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Review Article

Digital Resilience in Construction Projects: A Narrative Review of Data Governance, BIM, and Real-Time Decision Support Systems

*[1]Innocent Junior Opara, [2]Jamiu Lateef, [3]Enoch Nii-Okai, [4]Bright Peter Saah, [5]Elijah Kordieh Mensah, [6]Gopal Fosu Oppong Wiafe, [7]Ayodeji Olayode

About Article

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About Author

[1] Department of Computer Information System, Prairie View A&M University, Texas, USA

[2] Department of Civil and Environmental Engineering, Case Western Reserve University, Cleveland, Ohio, USA

[3] Department of Geological and Mining Engineering and Science, Michigan Technological University, Houghton, USA

[4] Department of Civil and Environmental Engineering, Lehigh University, Bethlehem, PA, USA

[5] Department of Environmental Studies, University of Montana, Missoula, USA

[6] Department of Mining and Minerals Engineering Univeesity of Alaska Fairbanks, USA

[7] Department of Civil Engineering, Federal University, Oye-Ekiti, Ekiti State, Nigeria

Contact @ Innocent Junior Opara
dcentoprah@gmail.com

ABSTRACT

This paper examines how data governance, Building Information Modelling (BIM), and real-time decision support systems (RT-DSS) collectively contribute to digital resilience in construction projects. As the construction sector undergoes rapid digital transformation, the ability to ensure reliable, secure, and adaptable digital systems has become essential for sustaining project performance under uncertainty. Through a narrative synthesis of recent studies, this paper identifies three key dimensions of digital resilience: data integrity through governance frameworks, collaborative integration enabled by BIM, and adaptive decision-making supported by real-time analytics. Together, these dimensions form the foundation of a resilient digital ecosystem capable of anticipating, mitigating, and recovering from disruptions. The paper proposes a conceptual framework that integrates these components into a continuous feedback loop of learning and adaptation, offering a structured pathway for enhancing digital resilience in construction management. The study's main contribution lies in unifying fragmented research on digital technologies into a cohesive theoretical model that links governance, integration, and intelligence as the pillars of resilient project delivery.

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1. INTRODUCTION

1.1. Background

Digital resilience refers to the ability of an organization or a system to be sensitive to digital issues, tackle them, and recuperate effectively and yet maintain its functions properly. This functionality has all gained significant importance separate of the fact that the procedures of construction projects delivery require more and more data-based technologies platforms. The planning of building initiatives and their implementation in a new way have become possible due to Building Information Modeling (BIM), the Internet of Things (IoT), and cloud-based management platforms. Through these tools, much project information can be produced and shared which in turn can enable the individuals collaborate with each other and come up with more informed decisions throughout the project (Zhang *et al.*, 2025).

At the same time, the vulnerability of construction companies to risk is now also greater because digital integration is getting more intensive. Cybersecurity threats, malfunctioning of the system, data corruption, and challenges with supply chains may affect the effectiveness of the project and the time taken. The achievements of these data are the need to develop powerful digital systems that have the ability to withstand uncertainty. Digital resilience is not only a technical goal, but also a strategic necessity that cannot be separated in any way in its relation to the long-term goals of the sector expansion, creativity, and effectiveness(Saeed *et al.*, 2023).

1.2. Problem statement

Although the construction industry is enhancing its capacity to use more complex digital utility, it is still a very long way to go before it can integrate wholly on digital resilience. The problem of data fragmentation is major as it spreads the information by many systems and many people and makes it less reliable and harder to reach. All these problems are worsened by a lack of the proper structure of governance and create a barrier to determining who owns data, helping preserve it, and introducing a gap in the data interoperability of digital tools.

Also, project teams cannot respond to and solve new risks on a timely basis because they do not regularly use real-time support systems (RT-DSS). Lack of integrated processes of making decisions that include data means that organizations face a challenge of changing with changes or continuing to gain pace in times of crisis. It means that the construction industry is still not digital resilient enough to predict, overcome, and recuperate difficulties(Agwa & Celik, 2025).

1.3. Purpose and objectives

This paper aims to explore how data governance, Building Information Modelling (BIM), and real-time decision support systems (RT-DSS) can collectively enhance digital resilience in construction projects. It seeks to integrate existing theoretical and practical perspectives to develop a conceptual framework that connects these three components within a unified resilience model.

The specific objectives are to:

i. Examine how data governance frameworks influence the reliability, accessibility, and security of digital construction data.

ii. Assess the role of BIM in facilitating collaboration, interoperability, and information continuity across project stakeholders.

iii. Evaluate how RT-DSS technologies support adaptive and data-driven decision-making during project execution.

iv. Identify key challenges, gaps, and interdependencies among data governance, BIM, and RT-DSS in achieving digital resilience.

v. Develop a conceptual framework that integrates these dimensions into a cohesive model for resilient digital construction management.

1.4. Structure of the paper

The rest of this paper is organized in the following way:

- Section 2 provides a literature review of digital resilience in terms of its connection with data governance, BIM, and RT-DSS.
- Section 3 explains the research methodology in this narrative review, the selection and synthesis processes.
- Section 4: This section outlines and addresses the main findings and how these digital aspects would enhance resilience in construction.
- Section 5 summarizes the key insights, implications and recommendations on the further research at the end of the paper.

2. LITERATURE REVIEW

2.1. Concept of digital resilience

Generally, resilience can be defined as the ability of a system to recover after interruptions, adapt to the new environment, and revert to the intended activity. The construction process and the company structure were long held to as the concept refers to the construction process in the construction industry. Nevertheless, an emphasis on digital resilience has increased in the recent past courtesy of the greater dependence on interdependent systems and data-driven operations in initiatives. Digital resilience in this case involves how the libs of data and information systems and analytics can remain useful to the operations and decision-making process in the case of error or uncertainty (Zhang *et al.*, 2025).

In the face of a VUCA environment, organizational resilience has become a critical factor in sustaining enterprise performance. This study explores how digital transformation influences organizational resilience through its impact on the key components of organizational systems, specifically innovation capability and agile response. Using data from Chinese A-share listed firms over the period 2007–2023, the study finds that digital transformation significantly enhances organizational resilience, with robust results across various tests. The analysis highlights that digital transformation strengthens resilience by optimizing innovation capability and improving agility within organizational systems. Heterogeneity tests reveal that these effects are particularly strong in firms located in eastern and central regions, operating in capital-intensive industries, and at growth or maturity stages. These findings underscore the systemic role of digital transformation in building adaptive, resilient organizations that can better navigate uncertainty and complexity. This study contributes to understanding the dynamic interplay between digital technologies and organizational systems, offering practical insights for enterprises aiming to

leverage digital transformation for sustainable growth and high-quality economic development (Zhang *et al.*, 2025).
Digital resilience is viewed more as a dynamic capability than an unalterable characteristic in terms of systems. It offers a dependable technical base (stable systems and infrastructure), data integrity (timely and precise data), and adaptable decision-making (possibility to change procedures or tactics in regard to new information). This approach goes beyond traditional ICT-related concerns (including cybersecurity and unavailability) to include activities like process maintenance, collaboration to solve problems, as well as learning as a team. Digitally resilient project teams in the real world proactively plan in advance, make adaptation to risk when needed, and use information obtained, almost real timely, to be productive in case of unexpected situations.
This improvement is based on the principles of the complex adaptive systems thinking and risk management. These bodies of work view projects as collections of people, tools and processes. The ability of many persons to respond to, perceive and feel the environmental changes gives resilience. Digital technologies can offer technical capabilities and also create learning and collaboration opportunities to increase the resilience of projects in the long term (Li & Sukhotu, 2025).

2.2. Data governance and information management

Data governance represents a set of laws, functions, and processes that ensure the precision, security, and usefulness of the data at any time. The issue of governance in the construction industry is especially severe since many forms of data are used throughout the construction process, both when designing, procuring, and operating a building. Good governance sets proper principles on how information should be acquired and used, the privacy and integrity of the information, and the owners of a given data (Onoja *et al.*, 2021).
Weak governance is commonly associated with real world issues in the research, including inconsistent naming and formatting policies, record duplications and accountability deficit. Clients, designers, contractors, subcontractors and suppliers are the people involved in construction works. All these individuals have various tools and data standards. In the event of the absence of governance, it is this diversity that leads to fragmentation and less useful data in decision making (Zheng *et al.*, 2024).
The standard of ISO 19650 and similar standards are frequently used as a base point as they establish explicit rules, methods and expectations of how information should be handled. Overall, good governance causes things to be clearer, easier to get information, and it provides the stakeholders with increased confidence in collective knowledge. Companies can be able to solve issues as they arise and they can make future plans when there are guidelines in place since they are aware that information, they possess is practical (Abanda *et al.*, 2025).

2.3. Building Information Modeling (BIM)

The current trend is Building Information Modeling (BIM) as the most prevalent way of bringing together all the information regarding a project. BIM is a virtual environment where anybody is able to visualize their work, plan it, and coordinate. It integrates geometry, schedules, cost and data of performance. The actual benefits, less disagreements, less on-site surprises, and better teamwork, are a reality as there is a lot of evidence to that effect.
BIM assists in resilience not only in keeping things in order. It maintains flow of information and allows simulation. Individuals will be able to test the outcome of what-if on the data of other fields. This aspect assists in future planning and in many instances contributes towards flexibility of teams when things fail to go as planned since it is possible to make decisions according to an existing integrated information on the project (Rodríguez & Francisco, 2023).
Keeping this in consideration, BIM maturity is highly varied in various parts of the industry. Among the common challenges are that there is no uniformity in standards, integrating between various apps is often difficult and companies do not wish to alter their ways of doing things. To address these gaps, we should have better governance, more funding in platforms to work in collaboration and a culture change to utilize information to make decisions and share good practices (Bayzidi *et al.*, 2025).

2.4. Real-time decision support systems (RT-DSS)

Real-Time Decision Support Systems (RT-DSS) refers to the technology and processes of collecting real time data, analyzing it and providing it with practical guidance to the decision makers. RT-DSS applications in construction usually include the data provided by IoT sensors and equipment telematics as well as logistical records and increasingly by digital twins and machine learning models. The aim is to see instantly whether the plan is deviated or not; whether it is a late delivery, some environmental risk or unexpected drop in production and also assist in rectifying the situation (Kayvanfar *et al.*, 2024).
Feedback loops and RT-DSS are one thing. Continuity provides alarms and visualizations that help the teams make decisions on the first step to be taken. Using digital twin simulations, you can simulate ways of preventing problems even before you implement them at the place of work. This reduces the risk of wrong going on. The predictive models, as well as the simple thresholds, are analytical techniques that make the early warning systems even superior (Carneiro *et al.*, 2021).
This is not something to be easily implemented. RT-DSS projects are generally very expensive initially and the data sources are not sufficiently integrated, neither can they be easily integrated with the older project management systems. It should have data pipelines that can interface with one another, a governance plan that ensures that the data is of high quality and BIM-based processes in order that insights may be assemble to generate a clear vision of the project.

2.5. Interconnectedness and theoretical integration

Data governance, BIM and RT-DSS come together to build a tightly integrated chain of tools that guarantee the smooth running of digital systems. Governance sets the rules and standard requirements that ensure the reliability of the data. The multidisciplinary, structured warehouse of storing most of the information where the data is put into context is BIM. RT-DSS converts contextual information to information which is almost real-time and can be utilized to make decisions(The Role of Data Governance in Ensuring System Success and Long-Term

IT Performance: A Systematic Review[v1] | Preprints.Org, n.d.). The three-way communication acts as a resilience architecture: The governance brings about trust in the inputs, BIM offers integration and a common understanding and RT-DSS offers flexibility and quickness. It has been found among the literature that resilience is not the outcome of one type of technology; it is the outcome of interactions between many components in technical and organizational ecosystems.

In line with the theoretical frameworks of socio-technical systems and cyber-physical integration, this concept proves right when the performance of the personnel, the tools, the policy and the procedure are in agreement. Resilience and ability to adapt to challenges and recover can be achieved through the use of standards, interoperable platforms, training, and learning that is continuous (Bressane *et al.*, 2024).

2.6. Critical analysis of literature

While previous studies have established the technical functions of data governance, BIM, and RT-DSS, there remains limited critical understanding of how these systems jointly enable or constrain digital resilience. Data governance is frequently presented as a procedural safeguard, yet it also determines organizational adaptability; overly rigid governance models may ensure compliance but stifle innovation and rapid decision-making. Similarly, BIM enhances information integration, but its resilience benefits depend on cross-organizational maturity, data interoperability, and a culture of transparency conditions that are unevenly developed across the sector. RT-DSS technologies promise real-time adaptability, but they introduce dependencies on data quality, algorithmic reliability, and user competence. Few studies interrogate the trade-offs between automation and human judgment or the ethical implications of algorithm-driven decisions during crises. Taken together, the literature suggests that digital resilience is less a product of individual technologies than of the alignment among governance, collaboration, and intelligence systems. A truly resilient digital ecosystem therefore requires not only technical integration but also organizational learning, data ethics, and leadership commitment.

3. METHODOLOGY

3.1. Research design

This study employed a narrative research design, as it base its approach to qualitative interpretation, rather than statistical remuneration. The aim is to develop a developed conceptual framework of the digital resilience in the construction project through synthesis and interpretation of already existing theoretical and empirical studies. This approach is different to systematic or meta-analytic approaches in that it harmonizes a wider spectrum of academic and industrial opinions, thus supporting a more comprehensive understanding of the mechanisms through which digital systems can help to bring resilience.

3.2. Searching strategy

To discover scholarly sources, we used trusted academic databases such as Scopus, Web of Science, ScienceDirect, and Google Scholar. To minimize the number of search results, Boolean operators and specific keyword combinations such as digital resilience, data governance in construction, Building Information Modeling, and real-time decision support systems were applied. The search was conducted recursively and focused on publications from 2010 to 2025, encompassing both foundational and recent studies on digital transformation and resilience in the construction sector.

3.3. Selection criteria

The criteria used to select them were their relevance, credibility, and efficacy to the issues of resilience and digitization. Peer-reviewed and published papers on the topic and published in 2010 and 2025 were considered the most important ones. To give the works a practical point of view, they also included large industrial publications and professional standards, like ISO 19650. Such a mix of scholarly and professional pieces of information made sure that the theoretical and practical sides were adequately represented.

3.4. Examining and assembling information

The literature that was selected was subjected to thematic analysis so as to establish recurring themes and conceptual associations and gaps in the current research. The findings were divided into 3 major themes: 1. Data governance and digital resilience 2; BI modeling and design-scenarios; and 3. On the spur of the moment decision making and dynamic management.

We did not use quantitative synthesis software, e.g., PRISMA guidelines or citation counts because our major goal was to synthesize ideas and not to contrast the numbers. On the other hand, the assessment involved the teamwork of digital governance, modeling and analytics to improve the efficacy of construction practices.

Although this paper follows a narrative review design, the literature search and selection were conducted systematically to ensure transparency and reproducibility. The process included four main stages: identification, screening, eligibility assessment, and inclusion. Table 1 summarizes the number of records at each stage.

Table 1. Summary of literature search and selection process.

Stage	Description	Number of Records
Identification	Articles retrieved from databases (Scopus, Web of Science, ScienceDirect, Google Scholar) using Boolean keyword combinations such as *"digital resilience," "data governance," "BIM," and "real-time decision support systems"*	287
Screening	Duplicates and non-English papers removed; titles and abstracts reviewed for relevance	121

Eligibility	Full-text review of relevant studies focusing on data governance, BIM, or RT-DSS within construction contexts	68
Included	Final papers meeting relevance, credibility, and thematic alignment criteria	42

The selected studies (n = 42) represented both academic research and industry publications published between 2010 and 2025. The mix ensured theoretical and practical balance. Although quantitative synthesis (e.g., meta-analysis) was not feasible due to conceptual diversity, the selection process followed transparent, stepwise screening consistent with narrative review standards.

4. RESULTS AND DISCUSSION

4.1. Key themes and insights

In the literature review, three related themes were identified such as reliable data, responsive decision-making, and digital integration as critical to the creation of digital resilience in construction projects.

First, collaboration facilitation and the exchange of all information on the project is provided by implementing digital integration tools (Building Information Modeling or BIM and systems of real-time information). When all the design, procurement, operation data are located on the same digital space, it is easier to communicate and cooperate. Such an integrated structure does not only ease the observation of project undertakings by project teams but also helps the stakeholders to recognize the possible hazards in a project beforehand, so that they can rectify the problems before they deteriorate (Miao *et al.*, 2024).

The second factor is the most important aspect of reliability of data, and it is based on it all reliable digital systems are built. Good data governance is one that makes sure that the information which is passed across the BIM and real-time platforms is uniform, accurate, and safe. The integrity of the data ensure that project teams make decisions in a more confident manner, which leads to a decrease of the level of uncertainty and enhances results. To conclude, the governance mechanisms are the building block of the digital resilience to grant all processes on trustful data (Jayathilaka *et al.*, 2024).

Lastly, responsive decision making is one example of how resilience may evolve over time. IoT devices, real-time analytics, and predictive models should assist the decision-makers to stop responding to the calamities, but forecast and prevent them. Managers require these talents to ensure that things remain in smooth running even in situations when change or unpredictability of circumstances occur. This has the advantage that the companies are able to survive until such time when things go astray (Kolivand *et al.*, 2025).

Table 1 provides an overview of various roles, key enablers, challenges and contributions of the three key fragments in collaboration with each other to transform the construction projects into a more digital-strong entity.

Table 2. Summary of literature identification, screening, and inclusion process for the narrative review

Component	Primary Function	Key Enablers	Challenges	Contribution to Digital Resilience
Data Governance	*Defines rules, standards, and accountability for data management and security.*	ISO 19650 compliance, data ownership protocols, interoperability frameworks.	Fragmented data systems, inconsistent formats, unclear accountability.	Builds data integrity and reliability across all project phases, providing the foundation for well-informed decisions(Eke & Stahl, 2024).
Building Information Modeling (BIM)	Integrates project data in a shared digital workspace covering design, construction, and operations.	3D visualization tools, cloud-based collaboration, common data environments.	Low BIM maturity, limited adoption, interoperability issues.	Improves coordination, predictive analysis, and knowledge continuity throughout the project lifecycle(Miao *et al.*, 2024).
Real-Time Decision Support Systems (RT-DSS)	Enables adaptive, data-driven decision-making using continuous project monitoring.	IoT sensors, digital twins, analytics dashboards, real-time metrics.	High implementation costs, fragmented data flows, skills shortages.	Strengthens proactive risk management, situational awareness, and operational flexibility(Abikoye *et al.*, 2024).

Source: Compiled by the authors from literature synthesis (2010–2025).

4.2. Obstacles to digital resilience

Although digital technologies have the potential to support the sustainability of the construction infrastructure, it still faces many challenges that may hinder its full usage and application. One of the major challenges that remain is the unwillingness of the businesses to implement the digital technologies. Still, there are many institutions, which follow outdated management trends, according to which digital operations are unnecessary or harmful. People that do not know about computers, or simply do not want to spend money on the training, often maintain this point of view (Thirumal *et al.*, 2024).

The second major problem is that data silos persist. This implies that knowledge is still scattered across software systems which do not work together. Such fragmentation makes passing of data in time and effectively a very difficult process. This might lead to the owing of project teams doing the same work several times or not comprehending the action of other teams. Also, the lack of clear standards of data governance makes the maintenance of consistency and accountability difficult. It leads to the loss of trust in digital data and analysis erroneousness (Thirumal *et al.*, 2024).

The problems are also worsened by the fact that technology is comprised of numerous elements. The BIM platforms, databases and decision-support systems are more difficult to co-operate and share information when they are independent. To curb these difficulties, we must as an urgent measure invest in technology and introduce an equitable organizational restructuring. To create a flexible and powerful project environment, it is important to promote the governance frameworks, guarantee that the entire staff follows the same data management rules, and develop a digital collaboration culture.

4.3. Digital resilience integrative framework

Figure 1 illustrates a conceptual framework that illustrates the collaborative efforts of data governance, Real-Time Decision Support Systems (RT-DSS), and Building Information Modeling (BIM) to establish a digital resilience framework.

• Data Governance is a collection of regulations that regulate the security, consistency, and integrity of data. It ensures that all digital processes are founded on information that can be verified and trusted.

• The primary location for the convergence of data from a variety of sources is Building Information Modeling (BIM). It facilitates the exchange and interpretation of information among project teams by simplifying the process of visualizing, collaborating, and formulating predictions.

• Real-Time Decision Support Systems (RT-DSS) subsequently utilize these data streams to produce pertinent information that enables individuals to make informed and timely decisions during the course of a project (Jones *et al.*, 2023).

A learning and feedback loop that never concludes is created by the combination of these three elements. Data governance ensures that the information is accurate and dependable. BIM organizes and interprets it, while RT-DSS converts it into strategic actions. This loop becomes increasingly robust as initiatives evolve and organizations acquire additional knowledge. This results in the construction industry's digital ecosystems being more resilient, adaptable, and intelligent (Brous *et al.*, 2020).

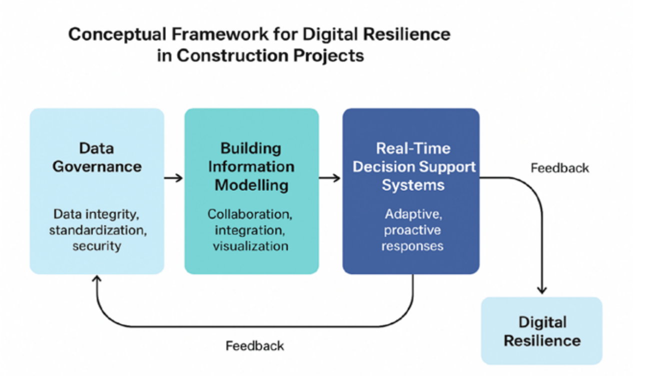

Figure 1. Conceptual framework for digital resilience in construction projects: interactions among data governance, bim, and real-time decision support systems.

4.3.1. Critical discussion: integration challenges and theoretical advancement

Despite the apparent complementarity of data governance, BIM, and RT-DSS, their integration remains complex due to deep socio-technical tensions within the construction ecosystem.

At a technical level, incompatibilities among data standards, legacy systems, and proprietary software hinder seamless data exchange. Each subsystem governance platforms, BIM environments, and decision-support tools operates with distinct data structures and ownership protocols, making interoperability both technically demanding and politically sensitive.

However, the more persistent obstacles are organizational and cultural. Data governance introduces formality, accountability, and compliance, while BIM and RT-DSS demand flexibility, collaboration, and rapid iteration. These conflicting logics control versus adaptability often create resistance among stakeholders. Managers fear data exposure or loss of authority; professionals struggle with shifting responsibilities and steep learning curves. Such human-organizational frictions demonstrate that digital resilience is not purely an engineering problem but a social coordination challenge embedded within institutional norms and power dynamics.

The proposed Digital Resilience Integrative Framework advances existing theory by reconceptualizing resilience as an emergent property of socio-technical alignment, rather than as a static technological capability. Unlike earlier models that treat governance, modeling, and analytics as isolated enablers, this framework situates them within a continuous feedback cycle of data validation (governance), integration (BIM), and intelligent adaptation (RT-DSS). It therefore bridges the gap between descriptive digital-tool literature and resilience theory by emphasizing learning loops, cross-system coherence, and organizational reflexivity as essential to sustainability.

Ultimately, this integration reframes digital resilience from a technological ambition into a dynamic governance practice, where both human judgment and machine intelligence co-evolve. Future empirical studies should examine how this alignment unfolds in real project environments, what governance structures enable it, and how organizational culture mediates its success.

4.4. Consequences for research and practice

The results also show that construction organizations need to place data governance as an important strategic goal, as opposed to a minor consideration. When clear governance structures are in place it becomes easier to standardize, secure and manage project information on different digital platforms. Using real-time analytics in BIM processes, the projects can become much more transparent and help the team to recognize the problems in the processes in a very early environment and provide the solution to them as they reveal(Hua *et al.*, 2025).

Digital resilience does not just simply emphasize the human factor. Business organizations should develop a digital culture that values openness and lifelong learning, hires specific leaders, and trains their workers to make the deployment of the new technology. Without these social and management elements, most likely, well-designed digital solutions cannot be regarded as effective.

Future studies ought to go beyond theoretical research to determine quantifiable measures of assessing digital resiliency in the construction industry. This would include frameworks or models that evaluate how real-time decision-making capabilities, the adoption of BIM and data governance maturity would influence the project outcomes. To explain how the concept of feedback loops in digital ecosystems is applicable in aiding adaptive learning and constant performance adaptations over time, longitudinal or case-based studies would be especially beneficial (Ye, 2025).

5. CONCLUSION

The purpose of this study was to examine the concept of digital resilience in the construction sector, especially relating to the relationship between data governance, Building Information modeling (BIM) and Real-Time Decision Support Systems (RT-DSS). The findings suggest that the ability to become resilient in a digital construction environment is achieved not through the use of individual tools, but by facilitating the fact that they are well connected and aligned with the collective goals.

Data governance defines the pre-conditions as it ensures that participants of the project can access and use information and keep it. BIM reinforces this ground by offering people with a platform upon which they hand-in-hand in planning and coordination through modeling data in various dimensions. RT-DSS enhances such properties by converting composite data into useful information that can be used by individuals to take real time, evidence-based decisions.

When these components are used in combination, the organization will be more flexible because the learning and adaptation cycle created will contribute toward it. Project teams will gain skills of immediate predictions of risks, immediate decisions upon occurrence of adversity, and immediate recovery of velocity when adversity strikes. This integration then leads to a culture of never-ending growth, reinforces choices, and clears the situation in the lifecycle of the project.

Nevertheless, its limitations are also mentioned in the review. The interpretation of the author and the examined content affects the conclusions, and little empirical evidence is provided on the application of the digital resilience frameworks to the real construction projects.

Future studies in the area should aim at creation of digital resilience maturity models to determine the readiness and competence of an organization. Empirical validation of empirical studies through large scale case studies or longitudinal studies would be a deeper way to understand the interaction between governance structure, BIM integration and real time analytics, in practice. These researches will play a crucial role in the reinvention of the theoretical framework into the practical approaches that will help the construction sector to create a more resilient, data-intensive, and adaptable digital future.

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