or method of appointment (ISO, 2018; Kaya & Özener, 2025).

Collectively, these principles position BIM as comprehensive digital information management methodology rather than merely a three-dimensional modeling. By supporting object-based parametric modelling, the management of information through the building lifecycle, common data environments, open standards for information exchange, collaborative workflows and international standards for information management, BIM represents the essential digital foundation upon which projects can achieve greater levels of coordination, better quality of information, and ongoing performance for buildings.

These principles have many benefits for the hotel development context: multi-disciplinary coordination of the project team is fundamental; continuity of operation requires accurate asset information; and reliability is a prerequisite of effective information management for hotels.

2.3.3 BIM Applications Throughout the Hotel Development Lifecycle:

The practical applications of BIM for hotel projects, after having talked about BIM concepts and principles, can be seen in its application at each stage of the hotel development lifecycle.

BIM is not an independent design tool, but an integrated information platform with continuity throughout the project lifecycle, which spans from planning, design, to construction, operation, maintenance and to asset management, thereby promoting cross-professional

coordination and information sharing of project members, breaking the fragmentation of information, assisting in decision-making at various project stages. In hotels, especially considering the operational continuity of hotels, the building systems are complex and its life cycle maintenance will be extremely important and needs continuous and accurate information from its design stage to maintenance stage.

Therefore, application of BIM in hotel projects covers the following steps, which are sequential from the conception and feasibility phase through the various stages including design coordination, structural design and MEP design, clash detection, cost estimation and quantities take-off, construction planning and construction execution, digital handover, and facilities management and asset lifecycle management (Li et al., 2021).

2.3.3.1 BIM for Feasibility and Concept Development:

The feasibility and concept development stage provides strategic guidance for the hotel development, taking the overall business goals, operational requirements, and market needs and converting them into initial planning and design solutions. During this phase, the project teams analyze the alternatives of development, limitations of site conditions, functional requirements, and space interrelationships to set up the appropriate hotel concept fulfilling the commercial goals and operational needs.

Hotel development requires an integrated design approach to consider room mixes, public spaces, back of house operations, circulation networks, and operator's brand standards in the earliest stage compared to the majority of other types of buildings. These decisions constitute the functional blueprint for the next stage of architectural design, structural design, and building services design (deRoos, 2012).

BIM, Building Information Modelling, serves the feasibility and concept development phase with its digitally integrated platform and processes to support the planning and design development as well as decision making prior to the detailed design phase (Lama & Fu, 2021).

The advantages BIM offers in feasibility and concept development lie in i lie in its ability to enable the collaboration and integration among the project teams as well as provide real-time design updates through parametric modeling of complex building designs (Ma et al., 2021).

BIM supports the concept development process by allowing project teams to evaluate various concept schemes, spatial relationships, room mixes and architectural designs through

modelling. By utilizing BIM to combine site-based information, user requirements, and different spatial layouts and design alternatives, information becomes clearer and is effectively communicated to stakeholders to support informed decisions (Forth et al., 2021).

Moreover, BIM enables designers to quickly simulate different building design strategies, as well as evaluating floor plan options, to understand spatial relationships of rooms and to manage the decision making for the initial conceptual stage of the development, where these decisions significantly affect the overall process.

Therefore, the integration of BIM in feasibility and concept development has allowed hotel owners, designers and consultants, to make better-informed development decisions while improving the coordination of project requirements and design criteria for subsequent architectural, structural, building services design, construction and facility operations phases (Forth et al., 2021; Lama & Fu, 2021).

2.3.3.2 BIM for Integrated Design and Coordination:

The integrated design and coordination are one of the most important stages of hotel development since it's the time to integrate architectural, building systems, structural and operational requirements into a coordinated design.

Hotel projects contain highly repetitive guest rooms together with complex public spaces, restaurants, kitchens, conference facilities, back -of-house and extensive MEP systems, these diverse functional requirements increase significantly the design complexity and the need of continues coordination among all stakeholders to ensure operational, aesthetic and technical objectives are achieved.

Therefore, the complexity of hotel requires an integrated digital coordination approach capable of managing multidisciplinary design information during the design stage (deRoos, 2012; Wang et al., 2017).

During this stage, BIM provides a common digital environment that enables designers including architects, structural engineers, MEP engineers, interior designers, hotel operator, and consultants to collaboratively develop and check a federated BIM model as opposed to instead of relying on separate discipline- specific drawings.

The collaborative workflows make it possible for the impacts of decisions to be reviewed collectively to ensure the consistency between the architectural design and another

disciplines, for example. In a hotel development, operator requirements for the room configurations, circulation, and mechanical, electrical, and plumbing systems can significantly impact the designs. BIM aids in this continuous coordination by synchronizing project information amongst disciplines as design information evolves and in doing so, leads to better design quality and a more accurate building representation (Wang et al., 2017).

During the design stage of hotel development, BIM-enabled Architectural, Structural and MEP coordination as a foundational element of robust clash detection. Complex and densely layered hotel building service networks, operating within limited ceiling voids, service shafts and repetitious guest-room configurations (HVAC ducts, plumbing, fire protection, electrical systems, telecommunications and low voltage) where the multiple building systems compete for limited spatial allocation.

These factors create considerable potential for clashes between design disciplines if coordinated via traditional 2D document production. BIM supports a holistic process to detect, visualize and categorize a wide range of clashes including physical, or “hard” clashes; clearance, or “soft” clashes and those of workflow co-ordination nature, through the facility of automatic clash detection, within an aggregated, Federated Digital model prior to construction commencement.

The validation of multidisciplinary design takes the form of architects, structural engineers, MEP engineers and the hotel operator, collaborating to evaluate alternative design solutions, validate compliance with operational standards and spatial demands and resolving any clashes identified via a coordinated update to the fed-up BIM model.

By highlighting, classifying and prioritizing the critical clashes early in the design development stage, design team re-works, construction rework, change orders, and programme delays can be minimized and the constructability and installation ease and overall reliability of coordinated design solutions enhanced.

In addition to previous BIM approaches and methods, advanced BIM systems also prioritize the detected clash clashes, based on severity and potential impact on project performance to project during life cycle, so the project team members allocate the coordination efforts appropriately. (Bitaraf et al., 2024).

Hotel projects require continuous collaboration among architects, structural engineers, MEP engineers, interior designers, hotel operators, cost consultants and other stakeholders

throughout the design stage. Different from the traditional way in which project information was transferred through isolated disciplinary documents, BIM provides an environment to achieve this by building a collaborative platform on a shared federated information model. Within this platform, multidisciplinary team work simultaneously.

Open communication among project participants leads to increased collaboration. Changes architectural design is transparent and immediately reflected to engineering disciplines through the shared information. Project team could have the chance to identify consequences of the changes in decision, maintain consistency between architectural, engineering and operational requirements and respond quickly to new requirements of hotel operator without affecting the whole design workflow.

Collaboration is extremely important in hotel projects as frequent update occur and evolution of operation requirements during design development including hotel guestroom planning, public space layouts, hotel's back of house spaces design, Food & beverage outlets and hotel brands standards.

BIM help this dynamic process by building a single central source of project of hotel project information for all stakeholders to review, update and validate throughout the design process in a consistency manner no matter which kind of BIM software applications they were used. OpenBIM-based collaborative work flow helps designers, consultants, contractors and hotel operators share information with less information fragmentation, increase communication effectiveness and improve multidisciplinary decision-making quality during design stage (Jin & Li, 2023).

BIM play significant role in design optimization and constructability review in the design phase of hotel development. In the context of hotel projects, design solutions must be implemented not only to fulfill architectural and functional requirements but also to enable efficient construction, easy maintenance, and cost-effective operation.

The BIM technology provides project teams with the tools for evaluating alternative design solutions by means of 3D visualization, constructability review, equipment accessibility assessment, and collaborative design review.

Through the implementation of BIM during the design phase, architects, structural engineers, MEP engineers, contractors and hotel operators are able to optimize room layout design, improve integration of various building systems, evaluate installation sequence, as well as

make full use of maintenance access and operational considerations for hotels, and then produce optimized designs which have fewer risks of construction clashes, faster installation, improved maintainability, greater overall project quality and reduce lifecycle costs (Luo et al., 2024).

Overall, BIM changes the hotel development design process from fragmented, discipline-based workflows to an integrated, information-driven process by allowing architectural, structural, MEP and operations requirements to be simultaneously addressed within one shared federated model. BIM promotes integrated, interdisciplinary collaboration, centralized information coordination and data management, automated clash detection and coordinated design review, design validation and constructability improvements.

As such it enhances quality and reduces errors and coordination problems, reworks, construction risks and total project lifecycle cost. Moreover, BIM facilitates building information continuity in the whole hotel development project lifecycle starting from design to construction and commissioning and finally operation and asset management.

2.3.3.3 BIM for Construction Planning and Project Delivery

2.3.3.3.1 BIM for Quantity Take-off and Cost Estimation (5D BIM):

BIM contributes to cost management by extending its capabilities beyond design coordination to the quantity surveying and cost estimation through integrated project information workflows, widely known as 5D BIM. Unlike a traditional method that relies on the manual measurement from two-dimensional drawings in quantity take-off, the 3D contains embedded quantity information which will automate quantity take-off.

Within the BIM environment, each of the building elements is associated with geometrical and non-geometrical information. Integrating building elements with quantity surveying and cost estimation results in more accurate and comprehensive quantity estimation with significantly minimizing manual calculations and time-consuming manual quantity measurement and cost estimation.

Furthermore, quantities information extracted from the BIM model can be dynamically connected to the BIM model so that, both quantities and cost estimates are automatically updated with any changes in design throughout pre-construction phases. As a result, project owners can have up-to-date and reliable cost estimation to support investment decision – making throughout pre-construction stages. Linking quantity take-off with cost information

will result in increased transparency, better informed value engineering analysis, streamlined procurement planning, and effective selection of investment alternatives based on evaluation of the impacts of design changes before construction begins (Alathamneh et al., 2024).

5D BIM is especially valuable in hotel development projects as these projects typically feature highly repetitive guestroom layouts in their hotel rooms alongside complicated and costly public areas, restaurants, kitchens, meeting and conference facilities, back-of-house facilities, and many large and detailed MEP systems, where accurate measurement and quantification of materials across many trades is critical.

Even minor one change, can have a disproportionate impact on total cost given the repetitive structure of hotel room layouts and services and so BIM allows hotel developers, QS, contractors and cost consultants to access continuously updated quantity information as design alternatives are considered and cost impact monitored during the course of design development. A case study involving a six-stories hotel building demonstrated that BIM provided a more accurate and complete material quantity estimate than traditional manual take-off methods, with significantly shorter take-off time.

The paper also found that material quantity directly exported from the BIM model could be automatically linked to the model elements to achieve better traceability, reduced human input errors, and also for reliable cost estimating and material procurement (Unthong et al., 2025).

Therefore, 5D BIM creates a reliable digital cost control framework, increasing the precision of estimating, enabling active control of project costs and supporting project financial management on hotel development projects.

2.3.3.3.2 BIM for Construction Planning and Scheduling (4D BIM):

Besides design coordination and cost management, construction schedules can also be associated with 3D digital models to create 4D BIM by integrating time dimension into the 3D model. In 4D BIM, project teams can link construction activities schedule to specific model elements to visualize the construction sequence and evaluate alternative schedules, optimizing resource use, considering construction logic, and assessing logistical implications before the start of construction.

Unlike current methods where schedule representation mainly relies on Gantt charts or network diagrams, the integration between schedules and 3D models can enhance

information sharing, project coordination, communication and decision making in projects by creating a dynamic visual representation of construction progress.

This collaboration and visualization will contribute to more reliable construction planning such as analyzing workload interactions, assessing temporary facilities, and planning on site logistics and construction execution strategies. This improves scheduling accuracy, risk management and productivity (Mayouf et al., 2024; Rehman et al., 2025).

In particular, 4D BIM provides significant value on hotels development, due to their inherently fast-paced nature, with numerous simultaneous operations, repetitive guest room floor layouts across multiple levels, MEP intensive building systems, finishes-intensive construction activities, and strict hotel opening deadlines and operational readiness requirements.

A delay in any construction sequence tends to have a cascading impact across following trades, testing and commissioning processes, and the hotel opening date.

Integrating construction schedules with aligned 4D BIM models can provide construction sequence simulation before construction begins, compare alternative sequences, analyze labor and material requirements and coordinate trades, specialist subcontractors and consultant disciplines within a cohesive digital environment. Collectively, these capabilities enable contractors, consultants, operators and clients to simulate construction processes, assess impacts of schedule disruption, and identify and resolve construction conflicts and risks before they impact project performance and project delivery during hotels development projects. (Mayouf et al., 2024; Rehman et al., 2025).

2.3.3.3.3 BIM Construction Monitoring, Progress Tracking and Quality Control:

BIM can enhance construction progress monitoring through a constantly updating 3D view of project development during its execution stage. BIM, connected with site inspections, progress reports, laser scanning, drone surveys and mobile field solutions, can be used by project team to contrast planned activities with reality on site, identify issues as they happen, and act quickly to avoid project delays and defects.

This digital system makes the process clearer, helps coordination among all parties, and allows efficient decisions (Mayouf et al., 2024; Rehman et al., 2025).

In the construction of hotels, site monitoring is even more crucial as various work packages-ranging from the architectural fit-out, MEP installations, FF&E readiness, specialized systems and specific hotel operator requirements-need to be completed in a well-coordinated order before they can be tested and commissioned, and the Operational Readiness prior to hotel opening.

With BIM, contractors, consultants, hoteliers, and hotel owners can monitor construction progress against the agreed project plan, check for proper installation quality, find those elements that are unfinished or not in conformity, and coordinate any remediation measures in a common digital space.

Thus, quality checks become more rigorous, rework reduces, site supervision improves, and the probability of delivering on schedule by the time of the hotel's launch becomes more robust (Borrmann et al., 2021; Mayouf et al., 2024).

BIM also plays a crucial role in the construction phase through the management of construction quality. Especially for hotel construction projects, the demand for high quality level on finishes, guest rooms, public spaces, MEP system, and requirements by hotel operator is much higher compared with that for typical buildings. In the construction stage, BIM can create a unique digital space for tracking and checking construction activities with design documentation, contractual agreements, and quality inspection procedures and check-lists.

Data onsite inspections, non-conformance reports (NCRs), deficiency logs and proposed remediation can be associated with individual elements in the model to identify and report outstanding work, verify ongoing work status, and check completion and quality to allow subsequent works. Through such workflow, more accurate, traceable, and less error-prone inspections could be carried out among contractors, consultants, hotels owners, and operators.

For hotels, high-quality finish works, furniture fixtures & equipment installation, MEP systems, and architectural construction are essential to the success of the hotel operation, so BIM based construction quality check supports efficient inspections, early detection and correction of flaws, compliance checks for operators' brands prior to testing and commissioning and hotel opening, leading to higher construction quality, reduced project delay and risk as well as lifetime cost of building quality defects (Wang et al., 2024; Chen & Luo, 2014).

2.3.3.4 BIM for Digital Handover, Facility Management and Asset Lifecycle:

2.3.3.4.1 Digital Handover and Asset Information Model (AIM):

Digital handover is one of the key applications of BIM at the handover from construction to operation. Instead of issuing disconnected papers, drawings, and manuals of the building components, the information associated with a BIM model can be delivered as a unified data environment to provide the owner, facility operator, and hotel manager with an authentic asset information of building to make them prepare to operate and maintain the facility (Borrmann et al., 2021; Sacks et al., 2021).

The process of digital handover improves the continuity of information, reduces data loss, and sets up a good starting point to operate and manage assets during the hotel's life cycle.

During the construction phase, the updated information about actual status of the completed building is updated in the model to provide a “as-built” BIM model of architecture, structure, MEP system. Verified data information like specifications, maintenance manuals, warranties of equipment are recorded and these are the basis of the Asset Information Model (AIM) for operation and management of the hotel building, maintenance plans, future refurbishment (Borrmann et al., 2021).

Digital handover typically adopts COBie (Construction Operations Building Information Exchange) as an information exchange standard to convey organized asset data like inventories, location, serial numbers, maintenance date, warranties and spare parts of hotel facilities. By providing standardized non-graphical information of building assets with standard, it is easy for BIM model to be transmitted and integrated into facility management system (East, 2016; Sacks et al., 2021).

Digital handover is particularly valuable for hotels as it can provide full and authentic asset information for hoteliers before opening to ensure they are ready for operating. The hoteliers can utilize full and accurate information to carry out preventive maintenance, comply with the law, and maintain hotel assets effectively over their lifecycle (Borrmann et al., 2021; Wang et al., 2024).

2.3.3.4.2 BIM-Enabled Digital Twin for Hotel Operations:

Once the digital handover is completed, the BIM not only serves as a database of information about assets but develops into a dynamic Digital Twin representing the real-time operational status of a physical hotel over its entire lifecycle. A BIM-enabled Digital Twin bridges the physical facility and its virtual representation, extending the purpose of BIM from a model primarily storing design and construction data to one that integrates with real-time operational data streams from Building Management Systems (BMS), smart sensors, and Internet of Things (IoT) enabled devices.

The integration creates a living digital representation of the hotel facility that allows real-time monitoring of its performance, analysis of its operational condition, and intelligent decision-making in hotel operations (Hu & Assaad, 2024; Revolti et al., 2024).

Thousands of operational data are continuously generated by HVAC systems, lighting, elevators, water supply networks, fire protection systems, indoor environment sensors, energy meters, occupant sensors and security systems in the hotel facility. Through BMS integration and IoT connectivity, real-time operational data is synchronized with the BIM to form an operational Digital Twin that accurately depicts the current condition of the building asset.

With this, the owners, facility managers, and hotel operators continuously monitor equipment performance, environmental condition, energy use and occupants' comfort in a unified platform and react faster to operational incidents (Hu & Assaad, 2024).

The capacity of BIM-enabled Digital Twin for predictive maintenance through live data is one of its significant strengths. By applying artificial intelligence (AI) and machine learning on top of the real-time sensor data, a Digital Twin can effectively identify anomalous patterns of operations, forecast equipment failure, estimate the need for maintenance and advise on the optimal operational settings, shifting the maintenance approach from reactive to predictive/condition-based maintenance, reducing equipment downtime, ensuring operational continuity, decreasing maintenance cost and extending equipment lifetime (Asare et al., 2024).

In the context of hotel facilities, the operation of building services directly impacts guest experience. Critical building services such as HVAC systems, guestroom environment

control, domestic hot water supply, lighting system, elevators and life safety system are indispensable in a hotel building.

Thus, the constant tracking of operational performance via BIM-enabled Digital Twin enables hotel managers to quickly detect any operational degradation in real time, optimize energy performance, enhance indoor environmental quality, maintain continuous operations and eliminate any failure that could negatively affect guest satisfaction.

Evidence of this approach was demonstrated through a pilot implementation at a Holiday Inn hotel where a BIM-based Digital Twin was implemented along with a suite of IoT sensors, BMS, and advanced intelligent diagnostics techniques to establish a comprehensive operational real-time management platform that enhanced fault detection speed, operational efficiency and energy consumption compared to current facility management practices (Lu et al., 2025).

Collectively, these capabilities position the Digital as the next evolutionary stage of BIM for the hotel operations, enabled predictive maintenance, real- time monitoring and asset performance optimization supported by 6D BIM. (Hu & Assaad, 2024; Asare et al., 2024).

2.3.3.4.3 BIM for Facility Management and Maintenance (6D BIM):

Following the implementation of a BIM-enabled Digital Twin, BIM extends its value far beyond project delivery by supporting the Facility management of the hotel assets. This capability, generally referred to as the 6D BIM, is applied during the Facility Management (FM) of a building. It offers facility managers and operators access to integrated data relating to all assets (e.g., equipment, systems, furniture, fittings, spaces) within a single digital environment.

With BIM, FM professionals gain centralized access to asset data, such as their specifications, maintenance records, warranties, operational and maintenance manuals, inspection reports, and lifecycle documentation. It removes the need to comb through a jumble of drawings and paper records and streamlines maintenance planning and decision-making about building asset operations throughout the building's lifespan (Abideen et al., 2024; Peng et al., 2024).

In hotels, facility management is particularly crucial due to the twenty-four-hour nature of the facilities and the constant need to provide a high level of guest comfort and service. Building systems like electrical power distribution, plumbing and sanitary systems,

ventilation and air conditioning (HVAC) systems, elevators, fire suppression systems, kitchen equipment, laundry services, and in-room systems and amenities necessitate continuous upkeep.

BIM aids in both preventive maintenances, with information on scheduling, manufacturers' recommendations, procedures and history of each asset that allow teams to prevent potential system failures, and corrective maintenance, which leverages digital information and drawings to quickly diagnose issues, identify affected components, access documentation, review repair histories, and coordinate repair efforts efficiently to minimize equipment downtime (Abideen et al., 2024).

Another essential operational need addressed by 6D BIM in hotels is space management. The diverse spaces in hotels, from guest rooms and suites, dining outlets, and meeting facilities to back-of-house operations, kitchens, engineering rooms, and storage, require precise allocation and management to adapt to current operations and future needs. BIM can support hotel operations in monitoring space usage, managing occupancy, directing maintenance, and assisting in renovation planning. By consolidating data related to the utilization, status, and operational history of each space and its assets, hotel operators and facility managers can optimize space efficiency and make better strategic decisions regarding facility layout and future investments (Lovell et al., 2024; Peng et al., 2024).

A case study conducted by Akdeniz and Ofluoglu (2024) demonstrated the practical implementation of a BIM-enabled FM framework at a four-star hotel and identified a number of improvements including more efficient management of assets, better planned preventive maintenance activities, and more effective management of space.

Their research highlights that adopting BIM into the FM process has helped to alleviate issues with information accessibility, planning, space management, and coordination, and provided hotel owners and facility managers with an integrated digital tool for managing hotels efficiently.

Overall, 6D BIM transitions the FM practice from a document-driven to an integrated digital one. By enabling preventive and corrective maintenance, space management and optimized lifecycle decision-making for building assets, it offers hotel developments enhanced operational performance, reduced maintenance costs, more resilient service delivery and a higher long-term value for the property (Abideen et al., 2024; Peng et al., 2024; Akdeniz & Ofluoglu, 2024).

2.3.3.4.4 BIM for Asset Lifecycle Management (7D BIM) Asset Performance Lifecycle:

Building on the capabilities for facility management enabled by 6D BIM, 7D BIM moves the building information modeling process into the realm of strategic building asset management through their entire life cycle.

Instead of being merely concerned with operational and maintenance activities on a day-to-day basis, 7D BIM facilitates the assessment of asset performance, life cycle cost analysis, and timely asset replacement for hotel owners and operators. By combining maintenance, operation, financial, and performance data in a centralized digital environment, 7D BIM supports a long-term value strategy for assets that reduces the risk associated with the asset life cycle and minimizes unnecessary capital expenditure (Atencio et al., 2025).

For hotel developments, the long-term care of assets is essential as these facilities are filled with many high-value assets which have varying lives. These include many systems such as those for the HVAC, elevators, and hospitality -specific systems care as well as the guestroom furniture, hotel kitchen equipment, electrical and plumbing systems, as well as the finishings of the interior (Elshabshiri et al., 2025).

Life cycle asset information in BIM makes the decision of when to replace these systems based on an actual operational view, when the systems are not functioning, maintenance costs associated, the remaining life of the systems, rather than simply using their remaining service life (Moradabadi et al., 2024).

Lifecycle Cost analysis for a building asset that is an important use of the information found in 7D BIM makes an analysis of the whole cost of ownership of an asset. This includes all the expenses associated with buying, running and maintaining that asset throughout its lifespan (Moradabadi et al., 2024).

This information in 7D BIM helps hotel owners to maximize their long-term financial interests, in the way that the hotel's capital is invested, and helps with timely investment and renewal decisions of assets within. As the lifecycle information is stored digitally, BIM-enabled life cycle analysis has shown to reduce long term operational costs and improves the decision-making in asset planning for hotel developments.

Lifecycle management supported by 7D BIM enable hotel operators to determine the optimal timing for replacing critical building assets, through analyzing the actual operational performance, maintenance history, lifecycle cost and remaining useful life. BIM enhances

the replacement planning by identifying the most appropriate time for asset renewal rather than relying on schedule replacement or responding on unexpected equipment failure. Therefore, the replacement activities will be coordinated during planned refurbishment programmes thereby minimizing operational disruptions, reducing emergency replacement costs, minimize long -term maintained expenditure and maintaining uninterrupted hotel operations.

In addition to optimizing the asset planning strategies, 7D BIM also supports the Sustainable life cycle, by enhancing the lifecycle – based asset management aligned with circular economy principle. BIM Model stores a comprehensive life cycle information enable the hotel owners and the operators to evaluate the environmental responsibility for replacement alternatives, maximize the recycling of building materials and minimize operational waste.

Furthermore, BIM contribute in the facility improvement in energy efficiency and resources optimization, allowing the hotel developers to reduce the environmental impacts while enhancing long – term assets value, sustainable building performance and operational resilience (Atencio et al., 2025; Elshabshiri et al., 2025).

2.3.4 Challenges and Limitations of BIM Implementation :

Although BIM delivers considerable benefits across the entire hotel development lifecycle, its adoption and success remain hampered by a blend of organizational, managerial, technical, human, financial, contractual and project-specific impediments.

From an organizational viewpoint, achieving a successful implementation of BIM needs leadership commitment, a clear implementation strategy, organization change management and a continuous collaboration between all stakeholders such as owners, operators, designers, consultants, contractors, suppliers, commissioning agents and facility managers. Obstruction of traditional working methods, lack of support from management, absence of clearly defined roles and dispersed communication may prohibit embedding BIM into processes related to the whole project.

The results from recent study about the readiness of BIM-based projects identify capability and coordination within the team, documents and approvals, model development and validation as key elements for a successful implementation and readiness to the construction phase (Radzi et al., 2025).

Technical and information management challenges further constrain effective BIM implementation, The utilization of multiple authoring, coordination, construction and facility management platforms might cause interoperability problems and data incomplete or inconsistent exchanges.

Poor model validation, unreliable asset information, inconsistent classification and naming structures, as well as weak management of the Common Data Environment (CDE) may diminish the level of trust in the information and compromise the utilization of BIM in the construction phase and throughout the building lifecycle.

Thus, information governance must consist of clear procedures for data generation, verification, authorization, accessing, updating, securing and ownership through time. This will become more evident when information needs to be transferred into facility management systems, where unreliable, redundant, or poorly organized data will be limited practical value (Gordo-Gregorio et al., 2025).

The issue of human resources is another bottleneck; In order to implement BIM, it will be required to have staff trained with modeling, coordination, information management and facility management skills.

However, a lack of skilled BIM professionals, unequal levels of competence between project stakeholders, insufficient training and understanding of life-cycle information may result in non-homogeneous production and in poor coordination of the models. These challenges are closely associated with finance issues such as software, hardware, consultants, training and models cost, integration systems and the necessity of their continuous update.

On a contractual and legal point of view, contractual issues will rise concerning ownership and Intellectual property rights on models, liability on reliance of models and their content, security obligation on data, and contractual liability for their maintenance or update across the life-cycle (Radzi et al., 2025).

In the context of hotel development, these difficulties are further amplified by the coordination requirements with: hotel brand operator and company standards; a very detailed and complex MEP and architectural layout, the design of specific hospitality equipment and of all the FF&E necessary for hotel opening; the testing and commissioning activities and the operational ready processes before hotel opening; the finalization of detailed asset information prior to hotel opening; Furthermore, the hotel development process also includes

the participation of various stakeholders: a development team, a construction team, an operator team, a commissioning team and a facility management team, each with its own tools, information standards and operational needs.

It is noted that, research on digital transition in the hotel sector faces challenges with respect to technological integration, adaptation to organizational structure, competencies of staff, and their adjustment to operational needs (Garca-Lpez et al., 2025).

Accordingly, without the leadership and collaboration of the project stakeholders, without experienced and capable individuals, reliable information governance, sufficient investment and clear allocation of responsibilities, BIM might just become another tool for model-production without being a life-cycle information management solution able to support the project development, operational readiness and facility management (Radzi et al., 2025; Gordo-Gregorio et al., 2025; Garca-Lpez et al., 2025).

2.3.5 BIM Adoption in Saudi Arabia:

The introduction of building information modelling in Saudi Arabia has been a progressive development aligned to the country's economic diversification, digitization and modernization agendas in relation to the built environment. Initial adoption of BIM was the remit of the individual AEC firms, although its uptake has spread throughout public infrastructure, residential, commercial, real estate, housing and significant tourism developments.

The state of BIM adoption in Saudi Arabia has previously been assessed as moderate and confined to larger companies and major projects; however, with increasing size and technical complexity of developmental programmes in line with Saudi Vision 2030, requirements for integrated digital information management, interdisciplinary coordination and streamlined project delivery have accelerated (Al-Yami & Sanni-Anibire, 2021; Algahtany et al., 2023).

Through integrating the national construction strategy with the objectives of the Saudi Vision 2030 to implement digital transformation in the AEC industry, the Saudi government has played a vital role to accelerate BIM adoption. A strong governmental commitment through regulatory regulations, professional education, research funding, and a national BIM deployment strategy has boosted the adoption of BIM in the Saudi AEC industry (Algahtany et al., 2023; Alaboud & Alshahrani, 2023).

The initiatives have contributed to improving construction productivity, strengthening the project management capabilities, encouraging the sustainable practice and increasing the overall value delivered by the public and private sector investment in built environment sector (Alaboud & Alshahrani, 2023).

A recent empirical study concluded that government commitment, organizational digital readiness, and supportive national policies are the most critical factors affecting the success of BIM implementation in Saudi Arabia (Iqbal et al., 2025; Algahtany et al., 2023).

With continued massive investments by Saudi Arabia to enhance its tourism and mega-infrastructure projects BIM has become more than a tool to create 3D models; it has become an information management tool that facilitates a full project life-cycle through information sharing among project stakeholders.

These initiatives are evident through major Vision 2030 projects such as NEOM, Qiddiya, The Red Sea, Diriyah Gate, and ROSHN, where BIM-enabled digital engineering practices are increasingly adopted to enhance multidisciplinary coordination, construction planning, managing costs, and improving asset information management for future operations and maintenance

The key drivers of BIM adoption in Saudi Arabia are associated with improving project performance-driven aspects of construction, with reduced time for designing cycle times and more efficient management of the construction phase planning and management were among the top 10 key drivers influencing adoption of BIM within the Saudi construction sector according to a recent study.

Other identified top drivers include better co-ordination, communication, information sharing, visualization, and control of project-level and site-level work, with further implication of integrated planning, project management, and lifecycle information management. This transition reflects the evaluation of BIM from a modeling technology to an integrated information platform with some of the Kingdom's giga-projects and mixed-use developments that involve the interaction of many consultants, designers, contractors, suppliers, operators, and public organizations that manage enormous amounts of information on projects (Iqbal et al, 2025).

Findings from Saudi projects also revealed the increasing role of BIM in contract administration, cost control, and overall project performance. Several research have indicated

that BIM enhance the quality of project information to enable more rational decision-making during the pre-tender phase and project delivery to reduce the cause of cost variation claims (Al-Gahtani et al., 2024).

Moreover, the development of BIM-based contractual framework for BIM-supported information coordination, and information sharing that promote more cooperation between project stakeholders and minimize construction claims occurrence in Saudi projects was introduced (Abougamil et al., 2024).

Thus, the application of BIM in the kingdom is expanding beyond generating 3D model to cover all aspects of the construction projects life-cycle, such as change management, cost control, contract administration and claim prevention and reduction. Also, the role of BIM has been extended to meet Saudi Arabia's objectives on sustainable development by its integration with environmental performance assessment and green building principles to support informed decision making on the efficient energy use, choice of materials, and the long-term performance of buildings (Alghamdi et al., 2022)

The fast-paced growth of Saudi Arabia's tourism and hospitality industry only heightens the importance of BIM in hotel development. Saudi Arabia is currently undertaking a remarkable program of tourism and hospitality investment as a major element of Saudi Vision 2030, with major hotel developments being initiated in cities such as Riyadh, Jeddah, Makkah, Madinah and emerging destinations such as the Red Sea, AlUla and Diriyah.

Saudi Arabia's Hospitality Market Review 2025 estimates that a total of 362,000 rooms are planned, of which approximately 78% of the new supply is concentrated within the luxury, upscale, and upper-upscale segments (Knight Frank, 2025).

This aggressive build-out is increasing the need for sophisticated digital delivery methods which can manage the complexity of these new projects and their specific operational requirements. Saudi hotel projects need to manage integration of architectural, structural, MEP, interior design, FF&E, specialist hospitality systems, operator brand standards, testing and commissioning, operational readiness, and lifecycle information.

BIM is capable of providing a unified digital space that promotes communication, information sharing, clash coordination, digital handover, and lifecycle management within hotels from design and construction through to operations and maintenance, a need that is becoming more crucial as Saudi Arabia continues to drive its hospitality sector, whilst also

pushing for wider adoption of digitalization across the construction industry and the tourism economy (Iqbal et al., 2025; Garca-Lpez et al., 2025).

Thus, adopting BIM for Saudi hotels should be recognized as a strategic digital platform for enhancing life cycle performance and accelerate the hotel project delivery , but as a tool to improve project performance, support the needs of the international hotel operators, contribute to effective operational readiness and ensure maximum lifecycle performance, supporting the Kingdom to realize Saudi Vision 2030 through the development of sustainable, digitally intelligent and life cycle-focused hotels (Knight Frank, 2025; Iqbal et al., 2025).

in conclusion, BIM implementation in Saudi Arabia is progressively transform from fragmentated organizational adoption to nationally integrated digital strategy supporting the mega scale projects and infrastructure development. Government incentives and strategies (Vision 2030 development strategies), growing complexity in building design and construction, rise in the requirement of sustainable development, and the rapid expansion of the hospitality sector have been facilitating increased application of BIM in Saudi Arabia.

It is apparent that maturity in BIM can be still different between projects and organizations but the trend is clearly moving towards comprehensive implementation across all project phases. This transition is expected to strengthen KSA's digital capabilities for future hotel planning, construction, management and performance (Algahtany et al., 2023; Al-Gahtani et al., 2024; Iqbal et al., 2025).

2.4 Artificial Intelligence and Building Information Modeling (AI–BIM) Integration:

2.4.1 Concept of AI–BIM Integration:

Artificial Intelligence (AI) and Building Information Modeling (BIM) are increasingly seen as synergistic digital technologies enabling a paradigm shift of intelligent transformation in the Architecture, Engineering, Construction, and Operations (AECO) industry.

Whereas BIM provides a comprehensive digital representation of building assets for physical assets that capture geometric, semantic, functional, cost, time and lifecycle information in a structured format, AI provides advanced computing power that turns information into knowledge through machine learning, predictive analytics, computer vision, optimization algorithms and automated reasoning. The two technologies not only serve as complements, but create an intelligent digital ecosystem where BIM provides authoritative project data

while AI derives actionable knowledge from that data for evidence-based decision making during an asset's life cycle (Pan & Zhang, 2021; Zhang et al., 2022).

The concept of AI-BIM integration, thus, is not simply a combination of two digital technologies but the creation of an intelligent information system which is the hub where project data is generated, updated, interpreted, analyzed and exploited in support of improved project delivery.

BIM as the authoritative source of information repository is accompanied by AI which makes the learning and reasoning from project information through identifying patterns, predicting future outcomes, uncovering risks, suggesting optimized options, and converting static project data into continuously learning dynamic knowledge to aid planning, designing, construction, operations and lifecycle management (Zhang et al., 2022; Zabin et al., 2022).

In this respect, AI-BIM integration leads to the paradigm shift of Intelligent Digital Project Delivery that departs from the conventional use of digital modeling solely for visualization and documentation to including prediction, automation, optimization, real-time decision making and learning across the full range of project delivery process for all disciplines, hence optimizing project outcomes (Pan & Zhang, 2021; Zhang et al., 2022).

In hotel development project delivery, the impact of AI-BIM integration can be profound due to multi-disciplinary involvement, the need to conform to international hotel operator standards, the integration of complex mechanical, electrical and plumbing (MEP), and furniture, fixtures and equipment (FF&E) systems, and planning for operational and ongoing maintenance needs.

Integrating AI with BIM in hotels allows owners, consultants, contractors, hotel operators and facility managers to operate in a connected, intelligent digital environment. By harnessing AI with BIM-BIM project participants can make smarter predictive decisions, improve inter-disciplinary coordination, enhance operational preparedness, and optimize asset lifecycle performance. Therefore, AI-BIM integration should be conceptualized as a strategic digital capability for achieving more intelligent and sustainable hotel development over its lifecycle (Zhang et al., 2022; Zabin et al., 2022) .

2.4.2 AI–BIM Integration Across the Hotel Development Lifecycle:

Transform Building Information Modeling to become more than just an information repository to intelligent decision – making support environment, introducing intelligent analytic abilities throughout the hotel project development lifecycle. Instead of being separate, independent technologies, AI and BIM are integrated in a single digital environment where the structured project information is continuously analyzed, predictive and automated decision-making, allowing stakeholders to make better decisions with greater efficiency, turning the hotel information into a powerful strategic intelligence tool that is developed as project progresses.

The following paragraphs consider how the AI-BIM integration applies at each phase of the hotel development lifecycle: Feasibility, planning & approvals, integrated design & value engineering, construction, commissioning & Handover and facility & lifecycle management.

2.4.2.1 AI–BIM for Feasibility and Investment Analysis:

The integration of AI and BIM revolutionizes feasibility and investment analysis by marrying the structured data of BIM with the analytical power of AI.

Traditional feasibility studies are static reports with occasional financial reviews; AI-BIM creates a living digital platform that continuously generates and updates project information via BIM, and analyzes it with AI to identify development opportunities, forecast performance, assess risks, and optimize investment choices (Zhang et al., 2022; Alaka et al., 2024).

BIMs continuously updated geometric, functional, technical, spatial, cost and scheduling data forms the foundation. AI's role is to integrate this with external information like market conditions, investor appetite, regulations, planning restraints, and economic trends.

Rather than evaluating elements in isolation, AI continuously assesses the ever-changing BIM model and associated data, allowing it to weigh multiple scenarios and support more thorough, evidence-based investments (Li et al., 2024; Zhang et al., 2022).

The synergy lies in the dynamic interaction between digital information and intelligent analysis. Anytime the BIM information shifts-a layout change, a cost increase, a schedule delay-AI reevaluates feasibility, financial return, risk, and investment attractiveness.

The feasibility exercise moves from a static document to an adaptive digital process, enabling informed decisions early in development (Silva et al., 2025).

This is critical for hotel development where decisions involve simultaneous consideration of design, operator needs, efficiency, coordination, function, guest experience, constructability, and long-term performance.

AI-BIM enables all these interconnected factors to be analyzed together, allowing stakeholders to compare options, reduce uncertainty, and refine investments prior to detailed design (Liu et al., 2025). AI-BIM redefines feasibility and investment analysis from a document-driven task to an intelligent, digital decision support system informed by a continually updated project database.

By uniting BIM's accuracy with AI's analytical capacity, stakeholders can achieve better investment outcomes, enhance project value, mitigate early risks, and establish a robust digital framework for hotels (Zhang et al., 2022; Alaka et al., 2024).

2.4.2.2 AI-BIM for Integrated Design and Design Optimization:

When we add Artificial Intelligence (AI) to the Building Information Modeling (BIM) tool, the design stage changes from a coordination exercise with a digital model to a process of intelligent decision-making with data inputs. In the new design approach, AI dynamically analyzes the changes in a BIM model in order to deliver design intelligence, develop and assess alternate design options, and optimize project outcomes throughout the design process.

The dynamic input/output process of AI and BIM enables decisions to be guided by a real-time assessment of project information rather than based mainly on experience and subjective design choices (Zhang et al., 2022; Bagasi et al., 2025).

In this environment, every update on the BIM model provides instant information for the analysis made by AI tools. As project information evolves over time, the AI system monitors the impact of design choices on various aspects, including building function, spatial efficiency, environmental performance, lifecycle outcomes, buildability, and investment performance.

In other words, instead of reviewing few design options individually, AI can generate and compares different design options based on the last version of a BIM model against multiple technical, functional, operational and financial criteria (Li et al., 2024; Zhang et al., 2022).

In fact, the primary benefit of the integration between AI and BIM in the design stage is the conversion of the design optimization into a continuous learning process. In this methodology, rather than reviewing the design at specific points in time, the AI iteratively

learns from the coordinated design information within BIM and makes predictions and proposes alternative options for decisions, prior to them being irrevocably made (Bagasi et al., 2025; Zhang et al., 2022).

Consequently, the quality of design can be improved by ensuring decisions are more data-informed and by reducing design iterations and uncertainty. This feature is especially valuable for hotels, given that hotel developments require concurrent optimization of many elements such as architectural layout, operator's brand requirements, guests experience, functionality relationships, operating efficiency, integration of building services, and the long-term asset value.

AI-BIM integration makes it possible to analyze such interrelated design requirements jointly within a unique digital platform to allow all stakeholders to compare alternative design solutions, as well as evaluate their operational and financial implications prior to moving into detailed design phase, which eventually enables more proactive, transparent, and appropriate decisions (Bagasi et al., 2025; Li et al., 2024).

Thus, AI-BIM integration reframes integrated design as an intelligent process driven by continuously updating information based on iterative AI analysis. Combining the structured information provided by BIM with the analytical and predictive capacities of AI, project teams can thus enhance design quality, facilitate evidence-based multidisciplinary decisions, and improve the performance and value of hotel projects (Zhang et al., 2022).

2.4.2.3 AI-BIM for Construction Planning and Scheduling (4D):

The use of AI to supplement Building Information Modeling (BIM) completely revolutionizes the process of planning and scheduling construction from one in which a manually developed program dictates progress to one of a continually adjusted, dynamically informed, and intelligently optimized process.

AI analyzes the developing information of the BIM model to automatically sequence activities, allocate resources, predict delays, identify constraints, and identify alternative, more efficient strategies, rather than relying on schedule updates that are made periodically in an already static schedule set forth at the commencement of construction (Awe et al., 2025; Al-Sinan et al., 2024).

The AI- BIM integration provides significant advantages for construction scheduling. A BIM model becomes a central, constantly updated source of project information; an activity in the

BIM model can be automatically analyzed by an AI algorithm in the context of previously executed work, or by evaluating its potential impact on remaining tasks to ascertain time impact, impact to other trades/tasks, availability of required resources, logistics/site constraints, workflow continuation, etc.

The AI assesses the many interactions of all construction activities, as well as construction constraints and organizational objectives, to suggest scheduling scenarios as an alternate method than a single revision in a given period, enabling the project to view these various alternatives and test impacts before moving to schedule revisions (Al-Sinan et al., 2024; Valdebenito & Forcael, 2025).

A core aspect of the application of AI to BIM Scheduling, however, is predictive capabilities. In addition to having the information from a dynamically updating model at its disposal, the AI, based on experience gleaned from similar past construction projects and the evolving data in the model, can identify areas in the future of a project where problems can arise, potentially even before they happen.

By identifying an activity or set of activities where there is a risk of significant impact to the critical path of the schedule and estimating the impact to the project timeframe as a result of such, the AI can suggest a modification or course of action prior to the impact of a given problem (Awe et al., 2025; Al-Sinan et al., 2024).

In this respect, AI-BIM in scheduling is invaluable in project delivery systems with extensive, interrelated components like hotels. Hotels require coordinated scheduling among various entities to be delivered such as structural, MEP systems, architectural finishes, specialist equipment, interior fit-out, long-lead items procurement, testing/commissioning, etc. Because a delay or sequencing error in one trade can have widespread consequences for numerous downstream activities.

A common challenge and significant benefit of AI-BIM scheduling is to model the impact of potential changes in a coordinated manner; stakeholders will now see multiple alternative methods of delivery and the consequences each holds, leading to fewer delays and a higher certainty of completion for even complex projects like hotels. (Rehman et al., 2025; Valdebenito & Forcael, 2025).

2.4.2.4 AI–BIM for Cost Estimation and Cost Control (5D):

The integration of Building Information Modeling (BIM) with artificial intelligence (AI) has transformed cost estimation from a number-based calculation practice to intelligent, informed project intelligence capable of continuously interpreting project information.

Instead of just utilizing BIM to take quantities and associate costs, AI learns patterns through interactions of project geometric, attribute, history, productivity, procurement, and market intelligence to yield better cost estimations that continuously update themselves. Therefore, cost management will move towards continuous, knowledge-driven intelligent decision support rather than fixed-procedure cost estimation (Jafary et al., 2026).

Unlike BIM 5D which primarily focuses on the automated quantification and cost calculation, the adoption of AI-BIM integration would add learning and reasoning capacities. The AI will learn from and iteratively improve on the process by recognizing past BIM-based projects that contain valuable implicit information about project cost through pattern recognition of previous project-level BIM attributes. As soon as the change is implemented in the BIM model, AI can interpret financial implications by estimating the project procurement changes, impacts on productivity, building material usage and overall value of a project, leading to better decision support than traditional cost update practices (Jafary et al., 2026; Avogaro et al., 2025).

Also, AI-BIM integration helps to identify and optimize costs with a scenario-based analytical framework. Rather than producing a single cost estimate, AI would simulate cost impacts with varying design, material, procurement and construction methods by performing simultaneous comparisons to achieve desirable and the most cost-effective solution that supports long-term investment while considering other factors like lifecycle performance. As opposed to the lowest cost decision-making practice that typically leads to trade-offs on performance and quality of asset over time, this framework would focus on cost optimization with overall project value (Avogaro et al., 2025).

In a hotel development context, the project costs are particularly susceptible to the brand standards from the operator, repeating layout in guest rooms, complicated MEP systems, high-end furniture fixture & equipment (FF&E) package and change request(s) occurring during the project delivery stage.

As a change on one repeating guest room would be projected on hundreds and impact other related building systems and procurement package, Consequently , that AI-BIM will

automate these estimations and financial implications in the BIM digital model prior to implementation for stakeholders including developers, consultants, contractors and hoteliers to reduce financial uncertainty and risk, and control project costs in alignment with operator requirements(Jafary et al., 2026; Avogaro et al., 2025).

2.4.2.5 AI–BIM for Facility Management (6D):

AI – BIM integration represents a profound shift from a facility data management function to an intelligent operational environment that can continually analyze building performance and enable autonomous decision-making throughout a facility's life. Rather than being merely a repository of asset information upon project completion, AI utilizes the information encoded in BIM models, along with operational, maintenance and sensor-generated data, to generate actionable insights while continuously learning from operational data , improving a facility's operational efficiency and performance.

In doing so, AI transforms facility management from its traditionally reactive maintenance practices into an intelligently managed operation that is driven by ongoing learning and data-driven decision-making (Sampaio et al., 2022; Zhang et al., 2022).

A primary outcome of integrating AI with BIM is the enabling of predictive facility management capabilities. Instead of performing maintenance based on predetermined schedules or when a malfunction occurs, AI proactively inspects and analyzes the operational patterns of BIM-connected assets for abnormal performance that could predict future failure, and prioritizes maintenance based on potential impact to operations and criticality of the asset.

By learning from past maintenance history and iteratively updating prediction models with real-time operational information, AI can support condition-based maintenance approaches that result in greater asset reliability, reduced downtime, reduced waste of maintenance resources, and extended asset service life.

The result is maintenance activities that are proactive and preventative rather than reactive, minimize operational disruption, and enhance facility performance (Sampaio et al., 2022; Zhang et al., 2022).

In addition to maintenance, AI-BIM integration augments intelligent facility operation by continually monitoring and evaluating how building assets interact with occupants' behavior, environmental factors, and their overall impact on the operational performance of the

building. AI can detect relationships and connections among multiple operating variables that are often invisible to traditional facility management systems, and continuously optimizes aspects of energy usage, HVAC operations, indoor environmental quality, utilization of spaces, and efficient use of resources.

AI-BIM allows a facility's overall operational performance to be assessed and optimized as an integrated digital ecosystem, using the BIM information as the underlying foundation, rather than viewing systems individually and analyzing their interaction with varying building conditions over time (Zhang et al., 2022; Sampaio et al., 2022).

This can have particularly critical impacts in the hotel sector, where business continuity directly influences guest satisfaction, compliance with brand standards, the efficiency of hotel operations, and profitability over the long-term.

Hotels operate 24/7 and rely on consistent performance of multiple interdependent systems such as HVAC, elevators, in-room guest facilities, kitchens, fire and life safety systems and other vital infrastructure.

Using AI-BIM integration can identify potential operational anomalies before they impact guest service, help in scheduling maintenance activities with minimal disruption to guests, and can dynamically adapt the operational priorities to the needs of the business and its occupancy levels, thus resulting in improved service continuity, optimized operational spending, higher asset reliability, and superior hotel facility performance throughout the lifecycle of the hotel.

2.4.2.6 AI-BIM for Asset Lifecycle Management (7D):

AI- BIM integration elevates digital information beyond mere project phases to facilitate intelligent lifecycle management of built assets.

Rather than segmenting planning, design, construction, operation and end-of-life as disjointed events, AI continually evaluates and learns from the data produced through the BIM-enabled asset lifecycle, creating a unified decision-support framework. This intelligence allows decisions concerning the asset to adapt dynamically as new information on the asset's technical performance, operation, environment, and overall behavior emerges over time (Adewale et al., 2024; Arajo et al., 2026).

A key benefit is the conversion of lifecycle information into lifecycle intelligence. Rather than relying solely on BIM as a repository of lifecycle information, AI continuously analyses

BIM-generated data with operational feedback, sustainability indicators, asset performance data, and environmental information, to identify recurring patterns which predict future asset performance.

This enables organizations to anticipate future asset behavior and optimize intervention strategies by using intelligence which is dynamically produced throughout the asset's lifespan, instead of static assumptions derived at the initial stages (Adewale et al., 2024).

Further support is lent to sustainable decision-making across the lifecycle of a building, as a result of combining the lifecycle data managed in BIM with AI capabilities for analytics and optimization.

A number of options can be analyzed concurrently to predict their long-term impacts on sustainability objectives, lifecycle cost, carbon emission, operational efficiency, and asset resilience. By doing this, organizations can make effective decisions, moving from the optimization of individual project stages to an optimum in the lifecycle of a project, where the final solution maximizes long-term value and addresses sustainability requirements (Arajo et al., 2026).

AI-BIM integration is particularly crucial in hotel developments, as hotels remain operational for many decades and typically require several refurbishment rounds, updates on technology, or modification of brand standards over their life. Hotels face a challenge to maintain operations, meet sustainability targets, control costs and achieve long-term value without impacting guest experience.

Through the integration of AI-BIM, hotels can leverage data produced throughout the life of the building from development and operation to make better decisions in areas like refurbishment, sustainability improvement, asset replacement and long-term investments, resulting in intelligent lifecycle management instead of only lifecycle reporting (Adewale et al., 2024; Arajo et al., 2026).

2.4.3 Challenges of AI-BIM Integration:

Although AI – BIM integration offers significant potential, effective implementation is limited by numerous integration-specific barriers. Unlike stand-alone adoption of either AI or BIM, the practical integration of AI and BIM demands these technologies to exist in a shared digital platform to enable continuous exchange, interpretation and updating of information throughout the project lifecycle.

Thus, most challenges are not with technology per se but with integrating the information, workflows and organizational process to enable effective integration of the two technologies (Awe et al., 2025; Li et al., 2024).

Data integration and interoperability pose as one of the major obstacles. AI-algorithms are dependent on organized, consistent, machine-readable data from BIM information, but variations in data structures, software, information standards, and exchange formats hinder the precise interpretation of BIM data by AI-systems.

This lack of interoperability results in unreliable automated analysis, which also limits the constant information flow needed to support intelligent lifecycle decision making (Awe et al., 2025; Li et al., 2024).

Information governance and organizational integration is another significant challenge as the integration requires coherent governance in terms of information quality management, ownership, verification process, responsibilities for model updates, and digital workflows between multiple stakeholders in the project. Without consistency of information management, even if there is access to powerful analytical algorithms, AI-generated outputs may be unreliable as AI systems depend on continuous, high-quality lifecycle information to learn effectively from BIM-enabled project data (Li et al., 2024; Awe et al., 2025).

2.5 Chapter Summary:

The review of the literature in this chapter has established the theoretical and empirical underpinnings to support the integration of Artificial Intelligence (AI) and Building Information Modeling (BIM) in the hotel development process.

The chapter commenced by looking at the evolution of Artificial Intelligence and its applications in business management, real estate development and the development of hotel projects. This was followed by an in-depth review of Building Information Modeling (BIM), including its origins, key principles, life cycle applications, and role in the hotel development projects.

The chapter further investigated the integration of AI and BIM throughout the lifecycle of a hotel development process, addressing its role in decision-making, multidisciplinary collaboration, managing costs and schedules, achieving operational readiness, effective facility management and long-term facility lifecycle performance.

Finally, the chapter examined key challenges encountered during AI-BIM integration, including those that relate to interoperability, information management, and organizational readiness and lifecycle information continuity.

The overarching conclusion is that although Artificial Intelligence and Building Information Modeling individually provide a range of benefits for the AECO sector, empirical evidence remains limited of how Artificial Intelligence and Building Information Modeling can be effectively integrated throughout the entire lifecycle of a hospitality developments, and little has been published on the application and impact of Artificial Intelligence and Building Information Modeling integration in the development of hotel projects within Saudi Arabia.

Much research published to date, however, has focused on technical implementations and specific phases of development with less research focusing on how Artificial Intelligence and Building Information Modeling integration impacts on overall project delivery and hotel business performance, further strengthening the research gap established in Chapter One, and providing the conceptual base for the conceptual framework and hypotheses presented within this dissertation.

CHAPTER THREE - RESEARCH METHODOLOGY:

3.1 Introduction:

This chapter represents the research methodology adopted to address the research problem which focuses on understanding the adoption of Artificial Intelligence (AI) and Building Information Modeling (BIM) for improving the performance of hotel development in Saudi Arabia. It also provides an in-depth description of the research methods selected for gathering data, analyzing it and testing the hypothesizes derived from the theoretical discussions and framework developed in the second chapter.

First, The Chapter begins by illustrating detailed information of research philosophy, approach, design and strategy used to answer the problem. The Chapter also justifies the selection of the research methods adopted in this study.

Second, it discusses the details of operationalization of the research variables, target population, and sampling method adopted for selecting the sample for conducting research, design and administration of research instrument, data collection method used, techniques to validate and reliability the questionnaire, and methods for data analysis and hypothesis testing along with research ethic applied.

All these details provided in this research methodology chapter provide systematic and objective framework for examining and empirically testing the interrelationship between AI, BIM, AI-BIM integration, and hotel development performance in Saudi Arabia (Saunders et al., 2023; Creswell & Creswell, 2023).

3.2 Research Philosophy:

The philosophical assumptions underpinning the collection, analysis and interpretation of the data generated by research is termed research philosophy. It also explains how knowledge is generated and clarifies the relationship between researcher, the problem being investigated and the methods chosen to study it (Saunders et al., 2023).

Therefore, a specific research philosophy should be considered to provide consistency among objectives, method and the analysis performed. It is crucial to establish one. The research philosophy applied in this study is positivist research philosophy. This research philosophy has been chosen as there is interest in investigating the relationship of Artificial Intelligence, Building Information Modelling, AI-BIM Integration and Hotel development performance.

A positivist researcher regards reality as objective, measurable and independent from the researcher that allows hypotheses to be formulated and tested on quantitative data and analyzed using inferential statistical methods (Creswell & Creswell, 2023).

Since this study employs a structured questionnaire, to collect quantitative data and applies statistical techniques to test hypothesis derived from the theoretical framework, the positivist philosophy is deemed the most appropriate research paradigm. Moreover, positivism emphasizes the structured acquisition and analysis of the quantitative data to explain causal relationship between the variables, thereby enhancing the reliability, objectivity and applicability of research findings. The primary objectives of this thesis are to statistically examine and validate the proposed conceptual framework investigating the interrelationships between AI, BIM, AI-BIM Integration and the hotel development performance. Consequently, a positivist philosophy is adopted as the most fitting epistemological framework (Saunders et al., 2023).

3.3 Research Approach:

The research approach defines how a study progresses from a theoretical framework to empirical investigation. According to Saunders et al. (2023), There are two primary research approaches namely deductive and inductive, A deductive approach starts with prior knowledge and well-researched theories and builds upon them to derive research hypotheses that need to be empirically investigated.

On the contrary, an inductive approach aims to develop new theories from data gathered from real world phenomenon (observations and qualitative data).

In this study, a deductive research approach was adopted because the primary research objective is to empirically test the conceptual framework and the hypotheses derived from the literature reviewed in Chapter Two.

The suggested relationships between AI, BIM, AI-BIM and hotel development performance based on past theoretical and empirical studies and examined using quantitative method in the form of a structured questionnaire is applied here to gather data.

The deductive approach is appropriate for quantitative research because it allows hypotheses to be objectively tested through statistical techniques and validating existing relationships through objective measurements (Creswell & Creswell, 2023).

As a result of this process, the data is analyzed by using statistics so that test results are obtained whether proposed hypotheses are support which confirm the impact of AI-BIM integration to hotel development performance in Saudi Arabia.

Therefore, the deductive approach is consistent with the positivist philosophy, research objectives, and conceptual framework and quantitative research design adopted for this study.

3.4 Research Design:

Research design refers to the overall strategy or plan that the researcher adopt to collect and measure variables and analyze the data and address the research questions and objectives. It indicates how research questions will be answered and thus determine the suitable and effective tools that collect data, which enable researchers not only to test the hypotheses but also generate useful findings (Saunders et al., 2023).

A quantitative research design was chosen because of the aim of this research. The study aims to measure specific, defined variables that have previously been identified as to their importance, and test these variables using numbers collected through a questionnaire. This methodology will allow for unbiased analysis of variables and testing of hypotheses based on objective statistical tests, where data can be statistically quantified, analyzed, and interpreted (Creswell & Creswell, 2023).

The study adopts a cross-sectional design because data are collected from respondents at a single point in time. The study adopts a cross-sectional research design since the current level of AI adoption, BIM, AI-BIM integration in the hotel development in the Saudi Arabian construction industry and their influence on hotel development performance will be studied. In addition, an explanatory research design will be utilized since the main intention of this study is to investigate the explanatory relationship between independent variables such as Artificial intelligence (AI), building information modeling (BIM), and AI-BIM integration on the performance of the hotel development in Saudi Arabia.

Data from both the questionnaire will be analyzed using statistical techniques, namely correlations and multiple regressions, so as to identify relationship between the independent variables and the hotel development. Accordingly, this research design Is aligned with testing the prosed hypotheses and exploring the interrelationships among the study variables.

3.5 Research Strategy:

Research strategy refers to the overall plan which underpins of empirical data to answer the research questions and achieve the research objectives. Research strategy has much to do with the nature of your research and the type of data you need to collected so as to be able to answer your question (Saunders et al. 2023, p. 138).

So, when seeking to establish relationship between variables that is to study in a clearly defined way and within a population that is sufficiently large, then the survey strategy “is among the most appropriate to be used. Therefore, this study makes use of the questionnaire survey to acquire the research data, this can help to generate standardized data for a large number of people that are subject to questions on the same subjects and in the same format and language, thus contributing to an increase in the data’s validity and reliability (Saunders et al. 2023, p. 140, Creswell & Creswell, 2023).

Data collection was achieved by the use of a questionnaire and that was designed for professionals that have been actively involved in hotel development projects in Saudi Arabia and specifically those who work as developers, consultants, contractors, project managers, architects, engineers and the like.

These professionals possess the practical knowledge and experience required to provide reliable empirical evidence regarding the AI and the BIM Adoption as well as their Integration the Hotel development projects. In addition, the survey strategy is considered “suitable for collecting perception based-data concerning organizational practices, adoption of new technology and project performance. (Saunders et al. 2023, p. 140).

The structured questionnaire will ensure that all respondents evaluated the study variables under same conditions and using the same measurement scale, thereby improving comparability and reliability of collected data.

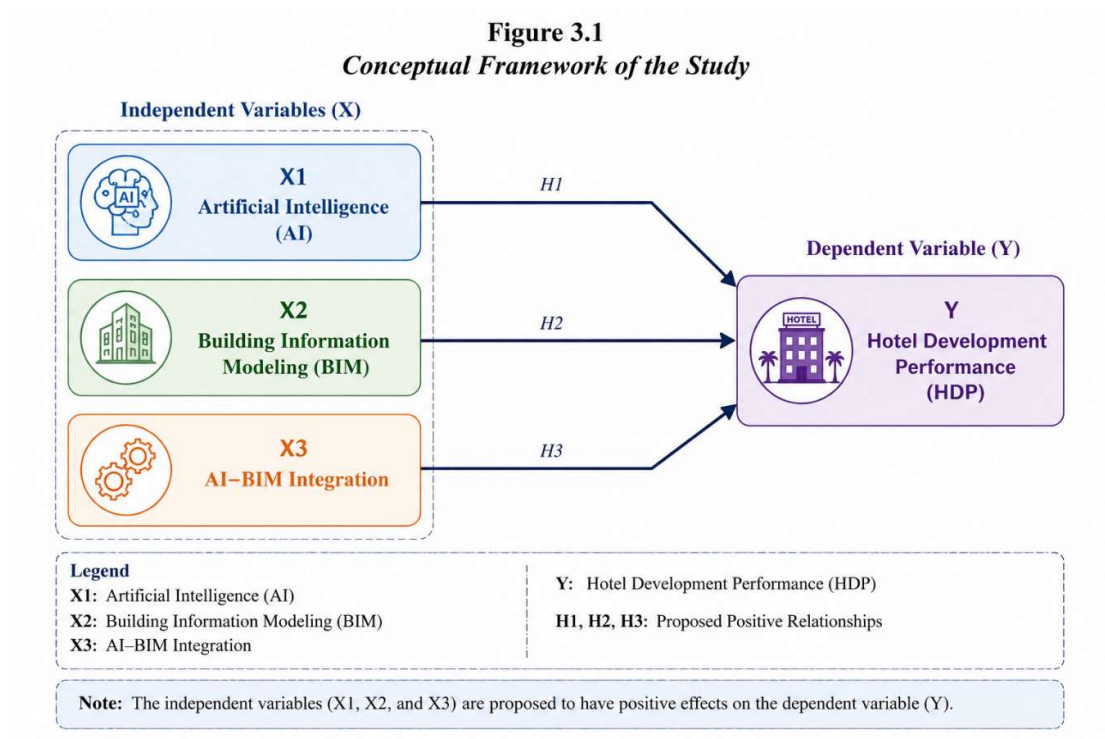
3.6 Research Conceptual Framework:

The conceptual framework provides a visual representation pf the relationships among the investigated variables in this research; based on the theoretical and empirical review of literature as discussed in chapter two. It is formulated and acts as the basis for hypotheses testing as well as conducting the empirical investigation (Creswell & Creswell, 2023).

Based on the literature reviewed, this study proposes that the Artificial Intelligence (AI), Building Information Modeling (BIM) and the Artificial Intelligence-BIM integration are the main contributing factor to the Hotel Development Performance (HDP) in Saudi Arabia.

This means the independent variables are the AI, BIM and the AI-BIM Integration, the dependent variable is the Hotel Development Performance. It provides a conceptual depiction of the way these variables influence the hotel development performance; it lays the ground to hypothesize these relations and interpret findings of the empirical study.

Figure 3.1: Conceptual Framework of the Study



3.7 Research Hypotheses:

Based on the research objectives, research questions, and the conceptual framework presented in this study, the following hypotheses are proposed:

Main Hypothesis

H1: Artificial Intelligence (AI), Building Information Modeling (BIM), and AI–BIM Integration have a statistically significant positive effect on Hotel Development Performance (HDP) in Saudi Arabia.

Sub-Hypotheses

H1a: Artificial Intelligence (AI) has a statistically significant positive effect on Hotel Development Performance (HDP).

H1b: Building Information Modeling (BIM) has a statistically significant positive effect on Hotel Development Performance (HDP).

H1c: AI–BIM Integration has a statistically significant positive effect on Hotel Development Performance (HDP).

3.8 Operationalization of Variables

Variables must be operationalized when research involves quantitative designs. It means that those conceptual definitions and meanings established through previous researches have to be converted to actual measurement which is in empirical format, in which it is used for real evidence investigation (van Driel, 2017; Saunders et al., 2023).

Based on the conceptual framework established in Chapter One and the reviewed literature mentioned in Chapter Two, there are three independent variables and one dependent variable involved in this research: Artificial Intelligence **AI (X₁)** as the independent variable 1; Building Information Modeling **BIM (X₂)** as the independent variable 2; and **AI–BIM Integration (X₃)** as the independent variable 3; the dependent variable is **Hotel Development Performance (Y)**. Implementation Challenges (**CH**) were also added as the fourth variable to identify what are the main barriers of AI-BIM implementation in Saudi Arabia.

However, it was analyzed in descriptive way and it is excluded from the hypothesis and regression analysis. All the constructs were measured with a structured questionnaire developed on the bases of valid measurement scale and items previously used in other researches and adapted to the context of hotel development in Saudi Arabia. A 5-point Likert-scale was used for responses in the questionnaire with the anchor labels: **1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree**.

Five measurement items are assigned to each construct to ensure consistent measurement of all study variables, enhance the reliability and facilitate the statical analysis.

3.8.1 Independent Variables:

Three independent variables which are the main technology dimensions expected to have impact on the development performance are also used:

Artificial Intelligence AI (X₁) refers to the extent of how Artificial Intelligence technology supports hotel market analysis, demand forecasting, site selection, feasibility studies and decision-making process regarding investment decisions in hotel development.

Building Information Modeling BIM (X₂) refers to the extent to which BIM is adopted to support multidisciplinary integration and collaboration, cost estimate, schedule management and life-cycle information management during hotel development process.

AI-BIM Integration (X₃) refers to the extent to which AI capabilities are integrated with BIM to support intelligent decision-making, risk management, cost reduction, scheduling process, predictive maintenance and asset life-cycle management in hotel development Projects.

3.8.2 Dependent Variable:

The dependent variable of this study is **Hotel Development Performance (Y)**. It measures the overall performance of hotel development projects in terms of financial performance, stakeholder satisfaction, return on investment, project delivery efficiency, and long-term operational performance.

3.8.3 Measurement of Variables:

This study adopted a multiple-item measurement approach for the variables as it measures each construct with several questionnaire items not just single items. This method strengthens measurement reliability and consistency.

This approach enables each construct represented by multiple measurement items, thereby improving construct validity and reliability. The items were adopted from relevant prior studies and were adjusted to the present research environment, hotel development project context in Saudi Arabia. **Table 3.1** presents the conceptualization of construct/measurement items used and **Table 3.2** presents operationalization construct. These tables provide the basis

for assessing the reliability and validity of the measurement model and for conducting correlation and multiple regression analyses.

Table 3.1: Operationalization Matrix of the Study Variables

Variable	Code	Type	Construct Measured	No. of Items	Measurement Scale
Artificial Intelligence	X ₁	Independent	AI adoption scope in hotel development	5	Five-point Likert Scale
Building Information Modeling	X ₂	Independent	BIM adoption depth in hotel development	5	Five-point Likert Scale
AI-BIM Integration	X ₃	Independent	Synergistic integration of AI and BIM systems	5	Five-point Likert Scale
Hotel Development Performance	Y	Dependent	Overarching hotel project performance metrics	5	Five-point Likert Scale
Implementation Challenges	CH	Descriptive	Barriers hindering AI-BIM implementation	5	Five-point Likert Scale

Table 3.2: Reference Mapping of Questionnaire Items

Variable	Code	Questionnaire Item Reference Codes
Artificial Intelligence	X ₁	AI-1, AI-2, AI-3, AI-4, AI-5
Building Information Modeling	X ₂	BIM-1, BIM-2, BIM-3, BIM-4, BIM-5
AI-BIM Integration	X ₃	INT-1, INT-2, INT-3, INT-4, INT-5
Hotel Development Performance	Y	HP-1, HP-2, HP-3, HP-4, HP-5
Implementation Challenges	CH	CH-1, CH-2, CH-3, CH-4, CH-5

3.9 Population and Sampling:

3.9.1 Target Population:

The target population refers to the entire group of people who has the required information, experience and professionals to respond appropriately to research questions (Saunders et al., 2023). In this research, the target population consist of all the professional directly engaged in hotel development projects in Saudi Arabia Kingdom as main parties and participants to various phases of hotel development projects and will give insight on the adoption and application of Artificial Intelligence (AI), Building Information Modeling (BIM), AI-BIM integration, and impact of AI-BIM on hotel development performance.

The participants in population were professional individuals from the following sectors of property developer, project management consultant, engineering consultants, architectural

and engineering design firm, contractor, hotel operator, facility management firm, government sector involved in the development of hotels.

Various professional position will be involved in the population as; Development Managers, project directors, project managers, BIM manager, construction manager, facility managers, engineers, architects and others as well related senior professionals that have direct exposure to hotel development works.

In addition, selecting professional members of different organizations and different professional functions will lead to more comprehensive representation of information from all phases of hotel development.

3.9.2 Sampling Technique:

As no comprehensive sampling frame exists for professionals involved in hotel development projects in Saudi Arabia, a non-probability purposive sampling approach was employed in this research study. Purposive sampling is typically used when participants are selected purposefully based on specific criteria and possess the knowledge and experience required or expertise to answer specific research questions (Creswell & Creswell, 2023).

Henceforth, only professionals who directly participate in hotel development projects and who are knowledgeable about digital construction activities, such as AI, BIM or related project management procedures, were contacted to take part in the survey. This approach ensured that all respondents have relevant professional experiences and are capable of providing reliable a practical response to the research questioner.

The survey questionnaire was distributed through multiple professional channels, including LinkedIn professional networks, WhatsApp groups dedicated to engineering and construction professionals, personal and professional contacts, engineering consultancy firms, property development companies, project management organizations, contractor companies, hotel operating companies, facility management organizations, and professional industry associations.

3.9.3 Sample Size:

One of the important steps in quantitative research study is to have sufficient sample size to ascertain reliability and statistical significance of results. For an appropriate sample size, the

study must have a sufficient size that allow multivariate statistical analyses to be employed, and to be able to estimate parameters stably (Hair et al. 2022).

Furthermore, the quantitative research must generate a sufficient number of valid respondents to enable testing of hypotheses and enhance the generalizability of the findings to the defined population (Saunders et al. 2023).

This study achieved the collection of 137 valid questionnaire responses from those who participate in hotel development project in Saudi Arabia. This sample size is considered adequate for undertaking analysis, namely descriptive statistics, reliability analysis, validity, correlation and regression analyses using IBM SPSS Statistics.

This sample size includes respondents from a diverse range of organizations and professional disciplines that take part in the hotel development industry, Therefore, the achieved sample size was considered sufficient to provide statistically reliable results and to support the empirical examination of the proposed research hypotheses.

3.10 Research Instrument (Questionnaire):

The primary data collection instrument for this study was a structured questionnaire developed to generate empirical data in order to test the research hypotheses and proposed conceptual framework. The research questionnaire was developed after thorough literature review on the existing theoretical and empirical research concerning Artificial Intelligence (AI), Building Information Modeling (BIM), AI-BIM Integration and Hotel Development Performance. The questionnaire items were adapted from previously validated measurement scales to best suit the context of hotel development projects in **Saudi Arabia** while the semantic meaning was retained.

The questionnaire has been divided into six sections, in logical order for the purpose of ease in response. The first section includes demographic data such as position of respondents, years of work experience, working in hotel development projects, AI awareness, BIM awareness.

The remaining sections measured the four main research constructs and an additional section addressing implementation challenges, namely artificial intelligence (X_1), building information modeling (X_2), AI-BIM Integration (X_3), hotel development performance (Y) and implementation challenges (CH). The five constructs each contain five items, which

aimed at representing different dimensions of their respective constructs. All questions used in this research were framed in a relatively simple language so as to reflect common practice of hotel development project professionals. To increase clarity and reduce potential inconsistency of responses, statements in the questionnaire were expressed concisely in an easy-to-understand format.

The complete questionnaire used for data collection is provided in **Appendix A**.

3.11 Content Validity and Reliability:

Prior to data collection, a questionnaire was reviewed with an academic experts and several professional industry personnel whose backgrounds, expertise and research interests covered hotel development, artificial intelligence (AI), building information modeling (BIM), project management, research methods, and hotel operations and management.

These panel members reviewed each question and made recommendations regarding content validity, relevance, clarity, intelligibility and appropriateness for use in Saudi Arabian hotel development projects. The pilot test provided a valuable input for refining and re-wording the questionnaire prior to distribution to participants. After data collection the reliability of the research instrument was analyzed using the Cronbach's alpha coefficient (IBM SPSS Statistics) (Field, 2024).

Cronbach's alpha analysis was undertaken to examine the internal consistency of scale measures included under each research variable. Full details of reliability analyses are presented in chapter Four.

3.12 Data Collection Procedure:

Following the completion of the questionnaire validation process, the final questionnaire was developed using **Google Forms** and distributed electronically through the selected purposive sampling approach. The survey was circulated via LinkedIn professional networks, WhatsApp engineering and construction groups, personal and professional contacts, and organizations involved in hotel development projects across Saudi Arabia. Participation in the survey was voluntary, and respondents were informed that all information would be treated confidentially and used solely for academic research purposes. The data collection process continued until a sufficient number of valid responses was obtained. A total of **137 valid questionnaires** were collected and considered suitable for statistical analysis.

3.13 Data Analysis Techniques:

The collected data were coded, screened, and analyzed using IBM SPSS Statistics (Version 29). Initially, data screening was conducted to identify incomplete responses, coding errors, and missing values before proceeding with the statistical analysis (Field, 2024).

Descriptive statistics were then used to summarize the demographic characteristics of the respondents and provide an overview of the study variables. The internal consistency of the measurement scales was evaluated using Cronbach's Alpha coefficient.

Pearson correlation analysis was performed to examine the relationships among the study variables, while multiple regression analysis was employed to assess the effect of the independent variables on Hotel Development Performance and to test the proposed research hypotheses. The results of these analyses are presented and discussed in Chapter Four.

Table 3.3: Summary of Statistical Analysis Techniques and Their Purposes

Analysis Technique	Purpose
Data Screening	To prepare and clean the dataset (handling missing values, coding errors, and outliers) before analysis.
Descriptive Statistics	To summarize respondents' demographic characteristics and provide an overview of the study variables.
Reliability Analysis	To evaluate the internal consistency of the measurement scales using Cronbach's Alpha coefficient.
Correlation Analysis	To examine the direction and strength of the linear relationships among the study variables.
Multiple Regression Analysis	To examine the effects of AI, BIM, and AI–BIM Integration on Hotel Development Performance.
Hypothesis Testing	To determine whether the proposed research hypotheses are statistically supported or rejected.

3.14 Ethical Considerations:

This study was conducted within the guidelines of acceptable ethical standards for academic research. Completion of the questionnaire was on a voluntary basis. All participants were made aware of the purpose of the study prior to completion of the questionnaire. Participants were also made aware of their voluntary participation in the study and that they had the right to refuse or withdraw from the study at any time and without prejudice (British Educational Research Association [BERA], 2024).

The researcher made every effort to safeguard the confidentiality and anonymity of the participants and no personally identifiable information was gathered. The data gathered has been solely used for the purposes of academic research and was stored securely with restricted access. All findings were reported as aggregate only and no participant, or institution, should be able to be identified (BERA, 2024).

3.15 Chapter Summary:

This chapter illustrated the research approach which has been taken for conducting the study, in order to meet the aims of the research as well as to investigate the hypothesized relationship between the relevant research constructs research constructs presented in **Chapter Two**. This chapter first defined the research philosophy, approach, design, and the strategy to be adopted for the study, which has been followed by a conceptual frame work and the proposed hypotheses. Then research design and its operational aspects, i.e., research variable operationalization, target population, sampling techniques, sampling size, questionnaire, were presented. The instrument designed for data collection for this research has also been discussed in this chapter with detailed methodological explanations.

Moreover, the chapter discussed the process of questionnaire validation and collection, ethics issues to be followed, and the procedures applied in the data analysis. Specifically, chapter has explained different quantitative analysis methods which were used to investigate the data, including screening, descriptive statistics, and inferential statistics; i.e. Reliability analysis, correlation, multiple regression analysis, and testing hypotheses, respectively. Finally, this Chapter established a sound methodological framework for studying the influence of Artificial Intelligence (AI), Building Information Modeling (BIM), and AI–BIM Integration on Hotel Development Performance in Saudi Arabia.

The following chapter is providing the results derived from the field survey and discusses on those statistical analyses in relation to the hypothesized models.

CHAPTER FOUR -DATA ANALYSIS AND RESULTS

4.1 Introduction:

This chapter presents the empirical findings of the study based on the quantitative data collected from professionals involved in hotel development projects across the Kingdom of Saudi Arabia. Following the research methodology described in Chapter Three, the collected questionnaire data were analyzed using IBM SPSS Statistics to examine the relationships between Artificial Intelligence (AI), Building Information Modeling (BIM), AI-BIM Integration, and Hotel Development Performance (HDP).

The statistical analysis aims to address the research objectives and answer the research questions by evaluating the level of AI and BIM adoption, the extent of AI-BIM Integration, and their influence on hotel development performance. In addition, the analysis identifies the implementation challenges associated with AI-BIM adoption and provides the empirical evidence required for developing the proposed National AI-BIM Framework presented in Chapter Five.

The chapter begins with respondents' demographic profiles, followed by descriptive statistics of the study variables. Reliability analysis is then performed to assess the internal consistency of the measurement scales. Subsequently, Pearson correlation analysis is conducted to examine the relationships among the study variables, followed by multiple regression analysis to evaluate the proposed hypotheses and determine the relative contribution of AI, BIM, and AI-BIM Integration to Hotel Development Performance. Finally, the chapter concludes with a summary of the key statistical findings that provide the empirical foundation for the discussion and framework development presented in the following chapter

4.2 Demographic Profile of Respondents:

A descriptive statistical analysis was conducted using IBM SPSS Statistics (Version 29) to examine the demographic characteristics of the respondents. A total of 137 valid responses were included in the analysis. The demographic variables comprised respondents' current position, years of professional experience, involvement in hotel development projects, level of Artificial Intelligence (AI) knowledge, and Building Information Modeling (BIM) experience. The results are presented in Tables 4.1 to 4.5.

Table 4.1: Current Position of Respondents (N = 137)

Position	Frequency	Percentage (%)
Consultant / PMC	22	16.1
Project Manager	21	15.3
Architect	14	10.2
Project Director	13	9.5
Contractor	11	8.0
Construction Manager	10	7.3
Facility Manager	9	6.6
Design Manager	8	5.8
BIM Manager	7	5.1
Hotel Development Director	6	4.4
Others	16	11.7
Total	137	100.0

Interpretation: Table 4.1 indicates that the respondents represented a broad spectrum of professional disciplines involved in hotel development projects. The largest group comprised Consultants/PMCs (16.1%), followed by Project Managers (15.3%), Architects (10.2%), and Project Directors (9.5%). This distribution demonstrates that the survey captured the perspectives of experienced professionals occupying key decision-making and technical roles throughout the hotel development lifecycle.

Table 4.2: Years of Professional Experience (N = 137)

Experience	Frequency	Percentage (%)
Less than 5 years	9	6.6
5–10 years	45	32.8
More than 15 years	83	60.6
Total	137	100.0

Interpretation: As shown in Table 4.2, the majority of respondents (60.6%) possessed more than 15 years of professional experience, while 32.8% had between 5 and 10 years of experience. Only 6.6% reported less than five years of experience. These findings indicate that the survey responses were predominantly obtained from highly experienced professionals, thereby enhancing the credibility of the empirical findings.

Table 4.3: Involvement in Hotel Development Projects (N = 137)

Response	Frequency	Percentage (%)
Yes	131	95.6
No	6	4.4
Total	137	100.0

Interpretation: Table 4.3 shows that 95.6% of the respondents had direct involvement in hotel development projects, confirming that the sample was highly relevant to the objectives of this study. Only 4.4% reported no direct involvement in hotel development projects.

Table 4.4: Knowledge of Artificial Intelligence (N = 137)

Level	Frequency	Percentage (%)
Basic	22	16.1
Intermediate	41	29.9
Advanced	52	38.0
Expert	22	16.1
Total	137	100.0

Interpretation: The results indicate that the respondents generally possessed a good level of knowledge of Artificial Intelligence. More than half of the respondents (54.1%) reported either Advanced or Expert knowledge, while only 16.1% indicated a basic level of AI knowledge.

Table 4.5: BIM Experience (N = 137)

Level	Frequency	Percentage (%)
Basic	37	27.0
Intermediate	30	21.9
Advanced	40	29.2
Expert	30	21.9
Total	137	100.0

Interpretation: Table 4.5 demonstrates that the respondents had substantial experience in Building Information Modeling. Approximately 51.1% reported Advanced or Expert BIM experience, indicating that the respondents possessed the professional competence required to evaluate BIM adoption and AI-BIM integration within hotel development projects.

4.3 Descriptive Analysis:

Descriptive statistical analysis using IBM SPSS Statistics (Version 29) was employed in describing and summarizing the gathered data by outlining the respondents' perspectives. These descriptive statistical procedures typically present summary measures (i.e. Measures of central tendency and measures of dispersion), which help in exploring the respondents' perception of the study variables prior to inferential statistical analysis (Field, 2024; Hair et al., 2022).

The mean (M) and standard deviation (SD) for all questionnaire items and for each of the study constructs were obtained in the descriptive analysis. The mean was utilized to assess the degree of respondents' level of agreement towards the statements of the questionnaire (which is measured on a five-point Likert scale, 1 = Strongly Disagree to 5 = Strongly Agree). The standard deviation (SD) was used to assess the variability of respondents' responses around the mean of the individuals are in relation to the mean score. Higher means typically imply greater levels of level of agreement, and lower SD indicates greater consistencies in individual responses (Field, 2024). For easier reference, the calculated means were categorized into five categories in Table 4.6

Table 4.6 *Interpretation of Mean Scores*

Mean Score	Interpretation
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.00	Very High

Source: Adapted from Field (2024).

The descriptive analysis begins by examining respondents' perceptions of Artificial Intelligence (AI) implementation in hotel development projects. Table 4.7 presents the descriptive statistics for the five AI measurement items, including the mean, standard deviation, rank, and interpretation.

Table 4.7 *Descriptive Statistics for Artificial Intelligence (AI) (N = 137)*

Code	Measurement Item	Mean	SD	Rank	Interpretation
AI4	AI improves hotel feasibility studies.	4.161	0.769	1	High
AI2	AI enables more reliable demand forecasting during hotel development planning.	4.117	0.697	2	High
AI1	AI enhances hotel development market analysis.	4.044	0.803	3	High
AI5	AI improves revenue prediction, cost estimation, and investment risk assessment.	3.985	0.767	4	High
AI3	AI supports better hotel site selection decisions.	3.774	0.955	5	High
Overall	Artificial Intelligence (AI)	4.016	0.632	-	High

Source: IBM SPSS Statistics Version 29.

Interpretation

The descriptive statistics presented in Table 4.7 indicate that respondents expressed a high level of agreement regarding the application of Artificial Intelligence in hotel development project (HDP), with an overall mean score of 4.016 (SD = 0.632). This finding indicates that professionals involved in hotel development acknowledge that Artificial Intelligence as a valuable technology capable of supporting strategic and operational decision-making throughout the project development lifecycle.

Regarding the five measurement items, AI4 (use of Artificial Intelligence in enhancing hotel feasibility studies reported the highest mean score (M=4.161) indicating that participants strongly agree on the capacity of AI to strengthen the evaluation of investment feasibility and facilitate more effective development decision-making. In turn, AI2 recorded the second-highest mean score (M=4.117) indicating strong agreement to the role of AI in improving accuracy in forecasting market demand and planning during the early stage of hotel development.

The other items attained relatively high mean scores as well. The item pertaining to AI for marketing analysis, namely AI1, got the second highest mean value of (M= 4.044), followed by AI5 which focused on forecasting revenues and cost estimation, and investment risk

assessment (M= 3.985). The findings indicate that participants consider AI to be a strategic tool in market analysis to evaluate investment opportunities more effectively and minimize risks of hotel development.

Similarly, AI3 which aims to measure the application of AI in hotel site selection achieved the lowest mean score (M=3.774), yet it still falls under the high level of interpretation, which implies that the participants recognize the value of AI in hotel site selection, yet still find its current use less widely implemented than its use in feasibility analysis and market forecasting.

Overall, the results illustrate that AI is considered to be a valuable digital technology capable of improving market intelligence, investment analysis, planning accuracy, and strategic decision-making within hotel development projects (HDP) in KSA. These findings align with the literature reviewed in Chapter Two, which identified AI as a key enabler of digital transformation and data-driven decision-making in the Hotel Development.

The second research construct examined in this study is Building Information Modeling (BIM). Table 4.8 presents the descriptive statistics for the five BIM measurement items. The table reports the mean, standard deviation, ranking, and interpretation of each item based on the responses of the 137 participants.

Table 4.8 *Descriptive Statistics for Building Information Modeling (BIM) (N = 137)*

Code	Measurement Item	Mean	SD	Rank	Interpretation
BIM1	BIM enhances multidisciplinary coordination and collaboration among project stakeholders.	4.387	0.788	1	Very High
BIM3	BIM improves quantity take-off and cost estimation during hotel development.	4.328	0.796	2	Very High
BIM2	BIM supports facility management and lifecycle information management.	4.248	0.784	3	Very High
BIM4	BIM facilitates project information sharing and communication among project participants.	4.197	0.812	4	High
BIM5	BIM improves project planning, scheduling, and progress monitoring.	4.182	0.806	5	High
Overall	Building Information Modeling (BIM)	4.269	0.644	-	Very High

Source: IBM SPSS Statistics Version 29.

Interpretation

Table 4.8 illustrate that there is a very high level of agreement about the contribution of BIM in hotel development projects (HDP) among all participants. This construct recorded evaluated in this study the highest overall mean score among all variables ($M=4.269$, $SD=0.644$) and indicating the perception that BIM serves as a key digital backbone of a hotel projects. BIM1 recorded the highest mean score ($M=4.387$), which measures the use of BIM to improve the multidisciplinary collaboration among the project stakeholders, also highlights the ability of BIM to integrate multiple disciplines (architectural, structural, mechanical, electrical, and plumbing) into a unified integrated digital environment.

BIM3 recorded the second – highest mean score ($M = 4.328$) which indicated a high level of agreement about BIM capability in accurate quantity take-off and cost estimation. BIM has an effective support to deliver more accurate quantity take-offs and more reliable cost estimate during the lifecycle of hotel projects. BIM2 had a high agreement score of) $M=4.248$ (These scores supported BIM's usefulness in terms of facilitating facility and information management throughout the post – construction operational phase.

Although BIM4 ($M = 4.197$) and BIM5 ($M = 4.182$) recorded the lowest mean score among BIM measurement items. However, both items remained within high level agreement group. These findings indicate that respondents recognize the role of BIM in supporting communication, sharing of information, project planning, scheduling, project monitoring and on-site progress tracking.

In conclusion the descriptive findings show that BIM is perceived as a digital technology which is well-established and understood when implemented in the hotel development projects of Saudi Arabia. BIM recorded the highest overall mean score among all-study variables reflecting respondents' perceptions that it enhanced project integration, information management, cost control and improved project delivery performance These findings are consistent with the literature reviewed in Chapter Two, that BIM provides a common digital platform for collaborative project delivery throughout the project and asset lifecycle, as outlined in Chapter Two.

The third construct examined in this study is AI–BIM Integration (INT), which represents the combined application of AI and BIM to support intelligent and dynamic decision-making throughout the hotel development lifecycle. The descriptive statistics for this construct are presented in Table 4.9.

Table 4.9 *Descriptive Statistics for AI–BIM Integration (N = 137)*

Code	Measurement Item	Mean	SD	Rank	Interpretation
INT3	AI–BIM Integration improves cost estimation and cost management.	4.102	0.789	1	High
INT5	AI–BIM Integration enhances facility operation and asset lifecycle management.	4.095	0.775	2	High
INT4	AI–BIM Integration improves project scheduling and delay prediction.	4.066	0.709	3	High
INT1	AI–BIM Integration supports intelligent decision-making throughout hotel development.	4.044	0.794	4	High
INT2	AI–BIM Integration improves project risk identification and mitigation.	4.022	0.809	5	High
Overall	AI–BIM Integration	4.066	0.617	-	High

Source: IBM SPSS Statistics Version 29

Interpretation

Table 4.9 indicates that respondents demonstrated a high level of agreement concerning the AI–BIM Integration (INT) in hotel development projects with an overall mean score of (M=4.066) and overall standard deviation of (SD = 0.617). The relatively low standard deviation indicates a high level of consensus among respondents regarding the perceived benefits of AI-BIM Integration. Among the five measurement items, INT3 showed the highest mean (M=4.102). The finding suggests that AI-BIM Integration is especially helpful for optimizing cost estimation and cost control. This result indicates that by integrating AI’s analytical capabilities with BIM’s structured digital information can enhance financial planning and cost control throughout the project lifecycle.

The second high scored item is INT5 (M=4.095), indicating a high level of agreement that the adoption of AI-BIM Integration would generate positive impacts for facility operations and lifecycle asset management following project completion. This result indicates that AI-BIM Integration extends its benefits beyond the construction phase into the operational and asset management stages.

The other AI–BIM integration items also have relatively high levels of agreement. INT4 (M=4.066) indicates that AI–BIM integration is effective in enhancing project scheduling and forecasting potential project delays, whereas INT1 (M=4.044) indicates the effectiveness

of AI – BIM integration in enhancing intelligent decision-making throughout the hotel development lifecycle. In comparison, although INT2 (M=4.022) recorded the lowest mean score, it remained within the high agreement category suggesting that respondents perceive that AI-BIM Integration can enable project risk identification and assessment and mitigation strategies.

From the overall analysis, it can be summarized that the Saudi hotel development practitioners recognize AI-BIM Integration as an emerging digital approach for improving performance in hotel development performance (HDP) by supporting intelligent & dynamic decision-making, prediction, cost analysis, scheduling, and lifecycle asset management. Furthermore, the consistently high mean scores across all AI-BIM integration items are consistent with the literature reviewed in Chapter Two, which emphasizes that integrating AI's analytical capabilities with BIM's structured digital information enhances decision-making, cost management, project scheduling, risk management, and lifecycle asset management throughout hotel development projects.

4.4 Reliability Analysis:

The internal consistency of the measurement items utilized in the current study was analyzed with IBM SPSS Statistics (Version 29). Internal consistency refers to the extent to which the items measuring the same construct produce consistent results. Cronbach's Alpha(α) is the most widely used measure of internal consistency, where values of 0.70 and over will demonstrate the items have acceptable reliability, values between 0.80 and 0.89 indicate good reliability and values of 0.90 or higher indicate excellent reliability (Field, 2024; Hair et al., 2022).

Table 4.12 presents the Cronbach's Alpha (α) coefficients for the five research constructs and the overall research instrument.

Table 4.10 *Reliability Analysis of the Research Constructs (N = 137)*

Construct	Number of Items	Cronbach's Alpha(α)	Reliability Level
Artificial Intelligence (AI)	5	0.846	Good
Building Information Modeling (BIM)	5	0.867	Good
AI-BIM Integration	5	0.855	Good
Hotel Development Performance (HDP)	5	0.846	Good
Implementation Challenges (CH)	5	0.746	Acceptable
Overall Questionnaire	25	0.940	Excellent

Source: IBM SPSS Statistics Version 29.

Interpretation

The reliability analysis presented in Table 4.12 indicates that the all the research constructs have acceptable level of internal consistency. The Cronbach's Alpha (α) value obtained for each construct is ranged between 0.746 and 0.867. These values are above the established cut-off value of 0.70 recommended by Field (2024) and Hair et al. (2022). Hence the measurement items reliably measured the variables under study and thus were deemed suitable for further statistical analysis.

The construct of BIM recorded the highest Cronbach's Alpha value among the 5 constructs with ($\alpha = 0.867$), indicating the highest level of internal consistency among its measurement items, suggesting that professional participants demonstrated consistent perceptions regarding the various elements related to BIM adoption in hotel development projects. The AI-BIM Integration ($\alpha = 0.855$), AI ($\alpha = 0.846$), and HDP ($\alpha = 0.846$) constructs all revealed high reliabilities indicating that the items included in the constructs provided reliable measures of their respective constructs.

The Cronbach's Alpha (α) value for the Implementation Challenges (CH) construct was ($\alpha = 0.746$) which was lower than those of the other research constructs, however the alpha coefficient for this scale is over the accepted minimum alpha value of ($\alpha = 0.70$) and indicates acceptable internal consistency. This relatively lower coefficient may have been influenced by the fact that it reflects multiple dimensions of organizational, technical, and financial, and governmental challenges encompasses several conceptually distinct categories of implementation barriers.

In conclusion, the research instrument recorded an overall Cronbach's Alpha (α) coefficient of ($\alpha=0.940$) an excellent internal consistency of overall internal consistency among the twenty-five measurement items. With this satisfactory outcome, the questionnaire was considered suitable for subsequent statistical analyses such as correlation analysis, multiple regression analysis and tests of hypotheses.

4.5 Correlation Analysis:

The relationships among the study variables were examined using correlation analysis in IBM SPSS Statistics (Version 29). The strength and direction of linear relationships were investigated using the Pearson's (r) correlation coefficient because composite scores were calculated for each construct from multiple five-point Likert-scale items, allowing the variables to be treated as continuous variables for statistical analysis.

Pearson's correlation analysis is commonly employed as a preliminary statistical technique before conducting multiple regression analysis and hypothesis testing (Field, 2024; Hair et al., 2022).

The correlation coefficient (r) ranges from -1 to $+1$, where positive values indicate a positive relationship between variables, negative values indicate an inverse relationship, and values closer to zero indicate weaker relationships. The statistical significance of the relationships was evaluated at the 0.01 significance level (two-tailed).

Table 4.11

Pearson Correlation Matrix of the Study Variables (N = 137)

Variables	AI	BIM	INT	HDP	CH
Artificial Intelligence (AI)	1.000				
Building Information Modeling (BIM)	0.614**	1.000			
AI-BIM Integration (INT)	0.707**	0.789**	1.000		
Hotel Development Performance (HDP)	0.581**	0.585**	0.741**	1.000	
Implementation Challenges (CH)	0.527**	0.450**	0.526**	0.516**	1.000

Note: Correlation is significant at the 0.01 level (2-tailed).

Source: IBM SPSS Statistics Version 29.

Interpretation

The results of Pearson's correlation coefficients for the five research constructs are presented in Table 4.13. It can be observed that all correlation coefficients are positive and significant at 0.01 level which means there are statistically significant positive relationships among the research constructs.

Building Information Modeling (BIM) had the highest positive relationship with the AI-BIM Integration ($r=0.789$, $p<0.001$). This implies a high and significant positive correlation, meaning that when as the level of BIM adoption increases, there is higher levels of BIM adoption are associated with higher levels of AI-BIM integration used in hotel development projects.

This outcome aligns with the research framework for this research, that BIM creates the digital information environment that enables the effective integration of AI technologies.

Similarly, the results indicate that AI-BIM Integration showed a strong positive correlation with Hotel Development Performance ($r=0.741$, $p<0.001$), which recorded the highest correlation coefficient to the dependent variable. This indicates that the higher AI-BIM Integration, the higher performance of Hotel Development can be expected and suggesting a strong positive association between the variables.

Artificial Intelligence also exhibited significant positive correlations with AI-BIM Integration ($r = 0.707$, $p < 0.001$) and Building Information Modeling ($r = 0.614$, $p < 0.001$). These results suggest that participants who reported higher levels of AI adoption also tended to report higher levels of BIM adoption and higher levels of AI-BIM integration.

Hotel Development Performance exhibited moderate positive correlations artificial intelligence ($r=0.581$, $p<0.001$) and building information modeling ($r=0.585$, $p<0.001$), suggesting improvement in any of these technological factors.

Implementation Challenges were also found to have significant and positive correlations with all study variables ($r = 0.450$ to $r = 0.527$). Whilst these correlations are considered moderate, they indicate a tendency that those respondents with higher awareness and adoption levels of digital technologies were also reported higher levels of awareness of the practical challenges in adoption of AI and BIM technologies.

Summary the overall correlation analysis reveals moderate to strong positive correlations Between the independent variables and the Hotel Development Performance, as well as initial evidence providing preliminary support for the proposed research hypotheses.

Additionally, none of the correlation coefficients was greater than 0.90, suggesting that multicollinearity is unlikely to be a concern and the study variables were considered suitable for subsequent multiple regression analysis (Hair et al., 2022).

4.6 Multiple Regression Analysis:

The multiple linear regression was performed with IBM SPSS Statistics (Version 29) to assess the combined effect of the three independent variables of Artificial Intelligence (AI), Building Information Modeling (BIM) and AI-BIM Integration (INT) on the dependent variable of Hotel Development Performance (HDP). This analysis determines the extent to which each independent variable uniquely explains the variation in Hotel Development Performance while controlling for the influence of the remaining independent variables (Field, 2024; Hair et al., 2022).

The regression model was evaluated using the coefficient of determination (R^2), the overall model significance (ANOVA F-test), and the standardized regression coefficients (Beta) together with their statistical significance levels.

Table 4.12: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.745	0.555	0.545	0.412

Source: IBM SPSS Statistics Version 29.

According to Table 4.14, 55.5% of the variance in Hotel Development Performance can be explained by the regression model ($R^2 = 0.555$). For instance, adjusted $R^2 = 0.545$ revealed that even after adjustment for number of predictors, Hotels Development Performance (HDP) was collectively explained by AI, BIM, and AI-BIM Integration accounted for 54.5% of the variance of hotel development performance. This level of explanatory power is considered acceptable in behavioral, technology adoption, and management research, where multiple factors commonly influence organizational performance (Hair et al., 2022).

Table 4.13: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	28.174	3	9.391	55.330	.000
Residual	22.573	133	0.170		
Total	50.747	136			

Source: IBM SPSS Statistics Version 29.

The outcome of the ANOVA (Table 4.15) indicates that the overall regression model is highly statistically significant ($F = 55.330$, $p < 0.001$). The fact that all the three independent variables together are effective predictors of Hotel Development Performance (HDP) confirms that the overall regression model is appropriate for testing conceptual hypotheses set out in this research.

Table 4.14: Regression Coefficients

Predictor	Unstandardized B	Std. Error	t	Sig.
(Constant)	0.952	0.260	3.660	.000
Artificial Intelligence (AI)	0.114	0.080	1.424	.157
Building Information Modeling (BIM)	-0.015	0.090	-0.162	.871
AI-BIM Integration (INT)	0.662	0.105	6.315	.000

Source: IBM SPSS Statistics Version 29.

Table 4.16 presents the regression coefficients of the multiple regression analysis, the findings indicate that AI-BIM Integration is the only statistically significant predictor of Hotel Development Performance (HDP) ($B = 0.662$, $t = 6.315$, $p < 0.001$). This finding suggests that higher levels of AI-BIM Integration are associated with significant improvements in Hotel Development Performance. Furthermore, this positive effect remains significant after controlling for the independent effects of Artificial Intelligence (AI) and

Building Information Modeling (BIM), highlighting AI–BIM Integration as the strongest predictor in the regression model.

In contrast, Artificial Intelligence (AI) did not demonstrate a statistically significant independent effect on Hotel Development Performance (HDP) ($p = 0.157$). Similarly, Building Information Modeling (BIM) did not make a statistically significant independent contribution ($p = 0.871$) after controlling for AI–BIM Integration in the regression model. These findings suggest that although AI and BIM may each be associated with Hotel Development Performance, their individual effects are not statistically significant when AI–BIM Integration is included in the model. This indicates that the benefits of AI and BIM are primarily realized through their integration, rather than through the independent adoption of either technology, as evidenced by the non-significant individual effects of AI and BIM after AI–BIM Integration was included in the regression model.

4.7 Multicollinearity Diagnostics:

Before interpreting the results of the multiple regression analysis, the assumption of multicollinearity among the independent variables was examined using IBM SPSS Statistics (Version 29). Multicollinearity occurs when two or more independent variables are highly correlated, which may affect the stability and interpretation of the regression coefficients. The assessment was performed using Tolerance and the Variance Inflation Factor (VIF). According to Hair et al. (2022), tolerance values greater than 0.20 and VIF values below 5.00 indicate that multicollinearity is not a serious concern. Similarly, Field (2024) suggests that VIF values substantially below 10.00 indicate that the regression model satisfies the multicollinearity assumption.

The results of the multicollinearity diagnostics are presented in Table 4.17.

Table 4.15 *Multicollinearity Diagnostics (N = 137)*

Predictor	Tolerance	VIF	Interpretation
Artificial Intelligence (AI)	0.492	2.033	No multicollinearity
Building Information Modeling (BIM)	0.371	2.698	No multicollinearity
AI–BIM Integration	0.297	3.362	No multicollinearity

Source: IBM SPSS Statistics Version 29.

Interpretation

The multicollinearity diagnostics presented in Table 4.17 indicate that the regression model satisfies the assumption of independence among the predictor variables. The tolerance values ranged from 0.297 to 0.492, all of which are above the recommended minimum threshold of 0.20. Likewise, the VIF values ranged from 2.033 to 3.362, remaining well below the recommended maximum value of 5.00.

Among the independent variables, AI–BIM Integration recorded the highest VIF value (3.362), reflecting its expected association with both Artificial Intelligence and Building Information Modeling. However, this value remains substantially below the accepted threshold and therefore does not indicate problematic multicollinearity.

Overall, these findings confirm that the three independent variables measure related but distinct constructs and do not exhibit excessive intercorrelation. Consequently, the regression coefficients reported in the previous section can be interpreted with confidence, and the regression model is considered statistically robust and suitable for hypothesis testing.

4.7 Hypotheses Testing:

The research hypotheses were tested using the results of the multiple regression analysis conducted in IBM SPSS Statistics (Version 29). The overall significance of the regression model was assessed using the ANOVA F-test, while the individual sub-hypotheses were evaluated using the standardized regression coefficients, t-values, and significance levels. A hypothesis was supported when the relationship was positive and statistically significant at $p < 0.05$ (Field, 2024; Hair et al., 2022).

Table 4.16 *Summary of Hypothesis Testing*

Hypothesis	Statistical Result	Decision
H1: AI, BIM, and AI–BIM Integration have a statistically significant positive effect on HDP in Saudi Arabia.	$R^2 = 0.555$; Adjusted $R^2 = 0.545$; $F(3,133) = 55.328$; $p < 0.001$	Supported
H1a: AI has a statistically significant positive effect on HDP.	$\beta = 0.117$; $t = 1.424$; $p = 0.157$	Not supported
H1b: BIM has a statistically significant positive effect on HDP.	$\beta = -0.015$; $t = -0.162$; $p = 0.871$	Not supported
H1c: AI–BIM Integration has a statistically significant positive effect on HDP.	$\beta = 0.670$; $t = 6.315$; $p < 0.001$	Supported

Source: IBM SPSS Statistics Version 29

The research hypotheses were tested using the results of the multiple regression conducted using IBM SPSS Statistics (Version 29). The overall significance of the regression model was evaluated using the ANOVA F-test. The sub-hypotheses were assessed with use of the standardized regression coefficients, t-values, and significance levels. The hypotheses were considered supported when a statistically significant, positive relationship was demonstrated with a significance of $p < 0.05$ (Field, 2024; Hair et al., 2022).

The results presented in Table 4.18 show that the overall regression model was statistically significant, $F(3,133) = 55.328$, $p < 0.001$, and explained approximately 55.5% of the variance in Hotel Development Performance. Therefore, the main hypothesis H1 was supported, indicating that the three predictors collectively provide a statistically significant explanation of Hotel Development Performance in Saudi Arabia.

However, the results for the individual predictors differed. Artificial Intelligence recorded a positive standardized coefficient ($\beta = 0.117$), but its effect was not statistically significant ($p = 0.157$). Accordingly, H1a was not supported. This result does not mean that AI has no relationship with hotel development performance; rather, its unique contribution became statistically insignificant after controlling for BIM and AI–BIM Integration.

Building Information Modeling recorded a small negative standardized coefficient ($\beta = -0.015$) and was not statistically significant ($p = 0.871$). Therefore, H1b was not supported. The negative coefficient should not be interpreted as evidence that BIM reduces performance. BIM had a positive bivariate correlation with HDP, but it did not provide a significant unique contribution after the shared variance with AI–BIM Integration was taken into account.

In contrast, AI–BIM Integration demonstrated a strong positive and statistically significant effect on Hotel Development Performance ($\beta = 0.670$, $t = 6.315$, $p < 0.001$). Consequently, H1c was supported. This indicates that AI–BIM Integration was the strongest and only significant independent predictor in the regression model.

Overall, the hypothesis-testing results provide strong empirical support for the central argument of this study: the principal performance benefits are associated with the integrated application of Artificial Intelligence and Building Information Modeling rather than with their isolated adoption. These findings support the development of the proposed National AI–BIM Framework for hotel development projects in Saudi Arabia.

4.8 Chapter Summary:

This chapter presented the findings of the investigation into the relationships between Artificial Intelligence (AI), Building Information Modeling (BIM), AI-BIM Integration, and Hotel Development Performance (HDP) based on data collected from 137 professionals working on hotel development project life cycle in Saudi Arabia.

Chapter Four presented the descriptive statistics, reliability analysis, Pearson correlation analysis, multiple regression analysis and hypothesis testing which provided evidence addressing the research objectives and testing the research hypotheses. The descriptive statistics highlighted that respondents agreed on the use of AI, BIM, AI-BIM Integration, and HDP.

Among the three independent variables, Building Information Modeling (BIM) yielded the highest average overall mean score as it was most widely viewed as the digital foundation of communication for multi-discipline collaboration and information management. AI-BIM Integration had the next highest average score indicating a positive perception of AI-BIM Integration for smarter decision-making, project management coordination, scheduling, cost management and life cycle asset management.

Reliability of the measurement scales used in this study revealed that all scales demonstrated acceptable to good internal consistency which suggested the questionnaire can be trusted as a reliable tool to measure the study variables.

The Pearson correlation analysis indicated moderate to strong positive relationships exist between AI, BIM, AI-BIM Integration and Hotel Development Performance. Also, none of the correlation coefficients exceeded the recommended threshold of 0.80.

to confirming the suitability of the data for multiple regression analysis to conduct a multiple regression analysis.

Finally, the results of multiple regression analysis showed that the overall regression model was statistically significant and, that a large proportion of variation in Hotel Development Performance can be explained by the set of the independent variables.

Only AI-BIM Integration, however was the only statistically significant predictor in the multiple regression model; while the individual effects of Artificial Intelligence (AI) and

Building Information Modeling (BIM) were found to not be statistically significant after controlling for the effect of AI-BIM Integration.

This therefore suggests that most gains in HDP could be found through AI-BIM Integration, not the standalone use of AI or BIM. In summary, hypothesis H1 was supported by finding a significant positive relationship between the independent variables and Hotel Development Performance (HDP).

In contrast, H1a and H1b are not supported, while H1c supported by finding that AI-BIM Integration was the significant independent contributor to Hotel Development Performance. Furthermore, these findings provide empirical support for the Hotel development of the Proposed National AI-BIM Framework and contribute to the digital transformation objectives of Saudi Vision 2030 within the hotel development sector.

CHAPTER FIVE-

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction:

This chapter reviews the study's findings within the context of research objectives, research questions, proposed hypotheses and theoretical framework provided in Chapter Two. Instead of providing raw statistical results again, this section focuses on interpreting the statistical outcomes and illustrating how the outcomes contribute to existing the body of knowledge on Artificial Intelligence (AI), Building Information Modeling (BIM), and AI-BIM Integration for hotel development in Saudi Arabia.

This section is divided into discussions concerning the practical and theoretical implications of the outcomes and comparing with empirical studies to demonstrate agreements and contradictions. It examines how AI-BIM Integration acts as a transformative digital practice to enhance the hotel development's performance in Saudi Arabia, it sets out a proposed National AI-BIM Framework based on the research outcomes, illustrates theoretical and practical implications of the study, provides implications for the construction stakeholders and policy makers, highlights limitations of the research and concludes with future work.

5.2 Discussion of Findings

The discussion presented in this chapter goes beyond statistical results analyzed in chapter Four to cover some of the key theoretical and practical implications of the research. While quantitative results demonstrated a number of statistically significant relationships between variables studied, an explanation of what these findings mean in the context of hotel development, digital transformation and the emerging construction industry in Saudi Arabia needs further exploration. Unlike conventional construction, hotel development entails multiple stakeholders whose goal extends beyond successful project completion and includes operational readiness, customer satisfaction, brand adherence, asset performance and investment value.

Therefore, the success of the implementation of digital technologies needs to be evaluated based on their contribution to the decision-making process, information continuity, cross-disciplinary collaboration and value creation across the hotel development lifecycle. The findings indicate that a successful digital transformation of hotel development projects is

driven less by the adoption of specific digital technologies and more by the creation of integrated digital management environment within organizations that enables project information to become a strategic organizational resource used to support planning, decision making, performance optimization and learning across the life of a hotel development.

The discussion is organized according to the research hypotheses to interpret the findings, compare them with previous studies, and highlight their theoretical and practical implications. It also provides the foundation for the proposed National AI-BIM Framework presented at the end of this chapter.

5.2.1 Discussion of the Main Hypothesis (H1):

H1 - Main Hypothesis: *Artificial Intelligence (AI), Building Information Modeling (BIM) and AI-BIM integration has a statistically significant positive impact on Hotel Development Performance (HDP) in Saudi Arabia.*

More than just indicating that digital technology supports Hotel Development Performance, this study's results imply that longer term improvement of Hotel Development Performance is more closely associated with an organization's ability to integrate AI and BIM into a singular, unified, digital project management system than its adoption as standalone technologies. Drawing on these findings from the statistical results of this study, it is clear that the ability of digital technologies to ensure coordinated, holistic, and continuous availability of information across the entirety of the project life cycle will most effectively promote and improve performance.

Unlike many construction projects, hotel development necessitates coordinating highly disparate operational, financial, technical, and brand-specific requirements throughout the span from conception to operation. As a result, achieving superior project performance hinges not only on optimization of individual technical work streams but, of more importance, on maintaining accurate, connected and continuous information throughout the complete conceptual, feasibility, design, build, commission, operational readiness, and ongoing operational and maintenance life cycle.

As such, digital technology generates more value from the continuity of information it can deliver and the more informed decisions it can support than when used merely as individual software solutions. An important conclusion to draw from the results of this study is that an

organization's digital maturity should best be considered an organizational capability as opposed to merely an investment in more advanced digital technologies.

AI technology and BIM tools bring significant capabilities for analysis and data management but the results show that it is the organization that can integrate these technologies effectively through well-developed governance, processes, and management capabilities that realizes the greatest gains in Hotel Development Performance; while standalone technology adoption is likely to provide siloed and limited results. Also, the results clearly demonstrate a need to differentiate technology adoption from digital transformation.

Although the adoption of AI solutions or BIM platforms may improve task execution in individual activities (e.g., design, planning, estimating, information management, site execution) but significantly higher Hotel Development Performance will be realized when the integrated utilization of these tools are applied as integrated workflows that support interdisciplinary cooperation, intelligent decision-making, and lifecycle information management, reiterating the role of organizational transformation not technology adoption in achieving improved project performance. Within the Saudi Arabian hotel development sector, this finding holds significant meaning.

The rapidly expanding portfolio of internationally branded hotels, many of which are part of extensive government and national development programs, requires the tight coordination of numerous stakeholders, in conjunction with the achievement of financial targets, operator needs, regulatory requirements, brand standards, and long term operational and facility management goals. To that end, the widespread adoption of a comprehensive digital infrastructure capable of maintaining continuous information flow through the full project lifecycle has become paramount.

In summation, the results supporting the primary hypothesis demonstrate that AI, BIM and perhaps most importantly their integration are not independent technological projects, but rather complementary organizational capabilities that work together to improve project coordination, quality of decision making, lifecycle information management and, by extension, Hotel Development Performance.

As hotel developments become increasingly complex and sophisticated, organizations with the capability to manage digital project delivery across their entire life cycle will fare far better than organizations that adopt these digital technologies on an isolated basis. Furthermore, the interpretation that AI, BIM and especially their integration are an

organizational capability provides the rationale for the establishment of a proposed National AI-BIM Framework outlined in the subsequent section of this document. The proposed framework advocates the development of a digital ecosystem that is anchored in governance, standardized data protocols, collaboration across disciplines and lifecycle orientation toward enabling improved Hotel Development Performance as part of an ongoing digital transformation of the Saudi Arabian hospitality construction sector.

5.2.2 Discussion on Sub-Hypothesis (H1a) Sub-Hypothesis (H1a):

Sub-Hypothesis (H1a):

Artificial Intelligence (AI) has a statistically significant positive impact on Hotel Development Performance (HDP).

In addition, these results also offer a more nuanced understanding of AI's role in hotel development. Unlike an assertion that the implementation of AI, per se, improves performance, these findings suggest that whether and how well AI functions in a development project is a function of the organizational context where AI is introduced. In other words, simply having AI technology does not help organizations excel at projects; organizations need to have the capacity to translate AI outputs into timely and insightful decisions about projects. This perspective aligns with the Dynamic Capabilities view, where competitive advantage arises not from technology, but from organizations' capabilities in managing (e.g., sensing, reconfiguring) their technology assets for operational process integration.

The regression analysis supports AI having a significant, positive relationship to Hotel Development Performance. However, AI primarily functions as an intelligent decision-support capability, rather than as a standalone management solution. A hotel development process necessitates a constant sequence of decisions pertaining to the stages of investment planning, project feasibility assessment, design coordination, construction procurement and sequencing, operational preparedness, asset facility management and performance optimization. As such, AI may be helpful in producing recommendations for decision-making, but it needs to be backed up with real time and accurate and integrated project data over the life of the hotel development.

This finding resonates with previous studies that emphasize the critical dependence of AI on organizational data, quality, availability, and integration. AI's potential and value depend not only on AI technology, but also on the availability of good data. Likewise, the literature review discussed in Chapter Two highlighted that digital technologies provide organizational

value when they are used to foster real time information flows, enable communication, collaboration and knowledge sharing across disciplines and project stages rather than functioning as a standalone application.

A further potential explanation is related to the development stage of digital transformation within the construction industry. In spite of growing use, AI application in construction still predominantly aims to automate single tasks or solve specific problems rather than being part of an integrated strategy along the whole project lifecycle. In complex hotel developments with high coordination requirements, it is difficult to fully achieve enhanced project outcomes if AI is only applied at isolated stages and not integrated across all phases from planning to facility management.

The findings suggest that AI delivers the greatest value in managerial functions, especially those involving high levels of analysis such as the forecasting of project risks and resource requirements, analysis of various scenarios, cost planning and strategic decision support. However, the efficacy of such functions relies significantly on the existence of a sound digital ecosystem that provides consistent, reliable and real time data on the project, therefore indicating AI to be more of an organizational capability and a key feature of the overall digital strategy rather than a standalone technological artifact.

From a practical management standpoint, these findings challenge the conventional practice of investing in AI as an independent digital technology initiative. Rather, organizations must invest first in digital readiness, Digital Governance, Data Quality, Work Force Skills and integrated Information management system prior to expecting AI applications to contribute meaningfully to Hotel Development Performance. These insights have important implications for hotel developers, consultant firms, contractors, hotel brands and government authorities seeking to accelerate digital transformation of the Saudi hotel development industry.

To summarize, although AI positively relates to Hotel Development Performance, the magnitude of AI's contribution is largely determined by the organization's level of digital maturity within an organization. This finding paves the way for the next discussion which focuses on Building Information Modeling (BIM) as the fundamental Digital Information infrastructure for making AIs more effective across the entire hotel development project life cycle.

5.2.3 Discussion of Sub-Hypothesis (H1b)

Sub-Hypothesis (H1b):

Building Information Modeling (BIM) has a statistically significant positive effect on Hotel Development Performance (HDP).

Regression analyses showed a statistically significant positive impact of BIM on Hotel Development Performance (HDP). These results imply that BIM is neither simply a technology capability in itself nor a direct source of competitive advantage but appears to be the digital information infrastructure in which organizational digital capabilities can be built. As BIM is being adopted more maturely across the industry, the strategic importance is changing from creating digital models to integrated digital project delivery.

The significant positive effect also makes sense to answer the research question of why BIM is affecting the HDP while it is not so transformational as one expected. That BIM supports the generation, organization, coordination and sharing of information in projects allows for a significantly better interdisciplinary coordination, improved transparency in designs, enhanced consistency in project information, and easier collaboration and communication among all stakeholders in a project, but this cannot alone guarantee the optimal outcome in terms of project performance.

The generation of high-quality project information, per se, provides limited value for the organization unless it supports effective, timely, and informed managerial decision making. In hotel development, the real value created by BIM is not the generation of the accurate 3D models per se, but the transformation of project information into organizationally useful knowledge that can be used for decision making across the entire project life cycle.

This is the more so, in hotel development, where the demands on information coordination are much higher than in many other construction projects, including architect, structure, MEP, interior, FF&E, operations planning, brand standard and asset/facility management, which all need to coordinate closely during a hotel development.

Without connecting information to facilitate decisions throughout the project, an accurate and coordinated 3D model alone is not sufficient. Yet another explanation for this is related to the fact that although many organizations have already adopted BIM software, most still perceive BIM as a design and coordination tool, not as a central information management platform for all stakeholders throughout the project life cycle.

That is, although many organizations may have widely deployed BIM technologies, it might have not reached its maximum potential value from the organizational and strategic perspective because it fails to integrate project information and related processes across the different project stages from planning, design, procurement, construction, commissioning and, subsequently, into operational readiness and long-term facilities management.

Based on the discussion from a managerial perspective, managers should consider investment beyond software deployment, such as creating CDE, strengthening information governance, ensuring effective life cycle information management and integrating the design data with facility management systems to be able to capitalize the real value of BIM as the digital information infrastructure, not the modeling technology.

In summary, we found that the true value of BIM lies not in the generation of the precise project models but in the development of integrated digital information environment that can enable collaboration, organization learning, asset lifecycle management and informed decision making in a hotel development. This interpretation of BIM leads logically to the following section on how Artificial Intelligence (AI) combined with BIM will be transforming project information into the basis of informed decision support systems, ultimately leading to a greater increase in Hotel Development Performance.

5.2.4 Discussion of Sub-Hypothesis (H1c):

Sub-Hypothesis (H1c):

AI-BIM Integration has a statistically significant positive effect on Hotel Development Performance (HDP).

The findings of this study suggest that the ultimate driver of performance enhancement comes not from the individual technologies of artificial intelligence (AI) or building information modeling (BIM), but rather from the organization's capacity to integrate both into a holistic decision-making system. This observation is conceptually important because it reconfigures our understanding of digital transformation in hotel development from one based on competing technologies to one focused on how technologies work in concert. BIM, on one hand, offers the facility of maintaining an integrated and coordinated model that brings together technical, spatial, financial, and operational data. Artificial Intelligence, on the other hand, introduces intelligence to this information in the form of patterns, trends, predictions, and sophisticated analytical tools for decision support. When the two are united, project teams transition from managing information to managing projects intelligently.

In effect, they enable moving from an informational capability to an intelligent one where information flows efficiently and is complemented by insight and analysis. A crucial implication of this argument is that true digital transformation is not simply measured by how many digital tools organizations adopt, but by their integration. When a multitude of tools is deployed, each functioning in isolation, information can become disjointed and the opportunity for strategic organizational learning decreases. Hence, rather than considering the adoption of digital tools as the benchmark for successful transformation, the focus should shift towards integration as a strategic capability that dictates technology's ultimate impact on performance.

This point is particularly pertinent to hotel development, due to its multidimensional and project-centric nature. For example, unlike other construction types, the operational requirements of a hotel should be a consideration from the very early stages of project development, influencing decisions regarding its feasibility, design, construction, handover, and ongoing operations. Therefore, an integrated flow of information and support for consistent, informed decision-making throughout the lifecycle of hotel projects are key factors in their success.

Moreover, the results build upon the literature base by repositioning digital transformation from a focus on the acquisition of digital technologies to their integration as a strategic capability. Past research has explored the value of either AI or BIM in isolating these applications. The current findings, however, illustrate a far more compelling return when both technologies are viewed as components of a seamlessly linked system, capable of providing seamless project management, effective collaboration, transparent governance, dynamic insights, and continuous lifecycle support.

Therefore, AI-BIM Integration is not the endpoint of digital adoption, but the genesis of a new era in which integrated information and intelligent insights coalesce with organizational processes to create unprecedented performance. From a strategic point of view, the findings of this study hold significant implications for Saudi Arabia's hospitality industry. As the size, complexity and technological sophistication of hotel developments increase and in order to meet the objectives of Vision 2030, future competitiveness of the industry will rely more heavily on organizations' ability to integrate digital capabilities than simply adopting new digital tools. Hence, a National AI-BIM Framework should be developed to enable widespread digital integration practices in Saudi hotel development.

5.3 Achievement of the Research Objectives:

The present study was undertaken to investigate the contribution of Artificial Intelligence (AI), Building Information Modeling (BIM) and a combined use of AI-BIM technologies on Hotel Development Performance (HDP) in Saudi Arabia, the present research was conducted. The study was governed by six research objectives that comprehensively cover technological, managerial and strategic perspectives in hotel development through digitalization of the development processes. Based on the empirical findings and their subsequent discussion and interpretation, all the objectives set forth in this research were achieved and the research results support the conclusions of the study and provide practical implications for industry practitioners while contributing to academic knowledge.

The attainment of each of the research objectives is highlighted in the sections following.

Research Objective One (RO1):

To determine the current level of adoption of AI and BIM in Saudi Arabian hotel development projects.

Research Objective One was successfully achieved. The findings indicate that the level of adoption of both Artificial Intelligence (AI) and Building Information Modelling (BIM) is quite high in Saudi hotel development projects, and hotel development professionals increasingly recognize both technologies as practical tools in the process of planning, coordination of multiple disciplines, management of information, sharing of data, and decision-making of projects.

This implies that the Saudi hotel development industry is moving forward beyond the basic stage of digital awareness towards high level of digital maturity and a sound digital infrastructure is already in place as supporting evidence to implement digital initiatives in a more advanced manner, especially in the context of AI-BIM Integration, which provides an important foundation for addressing the rest Research Objectives.

Research Objective Two (RO2):

To investigate the current level of integration between Artificial Intelligence (AI) and Building Information Modeling (BIM) throughout the hotel development lifecycle.

Research Objective Two was successfully achieved through the evaluation of how practitioners view AI-BIM Integration in a hotel development lifecycle context. The findings

demonstrate that practitioners recognize AI–BIM Integration, rather than the isolated use of AI and BIM, as providing greater value throughout hotel development projects.. The findings further indicate increasingly aware of connected digital workflows that would be useful for ensuring information flows seamlessly through design, planning, construction, commissioning, operation readiness and eventual facility maintenance. The achievement of this objective confirms that AI–BIM Integration is increasingly recognized as a strategic organizational capability for enhancing hotel development projects.

Research Objective Three (RO3)

To evaluate the impact of AI–BIM Integration on hotel development project performance throughout the project lifecycle, including project planning, multidisciplinary coordination, cost management, schedule performance, project quality, risk management, operational readiness, facility management, and long-term asset performance.

Research Objective Three was successfully achieved with the examination of the relationship between digital integration and hotel development overall performance.

The findings demonstrated that AI-BIM Integration brings about improvement to the project performance throughout the hotel development lifecycle rather than being limited to isolated project activities.

Therefore, it leads to enhanced integrated digital management which enables project coordination, decision making for managers and lifecycle information management, and the alignment of project delivery and operating goal, thereby improving overall Hotel Development Performance throughout the project lifecycle.

Research Objective Four (RO4)

To evaluate the impact of AI–BIM Integration on the business and investment performance of hotel development projects, including operational efficiency, lifecycle value, return on investment (ROI), investment performance, sustainability, and long-term asset value.

Research Objective Four was successfully achieved by broadening the measurement of project performance beyond conventional construction-based metrics.

The study's results indicate that AI-BIM Integration extends beyond project delivery into the domain of business and investment outcomes. This underlines the necessity of the hotel development perspective also encompassing its use and purpose as an ongoing, operating asset and consequently, demonstrates how digitally enabled project development and execution can also drive improved operating performance, lifecycle value, and more sustainable investment returns in the hotel asset lifecycle.

Research Objective Five (RO5)

To identify the critical success factors and implementation barriers affecting the systematic adoption and integration of Artificial Intelligence (AI) and Building Information Modeling (BIM) in hotel development projects in Saudi Arabia.

Research Objective five was successfully achieved by analyzing implementation issues described by industry practitioners.

Several organizational and technical factors that hinder effective implementation of AI-BIM such as data quality, interoperability between digital systems, Organizational preparedness, and workforce expertise were found.

Thus, this suggests that successful digital transformation requires more than mere availability of technologies, but also strong governance, capability, and strategic information management in order to achieve sustainable digital transformation in the Saudi hotel development sector.

Research Objective Six (RO6)

To develop a Proposed National AI-BIM Framework that supports the systematic integration of Artificial Intelligence (AI) and Building Information Modeling (BIM) throughout the hotel development lifecycle while aligning project delivery, operational requirements, business objectives, and the strategic goals of Saudi Vision 2030

The final research objective is to develop and present the proposed **National AI-BIM Framework** in the next sections of this chapter.

This framework has been constructed based on the results derived from the research as well as the theoretical basis extracted from the literature.

Rather than recommending isolated digital technologies, the framework provides an integrated implementation approach, it presents a comprehensive procedure for applying AI-

BIM across the hotel development project lifecycle to guide developers, consultants, contractors, hoteliers, facility managers, investors, and decision-makers in defining digital standards, enhancing project delivery and asset performance, and delivering projects according to Saudi Vision 2030.

Overall Achievement of the Research Objectives

The study successfully achieved all six research objectives. Additionally, the research provides a broader strategic perspective on digital transformation for Saudi Arabian hotels development projects beyond the associations between AI, BIM, AI-BIM Integration and Hotel Development Performance.

Notably, instead of analyzing digital technologies independently, the study illustrates the essential roles of integration across organizational domains, lifecycle information management, and digital governance as key determinants of Hotel Development Performance and organizational performance, laying a critical foundation for the proposed National AI-BIM Framework and enhancing the research's practical, policy, and academic significance.

5.4 Discussion of Research Questions

The preceding discussion demonstrated how the empirical findings addressed each of the research questions established in Chapter One. Rather than repeating the detailed discussion presented in the previous sections, Table 5.1 provides a concise summary of the principal findings corresponding to each research question. This summary highlights how the study achieved its research aims and provides a logical transition to the proposed National AI-BIM Framework presented in the following section.

Table 5.1: Summary of Research Questions and Key Findings

Research Question	Summary of Findings
RQ1: What is the current level of adoption of Artificial Intelligence (AI) and Building Information Modeling (BIM) in Saudi Arabian hotel development projects?	The findings indicate that both AI and BIM have reached a high level of adoption within Saudi hotel development projects, reflecting the industry's transition from digital awareness toward greater digital maturity.
RQ2: What is the current level of AI–BIM Integration throughout the hotel development lifecycle?	The findings demonstrate that industry professionals increasingly recognize AI–BIM Integration as an integrated digital workflow that enables continuous information management and collaboration throughout the hotel development lifecycle.
RQ3: How does AI–BIM Integration influence Hotel Development Performance?	AI–BIM Integration significantly enhances Hotel Development Performance by improving project coordination, managerial decision-making, integrated information management, and lifecycle project delivery.
RQ4: How does AI–BIM Integration influence business and investment performance in hotel development?	The findings reveal that AI–BIM Integration extends beyond project delivery by improving operational performance, lifecycle asset value, long-term investment outcomes, and overall business performance.
RQ5: What are the key challenges affecting the implementation of AI–BIM Integration in Saudi hotel development projects?	The study identified data quality, interoperability, organizational readiness, digital governance, and workforce capability as the principal factors influencing successful AI–BIM implementation.
RQ6: What framework can support the implementation of AI–BIM Integration in Saudi hotel development projects?	Based on the empirical findings and the theoretical foundation of the study, a National AI–BIM Framework is proposed to guide the systematic implementation of AI–BIM Integration throughout the hotel development lifecycle in alignment with Saudi Vision 2030.

Source: Author's own compilation based on the research findings (2026).

5.5 Proposed National AI–BIM Framework for Hotel Development in Saudi Arabia:

5.5.1 Rationale, Strategic Purpose and Development Basis:

Rationale for the Proposed National AI–BIM Framework

The justification for developing the proposed National AI-BIM Framework was driven by the growing need for a systematic and a systematic and nationally aligned implementation framework for digital transformation in the Saudi hotel development sector. Despite a

growing interest in using artificial intelligence (AI), Building Information Modeling (BIM) and other digital technologies for the development of hotel projects, the actual implementation and adoption of digital technologies is predominantly project- and organization-specific, rather than being implemented in a comprehensive, integrated way. The majority of digital solutions were adopted independently as separate initiatives, rather than as part of an integral framework guiding digital transformation throughout the hotel development lifecycle.

As such, considerable variation in implementation practices, information management, organizational readiness, and governance structures prevailed, hindering organizations from maximizing their digital transformation benefits.

In addition to the practical implementation issues identified above, the literature review identified a lack of a systematic implementation framework guiding the integrated implementation of AI and BIM in hotel development. Although several papers discussed AI, BIM, and digital transformation in the construction sector, or on an individual level, no integrated framework with a focus on the lifecycle approach, addressing the operational complexity of hotel development, has been presented in the extant literature, this implementation gap provided the primary rationale for developing the proposed National AI–BIM Framework.

Strategic Purpose

The strategic purpose of the proposed National AI–BIM Framework is to establish a unified nationally-directed model for the coherent application of both AI and BIM through-out the entire hotel development lifecycle within Saudi Arabia.

The framework will serve to improve information consistency, improve organizational digital capacity, enable multidisciplinary team collaboration, support evidence-based decision-making, and stimulate continuous improvement of project execution and long-term facility performance.

Crucially, it offers an actionable tool to facilitate the successful realization of the digital transformation objectives of Saudi Vision 2030 by fostering a systematic, collaborative, and resilient digital approach to project execution within the Saudi hotel sector.

Development Basis

Development Process of the National AI-BIM Framework The proposed National AI–BIM Framework was developed through the integration of complementary theoretical and empirical evidence. The theoretical foundation of the framework is derived from the detailed and comprehensive literature review reported in Chapter Two. This review explored key literature relating to the main concepts underpinning AI, BIM, AI-BIM integration, digital transformation, hotel development, relevant existing implementation frameworks and best practices at the global level, while highlighting the key knowledge gaps addressed in this research.

The empirical foundation of the framework is derived from the quantitative findings of this study, including the assessment of AI and BIM adoption, AI–BIM integration, implementation challenges, and their influence on hotel development performance.

The combination of these mutually supportive sources of evidence aims to transform the theoretical knowledge and the empirical results into an applicable implementation model that has specific relevance to the hotel development sector in Saudi Arabia.

Accordingly, the proposed National AI–BIM Framework should not be viewed merely as a technology adoption framework. Instead, it provides an evidence-based national implementation model that integrates governance, organizational capability, digital infrastructure, lifecycle information management, and intelligent digital technologies into a unified approach for enhancing hotel development performance throughout the entire project lifecycle in Saudi Arabia.

5.5.2 Strategic Objectives and Guiding Principles:

The proposed National AI–BIM Framework is founded on a fundamental principle, which is that digital transformation of hotel development should be thought of as a long-term national and organizational capacity rather than an application of various digital tools.

For this reason, a National AI-BIM Framework has been developed with the purpose of establishing a common strategic direction that facilitates the integration of AI and BIM within the hotel development cycle systematically.

Instead of a technology-led framework, a lifecycle-driven framework is employed in this approach where digital information, intelligent decisions, organizations and collaboration work together. Thus, the ambition is to establish a unified digital infrastructure which

supports delivery, operations, long-term asset performance, and continuous organization's learning and development. Accordingly, the framework is guided by a set of strategic objectives and design principles that define its underlying philosophy and provide the foundation for its implementation throughout the hotel development lifecycle in Saudi Arabia.

Table 5.2: Strategic Objectives of the Proposed National AI–BIM Framework

Strategic Objective	Purpose
SO1. Establish a unified national digital approach	Promote a consistent methodology for AI–BIM implementation across hotel development projects in Saudi Arabia.
SO2. Strengthen lifecycle information continuity	Ensure that project information remains accurate, accessible, and continuously updated from feasibility through operation and facility management.
SO3. Enhance intelligent decision-making	Enable data-driven decisions using integrated AI analytics and BIM information throughout the project lifecycle.
SO4. Improve multidisciplinary collaboration	Facilitate effective coordination among developers, consultants, contractors, hotel operators, facility managers, and government authorities.
SO5. Support long-term asset value	Extend digital information beyond project delivery to improve operational efficiency, maintenance planning, and lifecycle asset performance.
SO6. Align with Saudi Vision 2030	Contribute to national digital transformation, smart construction, sustainability, and hospitality sector development objectives.

Source: Author's own compilation based on the research findings (2026).

Guiding Principles of the Framework

The proposed framework is I guided by a set of fundamental guiding principles of how AI and BIM should be used within the hotel development projects.

These principles should provide guidance for organizations in order to ensure effective digital transformation in a standardized manner while maintaining sufficient flexibility in relation to the unique aspects of each individual project.

Table 5.3: Guiding Principles of the Proposed National AI–BIM Framework

Guiding Principle	Description
Lifecycle Integration	Digital processes should support all project phases rather than individual project activities.
Information as a Strategic Asset	Project information should be managed as a long-term organizational resource that supports decision-making throughout the asset lifecycle.
AI-enabled Decision Support	Artificial Intelligence should augment managerial judgement through predictive analytics and intelligent recommendations rather than replace human expertise.
Open Collaboration	All project stakeholders should operate within a coordinated digital environment that promotes transparency and efficient information exchange.
Digital Governance	Standardized policies, responsibilities, and data management procedures should ensure consistency and accountability across projects.
Continuous Improvement	Digital transformation should be viewed as an evolving organizational capability supported by continuous evaluation, learning, and innovation.

Source: Author's own compilation based on the research findings (2026).

Framework Philosophy

"Sustainable improvements in hotel development performance cannot be achieved through the isolated adoption of advanced technologies. Instead, long-term value is created when Artificial Intelligence, Building Information Modeling, governance, organizational capability, and lifecycle information management operate as an integrated digital ecosystem."

Here, technology is an enabler of better-informed decision-making not the goal; project information is an organizational asset that provides strategic support for planning, delivery, operation and ongoing improvement, throughout the hotel development lifecycle.

5.5.3 Framework Structure:

The National AI-BIM Framework is designed as an integrated lifecycle-oriented framework for enabling systematic adoption of Artificial Intelligence (AI) and Building Information Modeling (BIM) throughout the Saudi hotel development life-cycle. Instead of conceiving AI and BIM as independent tools, the framework understands the integration of AI and BIM as an organizational capacity to enable evidence-based decision-making, continuity of information, collaborative process among the stakeholders and asset long term performance during hotel development life-cycle. The framework is developed directly from the empirical findings of this study, where the statistical analysis had identified that both AI and BIM individually and especially the integration of AI and BIM have positive influence on hotel development performance (HDP) while identifies number of barriers for its implementation such as data quality, inter-operability among digital technologies, organizational preparedness, governance and work force skill. As such, the framework is proposed to address those crucial barriers while maximize those benefits found by the study in the context of hotel development in Saudi Arabia.

To achieve the aim, the framework has been conceptualized in six correlated layers which represent the strategic, organizational, technology, operational and performance dimension required for successful AI-BIM adoption in the Saudi hotel development life cycle. Every layer is designed to support the layer that follows, thereby creating a consistent and continuously moving pipeline of information and decisions ranging from national and organizational factors down to operational execution and long-term asset performance.

Layer one: National governance dimension. This layer of the framework defines the National level governance and policy which include aligning the AI-BIM adoption with the Saudi Vision 2030 and other national digital transformation initiatives, while integrate ISO 19650 standard, government regulations into the national governance policy for the uniform AI-BIM implementation within the country.

Layer two: Organizational readiness dimension. Apart from the technology, the success of AI-BIM implementation relies also on the readiness of the organizations. Such include executive leadership commitment, organizational digital strategy, effective organizational

governance structure, qualified work force competency, standardized BIM procedures and proficient information management practice. This finding is similar to the empirical results which reported that organizational readiness has been found as the most important barrier.

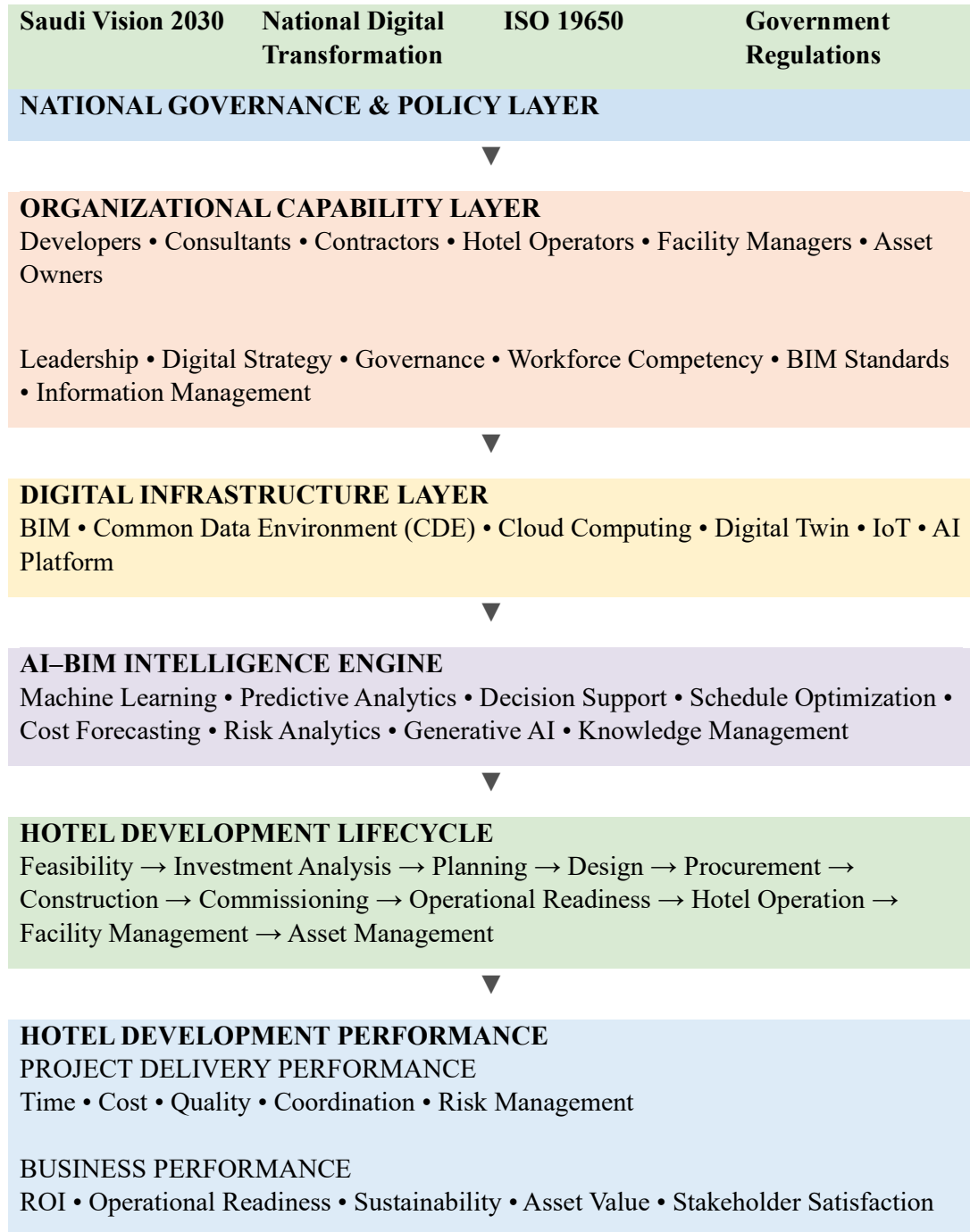
Layer three: Digital infrastructure dimension. It comprises the necessary digital environment for integrated information management such as Building Information Models, common data environment (CDE), cloud computing platform, digital twins, Internet of Things (IoT) technologies, and AI analytical engines.

Layer four: AI-BIM Integration dimension. This is the core layer of the proposed framework where integrated project information in BIM is utilized by AI technologies such as machine learning, predictive analysis, intelligent decision support, schedule optimization, cost estimation, automated risk detection, knowledge management, Generative AI etc.

The empirical findings confirmed that integrating AI and BIM creates greater benefits over implementing them individually. Layer five: Hotel development life cycle. The proposed AI-BIM environment is applied to the entire hotel development life cycle covering from feasibility and investment analysis, planning, multidisciplinary design, procurement, construction, commissioning and readiness for operation through hotel operations, facility management and finally to the asset long term maintenance. This enables better decision-making due to continuous flow of information across stakeholders.

Layer six: Hotel development performance dimension. It covers two categories of the expected outcomes, which are project delivery performance and business long term performance. The benefits in terms of improved schedule performance, cost control, project quality, multidisciplinary coordination, risk management, operational readiness, investment performance, ROI, sustainability, customer satisfaction, as well as long term value of the asset are expected to be achieved through the systematic implementation of the proposed framework.

Figure 5.1 – Proposed National AI–BIM Framework for Hotel Development in Saudi Arabia



5.5.4 Framework Implementation Process:

Successful uptake of the Proposed National AI-BIM Framework needs to be implemented in a progressive and phased manner as opposed to individual digital solutions. As such the framework sets out a five-stage implementation roadmap that leads organizations from assessing their existing digital maturity through to achieving a culture of continuous improvement. This roadmap is to assist developers, consultants, contractors, hoteliers and government agencies in implementing AI-BIM Integration consistently and in a structured manner whilst allowing for varying levels of organizational digital maturity.

Implementation commences with an Assessment of the organization's current digital landscape to consider existing AI, BIM and digital capabilities, organization governance, information management processes, workforce capabilities and technological infrastructure to identify potential strengths, weaknesses and implementation gaps before taking the first step in digital transformation.

The organizations can then progress to the Readiness phase to define their strategic goals, translated into their implementation plan, establish appropriate organizational governance and responsibilities, build digital competencies, define a standard operating procedures for information management and identify and obtain the necessary technical and organizational resources required to deliver on their strategy.

The third stage involves the Implementation of the integration of AI and BIM in hotel project delivery across all phases of the development lifecycle. The integration should be guided by the principles of this framework by focusing on ensuring the flow of information throughout the lifecycle, and the engagement of the multidisciplinary project teams rather than individual digital solutions.

As implementation takes place, an evaluation of performance will require Monitoring. The framework encourages the regular review of the organization's key performance indicators (KPI's), information quality, collaborative digital workflows, and project and business outcomes, alongside their compliance with information standards, so as to measure against strategic goals and enable corrections where necessary.

The final stage is one of Continuous Improvement because digital transformation is not an isolated project but an ongoing evolutionary organization. Lessons learnt from past projects, new technology, user feedback and the results of previous evaluations should be integrated

into future projects to enhance the organization's ability to continually improve hotel development performance.

Figure 5.2 summarizes the implementation process of the proposed National AI-BIM Framework through five sequential stages, from organizational assessment to continuous improvement.

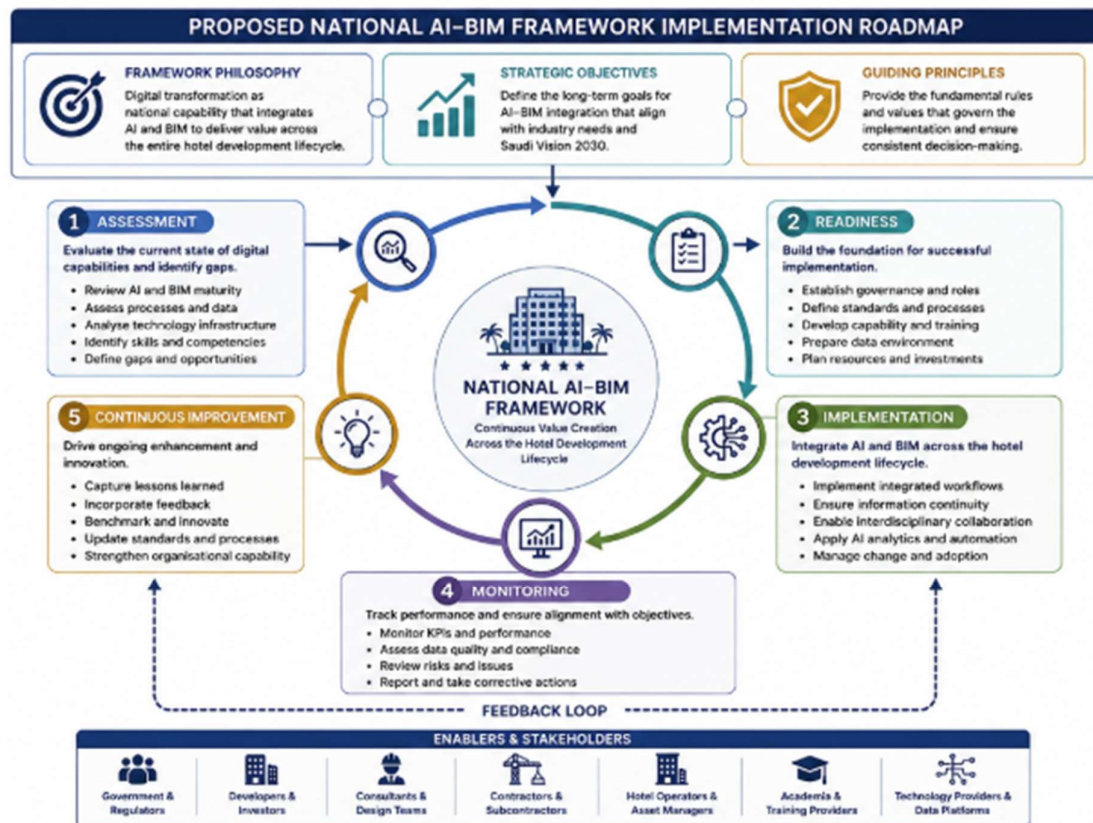


Figure 5.2 Proposed AI-BIM Framework Implementation Roadmap

Source: Author

5.5.5 Expected Outcomes of the Proposed National AI-BIM Framework:

The value of the proposed framework extends beyond technology adoption to focus on improvement in project delivery, capability within organizations, and the broader agenda of Saudi Arabia in relation to the digital transformation agenda. It is proposed that the **Expected Outcomes and Benefits** of the Proposed National AI-BIM Framework should be defined at three interconnected levels, namely: -

1. Project Level Benefits
2. Organizational Level Benefits
3. National Level Benefits

This is in keeping with the strategic perspective proposed for the framework and acknowledges that the real benefits of digital transformation should be realized and evaluated across projects, organizations and the construction industry as a whole.

Project outcomes

At the project level, the proposed framework aims to enhance the planning, delivery, and operational readiness of hotel development projects by promoting the seamless integration of digital processes and integrated information management throughout the project lifecycle. Consequently, the framework supports better-informed decision-making, stronger multidisciplinary collaboration, higher information quality, and greater consistency in project execution.

These improvements are expected to enhance schedule performance, cost control, quality management, and risk management while ensuring operational readiness and, ultimately, improving overall Hotel Development Performance.

Organizational Outcomes

At the organizational level, the proposed framework aims to strengthen organizational digital capability by supporting the establishment of effective governance structures, standardized information management practices, and collaborative digital working environments. Furthermore, the framework promotes organizational learning through continuous performance monitoring, knowledge capture, and lifecycle information management. By integrating Artificial Intelligence (AI) with Building Information Modeling (BIM), organizations are expected to enhance strategic decision-making, optimize resource utilization, strengthen workforce capabilities, and improve lifecycle asset management.

Collectively, these outcomes contribute to greater organizational resilience, improved operational efficiency, and enhanced competitiveness within the Saudi hotel development sector.

National Outcomes

On a national level the framework aims to complement the overall digital transformation strategy for the Kingdom by providing a standardized, coherent way to implement AI-BIM across hotel development projects. By promoting a better alignment between public and private stakeholders the framework allows for standard approaches to implementation, digital

maturity and information governance. Over the long term, its implementation will enable improved efficiency, enhanced industry digital maturity, increased investment confidence and the delivery of competitive hospitality products. In turn, these impacts will reinforce the national aspirations and targets set out by Saudi Vision 2030 by enhancing digital innovation, sustainability and performance for a key economic growth sector.

Table 5.4 Expected Outcomes of the Proposed National AI–BIM Framework (Evaluation Matrix)

Outcome Level	Expected Outcomes & Strategic Impact Indicators
Project Outcomes	Improved project planning, multidisciplinary coordination, lifecycle information management, decision-making quality, schedule performance, cost efficiency, risk management, operational readiness, and overall hotel development performance.
Organizational Outcomes	Enhanced digital governance, stronger organizational capability, standardized information management, workforce development, knowledge sharing, strategic decision-making, lifecycle asset management, and organizational competitiveness.
National Outcomes	Greater digital maturity across the hospitality construction sector, standardized AI–BIM practices, improved industry collaboration, increased investment confidence, support for Saudi Vision 2030, sustainable development, and enhanced international competitiveness.

5.6 Contributions of the Study:

This section contributes significantly to knowledge both academically and professionally in terms of digital transformation of hotel development. Rather than presenting anticipated contributions as discussed in Chapter One, the contributions made herein are directly extracted from the study empirical outcomes and the suggested National AI-BIM Framework. In synergy, they reinforce the existing body of knowledge concerning AI-BIM Integration, and offer useful guidance for optimizing hotel development performance in Saudi Arabia.

5.6.1 Theoretical Contributions:

This study extends the existing body of knowledge by providing empirical evidence, providing empirical evidence of how AI, BIM, AI-BIM Integration, and HDP interact in the

Saudi hotel development sector. This study demonstrates that AI and BIM are better treated in an integrated way since the integration has a higher strategic impact than implementing AI or BIM in isolation. AI-BIM Integration is modelled as an organizational capability in this thesis rather than simply an operationalization of technologies. The results have revealed that hotel development success depends not just on the adoption of digital technologies alone, but rather on the organization's maturity, data and information management, and information availability across the life cycle. The National AI-BIM framework which is constructed based on theoretical constructs and empirical results, forms a structured implementation approach. This National AI-BIM Framework provides a theoretical foundation for future studies on AI-BIM Integration, digital transformation, and life cycle information management in the hospitality construction sector.

Furthermore, the findings suggest that AI-BIM Integration should be viewed as the primary mechanism through which AI and BIM collectively enhance hotel development performance, thereby extending existing digital transformation theories beyond the independent adoption of individual technologies.

5.6.2 Practical Contributions

From a practical perspective, this study provides evidence-based guidance that can help improve the digital transformation initiatives of Saudi hotel development projects. Through providing empirical results that demonstrate and improve the hotel development projects. The National AI-BIM Framework presented provides a structured implementation framework that helps developers, consultants, contractors, hotel operators, facility managers, investors, and governmental agencies adopt AI-BIM throughout the hotel development lifecycle. The framework highlights governance, organizational capacity, infrastructure capacity, lifecycle information, and continual improvement rather than simply the adoption of new technology. The Framework assists in more informed decision-making, enhanced collaborative practices, readiness to operate, capacity for long-term lifecycle asset management, and building lasting capability within the organization by providing an implementation roadmap that helps guide practice in these areas. This practical insight helps the organization as a whole better align its practices with the objectives of digital transformation within Saudi Arabia's hotel development sector and supports the Saudi Vision 2030.

5.7 Conclusions:

This study investigated the impact of Artificial Intelligence (AI), Building Information Modeling (BIM), and AI-BIM Integration on Hotel Development Performance (HDP) in Saudi Arabia and to establish a National AI-BIM Framework to assist in digital transformation within the hotel development sector.

This study reveals that although AI and BIM have important digital contributions, their full strategic value is realized through a well-established, well-integrated application of AI-BIM into a cohesive information management environment across the entire hotel development lifecycle.

The empirical data support that the strongest contributor to HDP is the use of AI-BIM Integration. The data suggest that it is not enough to utilize digital technologies; that long-term project and business success hinges on organizational capability, effective governance, lifecycle information management, the digital infrastructure, skilled employees and adequate quality information.

The results support the perspective of the digital transformation as an organizational and strategic change. Given the theoretical base provided by Chapter Two and the evidence produced herein, a National AI-BIM Framework has been recommended which offers a **structured implementation framework** for implementing the proposed framework to hotel developments in Saudi Arabia; a framework which integrates governance, organizational capacity, the digital infrastructure, smart AI-BIM technologies, lifecycle information management, the implementation process and continual improvements, and provides an organized framework for all developers, consultants, contractors, hotel operators, facility management companies, investors and all government authorities to enhance collaboration, continuity of information, decision making, facility operational readiness, and long-term facility performance.

This research successfully delivered against its overall aim and research objectives while extending academic literature by illustrating the importance of AI-BIM Integration as an organizational capability. Further, the research contributed to knowledge by creating the first evidence-based National AI-BIM Implementation Framework for the hotel development sector in Saudi Arabia.

The proposed framework has the potential to enhance the effectiveness of hotel project delivery and organizational digital capacity, promote enhanced facility management through effective lifecycle information management, and support better project and asset performance through informed decision-making.

5.8 Recommendations:

This study concludes that successful AI–BIM Integration requires more than the adoption of digital technologies. The success of integration relies upon proper governance, organizational capability, digital infrastructure, the lifecycle information management, and effective collaboration between all of the stakeholders involved in hotel development. From these empirical findings and the resultant National AI-BIM Framework, the following recommendations are proposed.

5.8.1 Recommendations for Government

The relevant government bodies should lead in developing a **National Strategy** to encourage the Adoption of AI-BIM Integration within the hospitality development sector, as part of the digital transformation of the Kingdom.

National implementation guidelines should be formulated that provide guidance on information governance, interoperability, lifecycle information management, and standard approaches for the uptake of AI-BIM. Additionally, public bodies should aim to support adherence to international standards, such as the ISO 19650 series of standards, or the **OpenBIM** approaches, to enhance the exchange of information and foster collaboration. Incentives in the form of grants, pilot programs, accreditation programs, and public private partnerships should also be encouraged to accelerate digital transformation and enhance the digital maturity of the industry.

5.8.2 Recommendations for Hotel Developers

Hotel developers should regard AI–BIM Integration as a strategic organizational capability rather than an isolated technology investment. Developers should foster a digital transformation culture underpinned by business strategies supported by investment in digital infrastructure, information management systems and training and development of their staff. Developers should embrace the use of Common Data Environments (CDE), implement clear information governance protocols, and integrate AI-BIM throughout the hotel development

lifecycle in order to improve strategic and operational decision-making, ensure readiness for operation, optimize returns for investors and maximize the value of assets over time.

5.8.3 Recommendations for Consultants

To provide advice to clients to expand their role beyond traditional design coordination services and also embrace integrated digital project delivery across all project phases, across the design, pre-construction, construction, and operational phases of the hotel development. Greater emphasis should be placed on the importance of interdisciplinary working, information management standards, the quality of the data, software interoperability and also on helping clients to transition to the National AI-BIM framework by providing the digital implementation strategy, organizational readiness reviews, and lifecycle information management plans with ongoing performance evaluation.

5.8.4 Recommendations for Hotel Operators

Hotel operators should be actively involved from the early stages of hotel development rather than only at the stage where operational systems are required. The hotel operational needs, Asset data requirements, facility management information and brand standards should be incorporated into BIM models during design to maintain data continuity throughout the project lifecycle. Hotel operators should collaborate closely with designers in developing an organized Asset Information Model (AIM) for the facility to aid in the facility management, predictive maintenance, operational efficiency, and the long – term asset performance.

5.8.5 Recommendations for Future Researchers

Future research should test and improve the developed National AI-BIM Framework and examining real-world hotel development projects in Saudi Arabia. Comparative studies across different countries and studies based on other sectors (healthcare, commercial and residential) will increase the transferability and generalizability of the framework. Future studies should adopt a longitudinal research design to determine the development and organizational digital maturity and the adoption of AI-BIM over time.

It is also recommended to examine new technologies, such as Generative AI, Digital Twins, IoT, predictive analytics and others, and their integration with AI-BIM in enhancing the management of lifecycle information, organizational performance, and sustainability of the hotel developments.

5.9 Study Limitations:

This study has achieved the research aim and objectives, but several limitations should be considered when interpreting the findings and the application of the proposed National AI-BIM Framework. Firstly, this research was conducted in the setting of hotel development projects within Saudi Arabia. This setting was specifically chosen for the significance of the hospitality sector and its relevance to the Saudi Vision 2030 agenda; thus, the empirical findings and the proposed framework reflect characteristics specific to the Saudi hospitality industry.

Therefore, care should be taken when adapting the proposed framework for use in other countries or in other real estate sectors with varying regulatory regimes, organizational structures, and levels of digital maturity. Secondly, a quantitative cross-sectional study design based on a one-time survey data collection was employed. Although this design yielded statistically significant data demonstrating the relationships among the study variables, it does not address the progression of organization digital maturity, AI-BIM Integration and hotel development performance across project stages.

Consequently, the findings of this study reflect the state of practice during the data collection period. Thirdly, whilst supported by empirical data and relevant theory, the National AI-BIM Framework has not yet been tested in live hotel development projects. Thus, whilst an evidence-based approach to its implementation is provided, its actual application and impact on organizational practices is a topic for future validation. Lastly, this research concentrated on the organizational and management perspectives on the application of AI-BIM Integration.

The technical aspects, including, for instance, algorithm design, software systems development, system integration approaches and security implications of the AI-BIM technologies were outside the scope of this study. The primary focus was on the strategic, organizational capability, governance, and lifecycle information management of AI-BIM implementation in hotel development projects. Notwithstanding these limitations, this study provided reliable evidence for the critical importance of AI-BIM Integration on hotel development performance, as well as a National AI-BIM Framework that provides an evidence-based foundation for future implementation and validation in the near future in Saudi Arabia.

5.10 Future Research Opportunities:

The results of this research open several avenues for future research to extend the current understanding of AI-BIM Integration within hotel development and the wider built environment. While this study contributed an evidence-based National AI-BIM Framework for Saudi Arabia, this framework now should be rigorously validated and evaluated under a range of organizational and project scenarios.

It is therefore recommended that future research involves implementing and validating the framework in live hotel development projects, and quantifying its benefits for project delivery, operational readiness, lifecycle information management, and long-term asset performance. Comparative research studies should also be conducted across various countries and different real estate sectors to investigate the adaptability of the framework to varying regulatory frameworks, organizational structures, and digital maturity levels.

These should include, for example, research in healthcare, commercial, residential and mixed-use developments to generate a holistic understanding of AI-BIM implementation within the built environment. Moreover, research should address the development of organizational digital maturity models and quantifiable maturity assessment tools to gauge organizational preparedness for AI-BIM, and track digital maturity improvements over time. Long-term research studies that track changes in organizational capability, governance processes, and lifecycle information management throughout an implementation programmed are encouraged.

Last, research could explore the integration of novel digital technologies such as Generative AI, Digital Twins, Internet of Things (IoT), predictive analytics, cloud-based Common Data Environments (CDEs) and advanced data analytics within an AI-BIM driven digital environment. This will provide opportunities for further enhancements in intelligent decision making, information continuity, organizational performance, sustainability and lifecycle asset management throughout hotel development projects. In conclusion, future research is needed to extend the theoretical and practical knowledge on AI-BIM Integration as an organizational capability to facilitate digital transformation, improve project outcomes and promote long-term sustainability and competitiveness for the hospitality sector in Saudi Arabia.

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APPENDIX A: QUESTIONARE

Artificial Intelligence and Building Information Modeling Integration: Influence on Hotel Development Performance in Saudi Arabia

Dear Participant,

You are cordially invited to participate in this research conducted as an academic research about the effect of Artificial intelligence (AI) and Building Information Modeling (BIM) on hotel development performance in Saudi Arabia.

Your answers will not be related to you as an individual, and will be entirely confidential, and for academic purposes only.

Please rate your agreement with each statement using the scale provided.

SECTION A: Demographic Information

A1. Current Position *

- | | |
|---|---|
| ☐ Hotel Development Director | ☐ Project Director |
| ☐ Project Manager | ☐ Design Manager |
| ☐ BIM Manager | ☐ Consultant / PMC |
| ☐ Contractor | ☐ Hotel Operator |
| ☐ Investor | ☐ Architect |
| ☐ Facility Manager | ☐ Construction Manager |
| ☐ Other: _____ | |

A2. Years of Experience *

- ☐ Less than 5 years
- ☐ 5–10 years
- ☐ More than 15 years

A3. Did you get involved in hotel development projects? *

☐ Yes

☐ No

A4. Knowledge of Artificial Intelligence *

☐ Basic ☐ Intermediate ☐ Advanced ☐ Expert

A5. BIM Experience *

☐ Basic ☐ Intermediate ☐ Advanced ☐ Expert

SECTION B: Artificial Intelligence in Hotel Development (X1)

Rate your agreement with each statement from 1 (Strongly Disagree) to 5 (Strongly Agree)

Statement / Question	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
AI-1: AI Enhances Hotel Development Market Analysis	☐	☐	☐	☐	☐
AI-2: AI enables more reliable demand forecasting during hotel development planning	☐	☐	☐	☐	☐
AI-3: Better hotel site selection decisions powered by AI	☐	☐	☐	☐	☐
AI-4: AI improves hotel feasibility studies	☐	☐	☐	☐	☐
AI-5: AI improves predicting revenue, estimating expenses and risk in investing	☐	☐	☐	☐	☐

SECTION C: Building Information Modeling (X2)

Rate your agreement with each statement from 1 (Strongly Disagree) to 5 (Strongly Agree)

Statement / Question	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
BIM-1: BIM improves multidisciplinary design coordination	☐	☐	☐	☐	☐
BIM-2: BIM facilitates facility management and maintenance after project completion.	☐	☐	☐	☐	☐
BIM-3: BIM enhances the accuracy of quantity take-off or cost estimation.	☐	☐	☐	☐	☐
BIM-4: BIM enhances collaboration and information sharing among project stakeholders	☐	☐	☐	☐	☐
BIM-5: BIM facilitates project schedule planning and monitoring	☐	☐	☐	☐	☐

SECTION D: AI–BIM Integration (X3)

Rate your agreement with each statement from 1 (Strongly Disagree) to 5 (Strongly Agree)

Statement / Question	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
INT-1: The integration of AI and BIM improves strategic and operational decision-making in hotel development projects.	☐	☐	☐	☐	☐
INT-2: The integration of AI and BIM enhances the identification, assessment, and mitigation of project risks.	☐	☐	☐	☐	☐
INT-3: The integration of AI and BIM improves the accuracy of project cost estimation, forecasting, and cost management.	☐	☐	☐	☐	☐
INT-4: The integration of AI and BIM enhances project schedule planning, progress monitoring, and delay prediction.	☐	☐	☐	☐	☐
INT-5: The integration of AI and BIM improves facility operation, predictive maintenance, and asset lifecycle management in hotel development projects.	☐	☐	☐	☐	☐

SECTION E: Hotel Development Performance (Y)

Rate your agreement with each statement from 1 (Strongly Disagree) to 5 (Strongly Agree)

Statement / Question	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
HP-1: AI and BIM improve the financial performance of hotel development projects.	☐	☐	☐	☐	☐
HP-2: AI and BIM improve stakeholder satisfaction and overall project success.	☐	☐	☐	☐	☐
HP-3: AI and BIM improve Return on Investment (ROI).	☐	☐	☐	☐	☐
HP-4: AI and BIM accelerate hotel project delivery, enabling faster market entry	☐	☐	☐	☐	☐
HP-5: AI and BIM improve the long-term operational performance of hotel facilities	☐	☐	☐	☐	☐

SECTION F: Implementation Challenges In KSA (Descriptive Only)

Rate your agreement with each statement from 1 (Strongly Disagree) to 5 (Strongly Agree)

Statement / Question	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
CH1: High implementation costs limit AI and BIM adoption.	☐	☐	☐	☐	☐
CH2: There is a shortage of qualified AI and BIM professionals.	☐	☐	☐	☐	☐
CH3: Poor availability and quality of project data reduce AI effectiveness.	☐	☐	☐	☐	☐
CH4: Organisational resistance to change slows AI and BIM implementation.	☐	☐	☐	☐	☐
CH5: Limited standards, contractual requirements, and regulatory frameworks hinder AI and BIM implementation in Saudi Arabia.	☐	☐	☐	☐	☐

Thank you for your valuable time and participation!

الملخص

يشهد قطاع الهندسة والعمارة والإنشاء والتشغيل (AECO) تحولاً رقمياً متسارعاً نتيجة التطور المستمر في تقنيات الذكاء الاصطناعي (Artificial Intelligence - AI) ونمذجة معلومات البناء (Building Information Modeling - BIM). ورغم تزايد الاهتمام الأكاديمي والمهني بكل من الذكاء الاصطناعي ونمذجة معلومات البناء بصورة منفصلة، فإن الدراسات التي تناولت التكامل بينهما، ولا سيما في مشاريع تطوير الفنادق بالمملكة العربية السعودية، ما تزال محدودة. وانطلاقاً من ذلك، هدفت هذه الدراسة إلى تقييم أثر الذكاء الاصطناعي، ونمذجة معلومات البناء، وتكاملهما (AI-BIM Integration) في تحسين أداء مشاريع تطوير الفنادق، إضافة إلى تطوير إطار وطني مقترح يدعم التحول الرقمي في هذا القطاع بما يتوافق مع مستهدفات رؤية السعودية 2030.

اعتمدت الدراسة المنهج الكمي وفق الفلسفة الوضعية (Positivism) والمنهج الاستنباطي (Deductive Approach)، واستخدمت الاستبانة المنظمة أداة رئيسة لجمع البيانات من المختصين العاملين في مشاريع تطوير الفنادق بالمملكة العربية السعودية. وتم تحليل (137) استبانة صالحة باستخدام برنامج IBM SPSS Statistics من خلال الإحصاء الوصفي، وتحليل الثبات، وتحليل الارتباط لبيرسون، والانحدار المتعدد، لاختبار فرضيات الدراسة وتحقيق أهدافها.

أظهرت النتائج وجود تأثير إيجابي لكل من الذكاء الاصطناعي، ونمذجة معلومات البناء، وتكاملهما على أداء مشاريع تطوير الفنادق، إلا أن تكامل الذكاء الاصطناعي مع نمذجة معلومات البناء كان العامل الأكثر تأثيراً في تحسين الأداء. وتشير النتائج إلى أن القيمة الحقيقية للتحول الرقمي لا تتحقق من خلال تطبيق كل تقنية بصورة منفصلة، وإنما من خلال دمجها ضمن بيئة رقمية متكاملة لإدارة المعلومات عبر دورة حياة المشروع، بما يعزز جودة اتخاذ القرار، والتنسيق بين التخصصات، وتحسين الأداء التشغيلي، ورفع القيمة طويلة الأجل للأصول.

كما كشفت الدراسة عن عدد من العوامل الرئيسة المؤثرة في نجاح تطبيق تكامل AI-BIM، من أهمها جودة البيانات، وقابلية التشغيل البيئي بين الأنظمة، والجاهزية التنظيمية، والبنية التحتية الرقمية، وتوافر الكفاءات البشرية المؤهلة، الأمر الذي يؤكد أن نجاح التحول الرقمي يعتمد على القدرات التنظيمية والحوكمة وإدارة المعلومات بقدر اعتماده على التقنيات الرقمية.

واستناداً إلى النتائج النظرية والتجريبية، قدمت الدراسة إطاراً وطنياً مقترحاً لتكامل الذكاء الاصطناعي ونمذجة معلومات البناء، يوفر منهجية منظمة لتطبيق AI-BIM عبر جميع مراحل دورة حياة تطوير الفنادق، ويعزز الحوكمة الرقمية، وإدارة المعلومات، وبناء القدرات المؤسسية، والتحسين المستمر. كما يقدم الإطار دليلاً عملياً يمكن أن تستفيد منه الجهات الحكومية، والمطورون، والاستشاريون، والمقاولون، ومشغلو الفنادق، ومديرو المرافق، والمستثمرون، لدعم التحول الرقمي وتحسين أداء المشاريع بما يتوافق مع مستهدفات رؤية السعودية 2030.

الكلمات المفتاحية: الذكاء الاصطناعي، نمذجة معلومات البناء، تكامل الذكاء الاصطناعي ونمذجة معلومات البناء، تطوير الفنادق، أداء مشاريع تطوير الفنادق، التحول الرقمي، المملكة العربية السعودية.

بحث بعنوان

تكامل الذكاء الاصطناعي ونمذجة معلومات البناء لتعزيز أداء تطوير الفنادق في المملكة العربية السعودية: إطار وطني مقترح

إعداد الطالب/

محمد مصدق السعيد

الرقم الجامعي : 253001110

إشراف/

د. الفیصل عبد الحمید

د. فايز جراد

العام الدراسي:

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