GREEN BUILDING CONFERENCE
INNOVATIVE SOLUTIONS FOR A GREENER BUILT ENVIRONMENT

DOI: **10.5937/greenb26064K**
Review paper

APPLICATION OF DIGITAL TECHNOLOGIES IN THE DEVELOPMENT OF GREEN BUILDINGS: EXPERIENCES FROM SOUTH KOREA

Dragana Kerkez[1], Svetlana Nešović[2], Ivan Nešović[3], Jovana Krstić[4]

Abstract

In the context of climate change and rapid urbanization, the construction sector plays a crucial role in achieving sustainable development. This paper analyzes the role of BIM, IoT, Digital Twins, and AI in green building development, with emphasis on South Korea. Using a qualitative case study approach (Songdo, Sejong, Busan Eco Delta City), the findings show that integrating these technologies optimizes energy performance and resource management. Successful implementation requires institutional support, data standardization, and long-term strategy. South Korea's experience offers valuable lessons for advancing sustainable construction in Serbia.

Key words: *Green buildings, Building Information Modeling (BIM), Internet of Things (IoT), Digital Twins, Energy efficiency*

[1] Research Associate, Faculty of Applied Sciences Niš, University Business Academy Novi Sad, Serbia draganakerkez5@gmail.com, ORCid 0009-0008-2973-0791
[2] PhD, Associate professor, Faculty of Applied Sciences Niš, University Business Academy Novi Sad, Serbia, risticsvetlanaaa@gmail.com, ORCid 0000-0002-5927-9048
[3] PhD, Teaching Assistant, Faculty of Civil Engineering and Architecture, University of Niš, Serbia, ivan.nesovic@gaf.ni.ac.rs, ORCid 0009-0009-2169-7613
[4] PhD, Full professor, Faculty of Applied Sciences Niš, University Business Academy Novi Sad, Serbia, jovanaveljkovic86@gmail.com, ORCid 0000-0002-8269-0142

1. INTRODUCTION

Previous studies have demonstrated that smart technologies play a significant role in achieving sustainable development goals through improved energy efficiency, resource management, and enhanced resilience of urban systems [1, 2]. The Republic of Korea, through the development of smart cities such as Sejong, Songdo, and Busan Eco Delta City, has demonstrated the potential of integrating digital platforms, sensor networks, and data analytics systems into sustainable urban development [3, 4]. However, urban sustainability depends not only on infrastructure and city-wide systems but also on the performance of individual buildings that constitute the urban environment. In this context, green buildings represent the fundamental functional units of sustainable cities. Their importance is reflected in reducing energy consumption, promoting the efficient use of natural resources, and minimizing carbon dioxide emissions throughout the entire building life cycle [5, 6]. The development of green buildings is increasingly linked to the digital transformation of the construction sector. Technologies such as Building Information Modeling (BIM), the Internet of Things (IoT), Digital Twins, and Artificial Intelligence (AI) enable the collection, processing, and analysis of data during the design, construction, and operation phases of buildings, generating significant environmental, economic, and operational benefits [7, 8]. The aim of this paper is to analyze the application of BIM, IoT, Digital Twins, and Artificial Intelligence in the development of green buildings, with particular emphasis on the experiences of the Republic of Korea and the potential for their implementation in the Republic of Serbia. Based on the research objective, the following research questions were formulated:

1. How are BIM, the Internet of Things (IoT), Digital Twins, and Artificial Intelligence (AI) applied in the development of green buildings in the Republic of Korea?
2. What are the key technological, regulatory, and institutional mechanisms that support the integration of these technologies within the Korean context?
3. Which elements of the Korean model can be adapted and implemented in the Republic of Serbia, considering its economic, institutional, and developmental specificities?

The answers to these questions are derived through case study analysis and a comprehensive literature review, as described in the following section.

2. MATERIALS AND METHODS

This study adopts a qualitative research strategy based on the integration of a case study approach and a systematic literature review. Such a combined methodology enables a deeper understanding of complex phenomena within their real-world context while ensuring the theoretical grounding of the findings [8].

2.1. Case Study Selection

The case studies were selected through purposive sampling according to the following criteria:

- Representativeness – the selected projects are widely recognized in academic literature and international reports as leading examples of smart city development in South Korea.
- Diversity – the projects represent different stages and approaches to smart city development, including Songdo as an early smart city concept, Sejong as a national pilot project, and Busan Eco Delta City with a strong focus on climate resilience.
- Data availability – all selected cases are supported by official reports, peer-reviewed publications, and documents published by international organizations.

Based on these criteria, the following case studies were analyzed: Songdo International Business District, Sejong Smart City, and Busan Eco Delta Smart City.

2.2. Data collection and analysis process

Data collection involved a review of scientific publications indexed in Scopus, Web of Science, and Google Scholar. In addition, official documents issued by the Government of the Republic of Korea, the Ministry of Land, Infrastructure and Transport, as well as reports published by the World Bank and the OECD, were analyzed. Only publications published between 2010 and 2025, written in English or Korean, and focused on the application of digital technologies in sustainable construction were included in the analysis. The collected data were analyzed using thematic analysis. The reviewed materials were coded according to predefined thematic categories, including BIM applications, IoT applications, Digital Twin applications, Artificial Intelligence applications, regulatory and institutional mechanisms, as well as barriers and implementation challenges. Based on these thematic codes, conclusions were drawn regarding the patterns of digital technology integration within South Korean green building projects. To facilitate understanding of the research process, Figure 1 presents a schematic overview of the methodological framework employed in this study. The framework illustrates the sequential flow from case study selection through data collection, thematic analysis, and synthesis of findings. This structured approach ensures transparency and replicability of the research process.

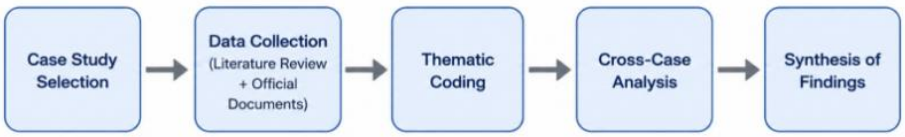


Figure 1. *Methodological framework: Case study selection → Data collection (literature review + official documents) → Thematic coding → Cross-case analysis → Synthesis of findings*

3. RESULTS AND DISCUSSION

3.1. Integration of Digital Technologies in Korean Green Building Projects

The analysis of the three case studies reveals distinct patterns in the application of digital technologies for green building development in South Korea. Table 1 provides a comparative overview of how BIM, IoT, Digital Twins, and AI are implemented across

the selected projects, highlighting both common approaches and project-specific characteristics.

The comparative analysis reveals that Songdo, as the earliest project, focused primarily on foundational infrastructure and integrated systems, establishing a baseline for subsequent developments [9]. Sejong represents a more advanced iteration, with stronger emphasis on data integration and predictive analytics, while Busan demonstrates the most sophisticated integration, particularly in the context of climate resilience and adaptive management. This evolutionary pattern suggests a learning trajectory in Korean smart city development, where each subsequent project builds upon the technological and institutional lessons of its predecessors.

Table 1. Comparative Analysis of Digital Technology Applications in South Korean Green Building Projects

Technology	Songdo IBD	Sejong Smart City	Busan Eco Delta City
BIM	Integrated BIM for design and construction coordination; LEED certification support	National BIM standards applied; energy performance simulation for all public buildings	BIM models integrated with GIS for flood risk assessment and climate resilience planning
IoT Sensors	Extensive sensor networks for energy monitoring; smart metering in all commercial buildings	Real-time monitoring of indoor environmental quality; smart water management systems	Comprehensive environmental monitoring (water quality, air quality, temperature); AI-integrated sensor networks
Digital Twins	City-scale digital twin for infrastructure management	Building-level Digital Twins for energy optimization; urban-scale simulation platform	Climate adaptation Digital Twin; building performance simulation for extreme weather scenarios
Artificial Intelligence	Predictive maintenance for building systems	AI-driven HVAC optimization; predictive energy demand forecasting	Machine learning for flood prediction; AI-optimized building energy management

Source: Authors' compilation based on analysis of Songdo IBD [9, 10], Sejong Smart City [3, 11], and Busan Eco Delta Smart City [4, 12]

3.2. Key Findings from Case Study Analysis

The analysis of the three case studies yields the following key findings:

Songdo International Business District: As one of the world's first large-scale smart city projects, Songdo demonstrates the importance of integrating digital infrastructure from the earliest planning stages. The project's building management systems

continuously monitor energy consumption and environmental conditions, achieving approximately 30% energy savings compared to conventional buildings [9]. However, the project also illustrates challenges, including high initial costs and the need for continuous system upgrades [13]. Sejong Smart City: Sejong represents a more comprehensive approach, integrating national BIM standards and establishing a Digital Twin platform for both urban and building-level management. The project has achieved significant improvements in energy efficiency, with public buildings demonstrating 25-35% reductions in energy consumption through AI-optimized HVAC systems [14]. The national pilot status of Sejong has enabled systematic testing and validation of innovative technologies. Busan Eco Delta Smart City: This project demonstrates the most advanced integration of digital technologies for climate resilience. The combination of AI-enhanced flood prediction models, real-time environmental monitoring, and Digital Twin simulation capabilities enables proactive adaptation to climate change impacts. The project's focus on water management and climate resilience distinguishes it from the other two case studies [4, 15].

3.3. Enabling Factors and Barriers

The cross-case analysis identifies several key enabling factors for successful digital technology integration in green building development. Strong government leadership and strategic planning emerge as critical success factors, with South Korea's national smart city strategy providing both funding and regulatory support [3]. Institutional capacity building, including training programs for BIM and digital literacy, has also been essential [16]. Furthermore, the establishment of data standards and interoperability frameworks has facilitated integration across different systems and platforms [17]. However, several barriers persist. High initial investment costs remain a significant challenge, particularly for smaller projects and retrofits. The complexity of integrating multiple technologies and ensuring interoperability between different systems also presents technical challenges [7]. Data privacy and security concerns, particularly regarding IoT sensors and building-level monitoring, require careful attention [16]. Finally, the shortage of skilled professionals with expertise in both digital technologies and sustainable construction continues to limit implementation capacity [18].

4. DIGITAL TECHNOLOGIES IN GREEN BUILDING MANAGEMENT

4.1. BIM as the Foundation of Digital Transformation

In South Korea, BIM has become one of the key digital technologies supporting the transition toward sustainable construction [13]. Since the implementation of the national BIM roadmap, its application has become mandatory for many public construction projects managed by the Public Procurement Service (PPS) and the Ministry of Land, Infrastructure and Transport (MOLIT) [14]. BIM has been widely adopted in large-scale projects, including administrative buildings, transport infrastructure, hospitals and public housing developments. The integration of BIM with energy simulation tools enables designers to evaluate alternative design solutions

during the early planning stages, resulting in improved energy performance and reduced embodied carbon [19]. In projects certified under the Korean Green Standard for Energy and Environmental Design (G-SEED), BIM supports compliance with energy efficiency requirements by facilitating daylight analysis, thermal simulations and life-cycle assessment [20]. These applications have significantly reduced design conflicts, shortened construction time and improved resource efficiency throughout the project life cycle.

4.2. IoT Sensors and Real-Time Data Collection

South Korea has extensively deployed IoT-based monitoring systems in green buildings and smart city districts such as Songdo International Business District, Sejong Smart City and Busan Eco Delta City [16]. Thousands of sensors continuously collect information on indoor environmental quality, occupancy, electricity consumption, water use and HVAC performance [17]. These data are integrated into centralized Building Management Systems (BMS), allowing real-time optimization of building operation. Several demonstration projects have reported energy savings ranging from approximately 15–30% through AI-supported HVAC optimization and occupancy-based lighting control [20]. Continuous monitoring also improves predictive maintenance and reduces operational costs while maintaining occupant comfort.

4.3. Artificial Intelligence and Digital Twins for Building Performance Optimization

South Korea is among the leading countries in implementing Digital Twin technology at both city and building scales [19, 21]. The national Digital Twin initiative, coordinated by MOLIT, has established digital replicas of urban infrastructure to support planning, maintenance and disaster management. At the building level, Digital Twins integrate BIM models with real-time IoT data to monitor energy performance, HVAC operation and indoor environmental quality [22]. In Songdo and Sejong smart cities, Digital Twin platforms are connected with urban Data Hubs, enabling simulation of different operational scenarios before implementation [22]. Artificial intelligence processes historical and real-time datasets to predict energy demand, detect equipment anomalies and optimize system performance. These technologies contribute to lower operational energy consumption, reduced maintenance requirements and improved carbon management.

4.4. Net-Zero Energy Buildings (NZEB) as a Future Development Direction

One of the most significant trends in contemporary sustainable construction is the development of Nearly Zero Energy Buildings (nZEBs) and Net-Zero Energy Buildings (NZEBs). These buildings are designed to minimize energy consumption while meeting their remaining energy demand through renewable energy sources. The implementation of BIM, IoT, Digital Twins, and Artificial Intelligence is a key prerequisite for the successful development of NZEBs. BIM enables energy performance simulations

during the design phase, IoT sensors provide continuous operational monitoring, while AI-based systems optimize energy consumption in real time [7, 11]. The development of NZEBs is particularly important in the context of European and global climate objectives, given that the building sector remains one of the largest consumers of energy and contributors to greenhouse gas emissions [21]. Consequently, net-zero buildings are expected to become one of the principal directions of sustainable construction development in the coming decades.

5. SOUTH KOREA AS AN EXAMPLE OF INTEGRATING DIGITAL TECHNOLOGIES AND GREEN BUILDINGS

The Republic of Korea is recognized as one of the global leaders in the implementation of smart city concepts and the integration of digital technologies into sustainable urban development. Through strategic government initiatives, substantial investments in digital infrastructure, and long-term planning, South Korea has developed several internationally recognized projects that combine smart city principles with environmental sustainability objectives. The most prominent examples include Songdo International Business District, Sejong Smart City, and Busan Eco Delta Smart City. These projects demonstrate how advanced digital technologies can contribute to the development of energy-efficient, resource-efficient, and environmentally responsible buildings and urban environments.

5.1. Songdo International Business District

Songdo International Business District represents one of the world's first large-scale smart city projects developed from the ground up. Beyond its smart city infrastructure, Songdo has achieved significant green building outcomes. The district includes multiple buildings certified under LEED and Korea's G-SEED certification system, with integrated building management systems enabling energy savings of approximately 30% compared to conventional buildings [23, 24]. The implementation of BIM throughout the design and construction phases facilitated coordination among stakeholders and enabled early-stage optimization of building energy performance. The district's centralized systems, including automated waste collection and district heating and cooling, demonstrate how building-level technologies can be integrated with urban-scale infrastructure to achieve sustainability goals [24].

5.2. Sejong Smart City

Sejong Smart City represents South Korea's flagship national smart city project, with particular emphasis on building-level innovation. The project mandates BIM for all public buildings, with integrated energy performance simulation and optimization throughout the design process [25, 26]. Public buildings in Sejong incorporate renewable energy systems, smart HVAC technologies, and AI-driven energy management, achieving 25-35% reductions in energy consumption. The Digital Twin platform extends to individual buildings, enabling real-time performance monitoring

and predictive maintenance. This building-level focus, combined with national BIM standards and data integration frameworks, makes Sejong a comprehensive testbed for green building technologies and practices [25].

5.3. Busan Eco Delta Smart City

Busan Eco Delta Smart City represents a new generation of smart city development characterized by a strong emphasis on climate resilience and environmental sustainability at the building level. The project integrates advanced water management systems, renewable energy technologies, and extensive IoT sensor networks that monitor building performance in real time [27, 28]. Buildings in Busan incorporate AI-assisted HVAC optimization, predictive maintenance systems, and climate-responsive design features. The Digital Twin platform enables building-level simulation of energy performance under various climate scenarios, supporting proactive adaptation to climate change. Through the integration of digital technologies and ecological principles at both urban and building scales, Busan Eco Delta City demonstrates how smart cities can contribute to both climate adaptation and sustainable development objectives [29].

6. IMPLICATIONS FOR SERBIA

The experiences of the Republic of Korea provide valuable insights for the future development of sustainable construction and digital transformation within the Serbian building sector. However, the direct transfer of Korean models is neither feasible nor desirable due to differences in economic conditions, institutional capacities, regulatory frameworks, and technological maturity. Instead, Serbia should focus on the gradual adoption of digital technologies through pilot projects, capacity-building initiatives, and the development of an appropriate regulatory environment. Particular attention should be given to strengthening BIM competencies, promoting interoperability standards, and establishing integrated digital platforms for building and infrastructure management. Public buildings represent a particularly suitable starting point for implementing innovative solutions. Schools, hospitals, administrative buildings, and other publicly owned facilities could serve as demonstration projects for the application of BIM, IoT technologies, Digital Twins, and Artificial Intelligence. Such projects would contribute not only to improved energy efficiency but also to the development of local expertise and institutional knowledge. Furthermore, stronger collaboration between government institutions, industry stakeholders, universities, and research organizations is essential for accelerating the adoption of digital technologies in the construction sector. The establishment of national standards and long-term strategic frameworks would provide additional support for sustainable digital transformation.

7. CONCLUSION

Contemporary challenges related to sustainable development, climate change, and increasing energy consumption require new approaches to the design, construction, and management of buildings and urban environments. The analysis of South Korean experiences confirms that the successful implementation of these technologies depends not only on technological innovation but also on institutional support, data standardization, long-term investment, and strategic planning. Projects such as Songdo International Business District, Sejong Smart City, and Busan Eco Delta Smart City illustrate how digital technologies can effectively connect the concepts of smart cities and green buildings, creating a foundation for sustainable and energy-efficient urban development. For Serbia, these experiences may serve as a valuable reference framework, provided that their application is adapted to local economic, institutional, and regulatory conditions. The gradual implementation of digital technologies, accompanied by the development of professional competencies, interoperable data platforms, and energy-efficient pilot projects, could significantly contribute to the modernization and sustainability of the national construction sector. Future research should focus on the quantitative assessment of energy savings and the economic feasibility of applying these technologies under different operational conditions.

LITERATURE

[1] Kerkez D., Vučetić J., Ristić S.: Pametne tehnologije u funkciji održivog razvoja: primer Južne Koreje. 3. Nacionalna naučna konferencija sa međunarodnim učešćem o obnovljivim izvorima energije i održivom razvoju, Niš, 166–173, 2025.

[2] Sharifi A., Allam Z., Elias Bibri S., Khavarian-Garmsir A.: Smart cities and sustainable development goals (SDGs): A systematic literature review of co-benefits and trade-offs. Cities, Vol. 146, 104659, 2024.

[3] World Bank Group Korea Office: Smart Cities in Korea: Lessons for Urban Development and Management. World Bank Group, Seoul, 2022.

[4] Han D., Kim J. H.: Multiple Smart Cities: The Case of the Eco Delta City in South Korea. Sustainability, Vol. 14, No. 10, 6243, 2022.

[5] United Nations Environment Programme: 2023 Global Status Report for Buildings and Construction. UNEP, Nairobi, 2023.

[6] Kibert C. J.: Sustainable Construction: Green Building Design and Delivery (4th ed.). Wiley, Hoboken, 2016.

[7] Lu Y., Wu Z., Chang R., Li Y.: Building Information Modeling and Green Buildings: A Critical Review and Future Directions. Automation in Construction, Vol. 83, 134–148, 2017.

[8] Ahmad T., Chen H., Wang J.: Artificial Intelligence in Sustainable Energy Industry: Status and Perspectives. Journal of Cleaner Production, Vol. 289, 125834, 2021.

[9] Lee S. K., Kwon H. R., Kim J., Lee D.: International Case Studies of Smart Cities: Songdo, Republic of Korea. Inter-American Development Bank, 2016.

[10] Jung J.: Songdo City: Blueprint or Black Sheep? Charter Cities Institute, 2024.

[11] Yin R. K.: Case Study Research and Applications: Design and Methods (6th ed.). Sage Publications, Thousand Oaks, 2018.

[12] Park H.: E8 Confirmed Participation in Busan Eco Delta Smart City Project. Asia Economy, August 23, 2024.

[13] Eastman C., Teicholz P., Sacks R., Liston K.: BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers (3rd ed.). Wiley, Hoboken, 2018.

[14] Amasyali K., El-Gohary N. M.: A Review of Data-Driven Building Energy Consumption Prediction Studies. Renewable and Sustainable Energy Reviews, Vol. 81, 1192–1205, 2018.

[15] Lange S., Santarius T.: Smart Green World? Making Digitalization Work for Sustainability. Routledge, London, 2020.

[16] Azhar S.: Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. Leadership and Management in Engineering, Vol. 11, No. 3, 241–252, 2011.

[17] Wong J. K. W., Zhou J.: Enhancing Environmental Sustainability over Building Life Cycles through Green BIM: A Review. Automation in Construction, Vol. 57, 156–165, 2015.

[18] Atzori L., Iera A., Morabito G.: The Internet of Things: A Survey. Computer Networks, Vol. 54, No. 15, 2787–2805, 2010.

[19] Al-Fuqaha A., Guizani M., Mohammadi M., Aledhari M., Ayyash M.: Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications. IEEE Communications Surveys & Tutorials, Vol. 17, No. 4, 2347–2376, 2015.

[20] Minoli D., Sohraby K., Occhiogrosso B.: IoT Considerations, Requirements, and Architectures for Smart Buildings—Energy Optimization and Next-Generation Building Management Systems. IEEE Internet of Things Journal, Vol. 4, No. 1, 269–283, 2017.

[21] Smart City Korea. (2024). Smart City Data Hub. Ministry of Land, Infrastructure and Transport. Retrieved June 10, 2026, from https://smartcity.go.kr

[22] Tao F., Zhang H., Liu A., Nee A. Y. C.: Digital Twin in Industry: State-of-the-Art. IEEE Transactions on Industrial Informatics, Vol. 15, No. 4, 2405–2415, 2020.

[23] Omar O., García-Fernández J., Gil D.: Artificial Intelligence Applications in Smart and Sustainable Buildings: A Review. Buildings, Vol. 13, No. 9, 2234, 2023.

[24] European Commission: Energy Performance of Buildings Directive (EPBD). European Commission, Brussels, 2024.

[25] Ding G. K. C.: Sustainable Construction—The Role of Environmental Assessment Tools. Journal of Environmental Management, Vol. 86, No. 3, 451–464, 2008.

[26] Choi Y.-S.: Smart City Development Projects in the Republic of Korea. United Nations Centre for Regional Development Working Paper Series, 2020.

[27] Kim J., Park J.: Evaluation of Korea's G-SEED Certification System and Sustainable Building Policies. Sustainability, Vol. 13, No. 15, 8456, 2021.

[28] Ferrara M., Monetti V., Fabrizio E., Filippi M.: The Role of Building Automation and Control Systems for Energy Efficiency in Buildings. Energy Procedia, Vol. 158, 3456–3461, 2020.

[29] OECD: Enhancing Compactness, Connectivity and Accessibility in Korea. OECD Publishing, 2025.