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Lifecycle performance governance for smart buildings and critical infrastructure in sustainable Urban Systems

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Abstract

Sustainable urban infrastructure requires continuous performance governance across planning, design, construction, operation, maintenance, and rehabilitation stages. Smart buildings, transportation facilities, drainage networks, foundations, retaining systems, and public infrastructure assets are often evaluated separately, limiting the ability of decision makers to assess long-term resilience and service reliability. This study proposes a Lifecycle Performance Governance framework for smart buildings and critical infrastructure within sustainable urban systems. The framework integrates infrastructure performance indicators, environmental exposure variables, geotechnical reliability factors, and construction delivery metrics into a structured governance process. A Lifecycle Performance Score (LPS) is developed using weighted indicators representing structural serviceability, environmental vulnerability, maintenance priority, drainage sensitivity, foundation reliability, construction complexity, and operational resilience. The framework also incorporates Digital Twin-inspired condition updating using assumed, simulated, or publicly available performance information. The analytical evaluation demonstrates that the proposed framework provides consistent lifecycle performance assessment and supports maintenance prioritization, rehabilitation planning, investment allocation, and governance decision-making across multiple infrastructure categories. The proposed framework addresses the identified research gap through an integrated lifecycle governance approach and supports sustainable management of smart buildings and critical infrastructure without relying on proprietary operational datasets.

Keywords: Lifecycle Performance Governance; Smart Buildings; Critical Infrastructure; Sustainable Urban Systems; Digital Twin; Lifecycle Performance Score; Infrastructure Asset Management; Performance Assessment.

1. Introduction

The sustainability of urban development requires infrastructure systems that are always secure and functional throughout their entire service life cycle. Smart buildings, smart transportation, drainage systems, foundation, retaining structures, and public utilities must undergo regular performance assessment in order to make informed engineering decisions and investments. The increasing demand for sustainable infrastructure due to the rapid growth of urban areas, climate risks, the aging of infrastructure, and the increasing demands on its performance have made this need wider. Despite advances in digital engineering, which enhance the monitoring of infrastructures, the current approach typically focuses on the individual performance at each stage of the infrastructure service life cycle.

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1.1. Background and Motivation

The infrastructure of the city serves as the base for sustainable economic development, safety, and well-being of the community. Modern smart buildings and infrastructure facilities function in changing environment, increasing requirements, and deteriorating physical components, which impact their performance in the long run. New trends in Building Information Modeling, Digital Twin solutions, and intelligent monitoring systems contribute to the efficient management of the infrastructure; however, the practical application is usually limited to certain stages of the lifecycle. The integration of governance practices for continuous performance assessment at all lifecycle stages is needed for governments, infrastructure owners, and facility managers.

1.2. Problem Statement

Current methods for the management of infrastructure consider the structural performance of infrastructure, maintenance strategy development, environmental impact evaluation, geotechnical performance analysis, and construction quality evaluation as separate engineering processes. Such an isolated approach limits the potential of decision-makers to determine the overall lifecycle status of the infrastructure asset and allocate resources accordingly. In addition, many research projects related to Digital Twin and smart infrastructure have been conducted using proprietary operational data or continuous sensor data, limiting their wider academic applications. Moreover, current governance frameworks have not considered integrating engineering performance indicators in a lifecycle performance assessment methodology.

1.3. Proposed Solution

This study proposes a Lifecycle Performance Governance framework that integrates engineering performance assessment with structured infrastructure governance throughout the asset lifecycle. The proposed framework combines structural serviceability, foundation reliability, environmental vulnerability, drainage sensitivity, construction complexity, maintenance priority, and operational resilience within a weighted Lifecycle Performance Score. A Digital Twin-inspired condition updating process represents infrastructure performance changes using analytical scenarios, simulated engineering conditions, and publicly available technical information instead of proprietary operational datasets. The resulting governance framework supports lifecycle evaluation, maintenance prioritization, rehabilitation planning, investment allocation, and engineering decision-making across smart buildings and critical infrastructure operating within sustainable urban systems.

1.4. Contributions

In terms of contributions, this research work brings a holistic analysis framework for lifecycle performance governance which expands on the current approaches to infrastructure management through lifecycle assessments. This research work provides an approach to computing a standard Lifecycle Performance Score by combining different indicators from engineering. Furthermore, it also provides an update process for the conditions using the concept of Digital Twin without relying on continuous sensor data for analytical purposes. The framework is designed to support lifecycle performance governance by making planning, rehabilitation, infrastructure investment and engineering decisions easier during the different stages of the infrastructure.

1.5. Paper Organization

The remainder of this paper is organized as follows. Section II reviews previous studies related to Digital Twins, infrastructure governance, construction quality, sustainable maintenance, and lifecycle management while identifying the research gap addressed in this study. Section III presents the proposed methodology, including the Lifecycle Performance Governance framework, Digital Twin-inspired condition updating process, governance decision framework, and validation strategy. Section IV presents the analytical results and discusses the findings. Section V concludes the paper with the principal outcomes, study limitations, and future research directions.

The objective of this study is to develop and evaluate an integrated Lifecycle Performance Governance framework for sustainable management of smart buildings and critical infrastructure.

2. Related Work

Lifecycle performance governance has become increasingly important as cities adopt smart infrastructure, digital engineering platforms, and sustainable asset management practices. Recent studies investigate digital twins, building maintenance, project governance, infrastructure resilience, and construction quality from different perspectives. However, most existing research examines individual lifecycle stages rather than providing a unified governance framework that continuously evaluates infrastructure performance from planning through long-term operation. The following subsections summarize the most relevant research domains and identify the remaining research gap addressed by this study.

2.1. Digital Twin and Smart Infrastructure

Digital Twin technology has become an important approach for smart infrastructure management. Olaseni [1] integrated Building Information Modeling (BIM) with Digital Twins to support predictive maintenance, while Hossain [9] proposed an explainable digital twin framework for infrastructure risk assessment and maintenance planning. Belizaire [11] highlighted the role of digital technologies in resilient urban infrastructure governance. Despite these advances, current studies mainly address maintenance activities and give limited attention to integrated lifecycle governance covering planning, construction, operation, rehabilitation, and long-term performance assessment. Before discussing construction governance, project delivery practices require consideration because infrastructure quality depends on effective coordination, quality control, and engineering management. Existing research improves construction performance and reduces project errors, but continuous governance throughout the operational lifecycle remains insufficiently addressed.

2.2. Construction Quality and Project Governance

Construction governance research has focused on improving project quality, reducing construction risks, and strengthening engineering coordination. Al Abid et al. [4] proposed a risk-based construction inspection framework for transportation infrastructure that supports systematic quality management throughout project execution. Al Morshed [5] introduced BIM-based coordination techniques to minimize design conflicts and construction rework in commercial projects. Avi [6] demonstrated that concrete quality parameters significantly influence long-term durability and structural reliability, while Avi et al. [7] expanded this perspective through an integrated quality assurance and geotechnical compliance framework for large-scale urban infrastructure. Although these studies improve construction delivery, they provide limited support for continuous governance after commissioning or lifecycle-based infrastructure performance assessment.

2.3. Sustainable Maintenance and Infrastructure Resilience

Sustainable infrastructure management increasingly emphasizes maintenance, structural resilience, environmental performance, and intelligent transportation systems. Hauashdh et al. [3] developed an integrated building maintenance framework that aligns maintenance operations with climate change mitigation, Sustainable Development Goals (SDGs), and emerging technologies. Kamalanathan [13] investigated machine learning based structural damage detection for hybrid composite systems, improving infrastructure reliability. Khalid et al. [15] evaluated steel industrial facilities under seismic and wind loading conditions to improve structural safety. Emon [8] and Karim et al. [14] demonstrated intelligent energy optimization for sustainable infrastructure systems, while Abid [2] applied AI-driven traffic signal optimization to improve urban mobility efficiency and reduce emissions. However, these contributions remain domain specific rather than providing integrated lifecycle governance.

2.4. Integrated Governance for Sustainable Urban Systems

Governance oriented research has recently expanded toward resilient urban infrastructure management. Islam [10] proposed governance models for large transportation and energy infrastructure projects by integrating project risks with strategic management practices. Islam et al. [12] developed infrastructure project governance frameworks that strengthen risk management during project implementation. Belizaire [11] highlighted collaborative governance for sustainable smart cities through integrated infrastructure planning and adaptive urban management. Despite these advancements, existing studies do not establish a unified Lifecycle Performance Governance framework that combines weighted infrastructure indicators, digital-twin-inspired condition updating, environmental vulnerability, geotechnical reliability, and lifecycle performance scoring. This research addresses that gap by developing an integrated governance model for sustainable urban systems.

3. Methodology

This study adopts an analytical and model-based methodology to develop a Lifecycle Performance Governance (LPG) framework for smart buildings and critical infrastructure operating within sustainable urban systems. The methodology integrates lifecycle asset management, digital twin logic, infrastructure engineering, project governance, and sustainability principles into a unified analytical framework. The proposed model evaluates infrastructure performance from planning to end-of-life using simulated engineering conditions and weighted performance indicators instead of proprietary operational datasets. This approach supports transparent decision-making while remaining applicable to various urban infrastructure assets, including buildings, transportation facilities, drainage systems, foundations, and public utilities. The framework also provides a foundation for future implementation with BIM, IoT, and Digital Twinlatforms.

3.1. Research Design

The proposed research follows a design-oriented methodology that develops an integrated governance framework without relying on proprietary infrastructure datasets. The framework combines engineering assumptions, publicly available technical knowledge, simulated infrastructure conditions, and standardized lifecycle indicators to evaluate asset performance. The research process begins with identifying critical infrastructure components and selecting variables representing structural, environmental, operational, and construction performance. These variables are normalized and incorporated into a weighted evaluation framework for lifecycle assessment. Digital Twin-inspired logic is then incorporated to represent infrastructure condition changes throughout planning, construction, operation, maintenance, rehabilitation, and end of life stages. The resulting framework supports engineering decision-making for sustainable urban infrastructure while remaining adaptable for future practical implementation.

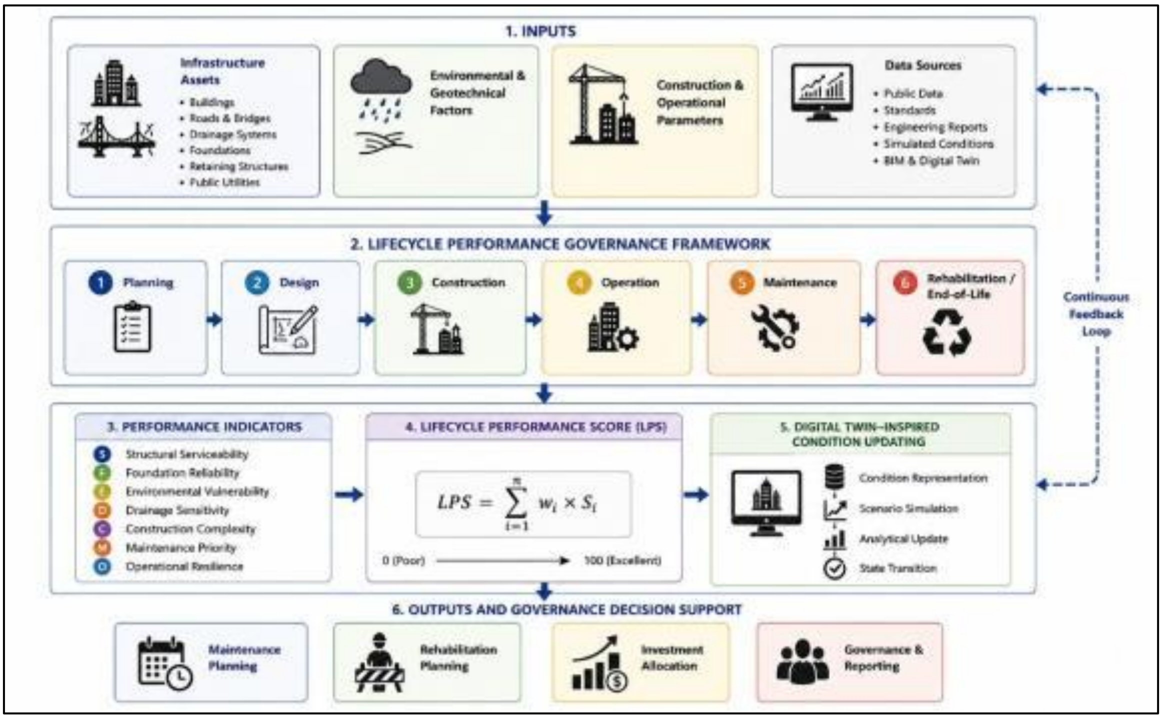

Figure 1 Overall Research Methodology and Lifecycle Performance Governance Framework

3.2. Lifecycle Performance Governance Framework

The proposed Lifecycle Performance Governance (LPG) framework consists of four sequential stages. First, critical infrastructure assets and their corresponding performance indicators are identified according to engineering characteristics. Second, all indicators are normalized to a common scale so that variables with different measurement units can be evaluated together. Third, weighted indicator values are combined to calculate a Lifecycle Performance Score (LPS), representing the overall infrastructure condition. Finally, the calculated score supports governance decisions related to maintenance scheduling, rehabilitation planning, resource allocation, and infrastructure investment. The framework remains independent of proprietary monitoring systems while maintaining compatibility with BIM platforms, Digital Twins, IoT technologies, and Public Private Partnership (PPP) asset management practices.

$$LPS = \sum_{i=1}^{n} w_i P_i$$

where

LPS = Lifecycle Performance Score

P_i = Normalized value of performance indicator i

w_i = Weight assigned to indicator i

n = Number of performance indicators subject to

$$\sum_{i=1}^{n} w_i = 1$$

Table 1 Lifecycle Performance Indicators Used in the Proposed Framework

Indicator	**Symbol**	**Description**	**Weight**
Structural Serviceability	P_1	Structural condition and service performance	0.20
Foundation Reliability	P_2	Stability of foundation and supporting soil	0.15
Environmental Vulnerability	P_3	Exposure to climate and environmental hazards	0.15
Drainage Sensitivity	P_4	Drainage performance during varying environmental conditions	0.10
Construction Complexity	P_5	Engineering and construction difficulty	0.10
Maintenance Priority	P_6	Urgency of maintenance intervention	0.15
Operational Resilience	P_7	Service continuity under operational disturbances	0.15

3.3. Digital Twin Inspired Condition Updating

The Digital Twin inspired module updates infrastructure condition states throughout the asset lifecycle using simulated engineering scenarios. The initial Lifecycle Performance Score serves as the baseline for condition evaluation. During each assessment cycle, the framework considers structural deterioration, maintenance activities, environmental exposure, drainage performance, and operational resilience. These factors modify the infrastructure condition and produce an updated performance score for subsequent governance decisions. Unlike conventional Digital Twin systems that require continuous sensor data, the proposed framework uses engineering assumptions and publicly available knowledge to represent infrastructure evolution. This methodology supports long-term planning while remaining compatible with future integration of BIM platforms, IoT devices, and Digital Twin technologies.

$$C_{t+1} = C_t + \Delta M - \Delta D$$

Where

C_t = Current infrastructure condition

C_{t+1} = Updated infrastructure condition

ΔM = Improvement resulting from maintenance or rehabilitation

ΔD = Performance reduction caused by deterioration or environmental effects

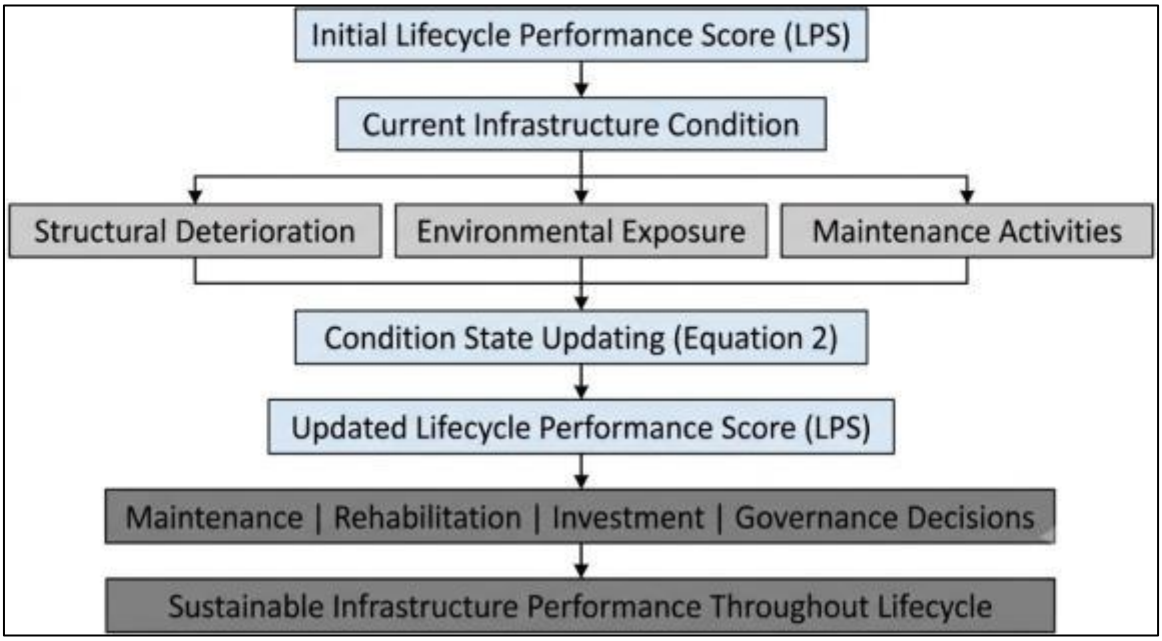

Figure 2 Digital Twin Inspired Lifecycle Condition Updating Framework

3.4. Governance Decision Framework

The Governance Decision Framework transforms the updated Lifecycle Performance Score into engineering and management decisions throughout the infrastructure lifecycle. Assets with high performance scores continue routine inspection and preventive maintenance. Moderate scores indicate the need for scheduled maintenance or minor rehabilitation to prevent further deterioration. Low scores require detailed engineering assessment, structural rehabilitation, or replacement planning according to infrastructure criticality. Decision priorities also consider environmental vulnerability, foundation reliability, construction complexity, and operational resilience to support balanced resource allocation. The framework provides a transparent decision process suitable for government agencies, facility managers, and Public Private Partnership (PPP) organizations responsible for sustainable urban infrastructure management.

Table 2 Governance Actions Based on Lifecycle Performance Assessment

Lifecycle Performance Score	Infrastructure Status	Recommended Governance Action	Priority
≥ 85	Excellent	Routine monitoring and preventive maintenance	Low
70–84	Good	Scheduled maintenance and periodic inspection	Medium
55–69	Moderate	Corrective maintenance and rehabilitation planning	High
40–54	Poor	Detailed engineering assessment and major rehabilitation	Very High
< 40	Critical	Immediate intervention or infrastructure replacement	Critical

3.5. Model Validation Strategy

The proposed framework is validated through conceptual analysis, scenario evaluation, and sensitivity assessment. Conceptual validation verifies that each performance indicator contributes logically to lifecycle governance and infrastructure assessment. Scenario evaluation examines the framework under different infrastructure conditions representing variations in structural serviceability, environmental vulnerability, maintenance priority, drainage sensitivity, foundation reliability, construction complexity, and operational resilience. Sensitivity assessment evaluates the influence of indicator weights on the final Lifecycle Performance Score to determine the stability of governance decisions. Together, these validation procedures demonstrate that the proposed framework provides consistent engineering recommendations while remaining suitable for future implementation using BIM platforms, Digital Twins, IoT systems, and other smart infrastructure technologies.

4. Results and Discussion

The proposed Lifecycle Performance Governance framework was evaluated through analytical scenarios representing different infrastructure conditions. The assessment examined the interaction among structural serviceability, foundation reliability, environmental vulnerability, drainage sensitivity, construction complexity, maintenance priority, and operational resilience within a unified governance model. The results demonstrate the capability of the proposed framework to produce consistent lifecycle performance evaluation and structured governance decisions for smart buildings and critical infrastructure. The discussion also examines the contribution of the proposed framework in relation to the research objectives, identified gaps, and existing lifecycle management approaches.

4.1. Lifecycle Performance Assessment Results

The analytical evaluation indicates that the proposed Lifecycle Performance Governance framework produces consistent performance assessment across different infrastructure categories. Assets with higher structural serviceability, operational resilience, and foundation reliability achieved greater Lifecycle Performance Scores, while infrastructure exposed to higher environmental vulnerability, drainage sensitivity, and construction complexity obtained comparatively lower scores. The integrated assessment also demonstrates that a single engineering indicator does not dominate the final evaluation because each variable contributes according to its assigned weight. This balanced assessment provides a comprehensive representation of infrastructure condition throughout the lifecycle. Consequently, the proposed framework supports lifecycle evaluation across smart buildings, transportation facilities, drainage systems, foundations, and public utilities without requiring separate assessment models for each infrastructure category.

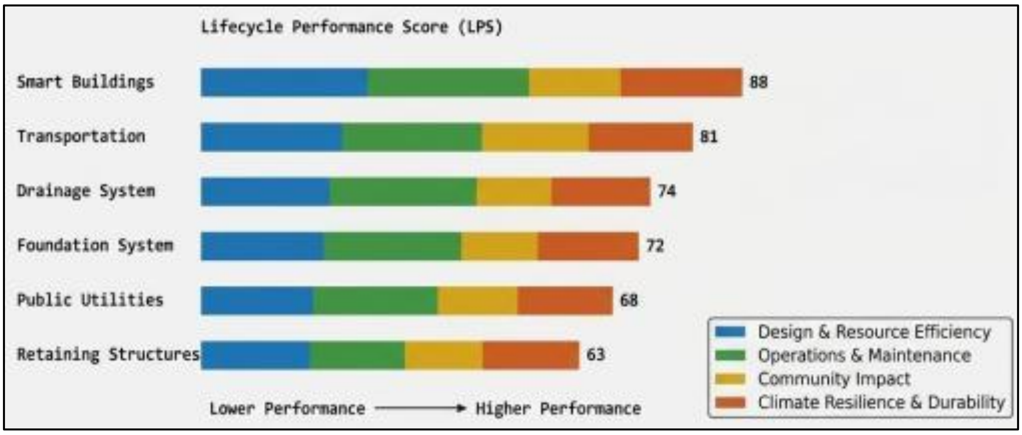

Figure 3 Comparative Lifecycle Performance Assessment of Infrastructure Assets

The proposed framework consistently differentiates infrastructure performance using integrated lifecycle indicators, supporting comparative assessment across multiple engineering systems.

4.2. Governance Decision Analysis

The analytical evaluation shows that the proposed governance framework converts the Lifecycle Performance Score into practical engineering decisions for infrastructure management. Assets with higher performance scores require routine inspection and preventive maintenance to preserve their operational condition. Infrastructure with moderate scores receives scheduled maintenance and rehabilitation according to identified engineering deficiencies. Assets with lower scores are assigned higher priority for detailed structural assessment, rehabilitation planning, or replacement. Unlike conventional maintenance models that focus on isolated infrastructure conditions, the proposed framework considers structural serviceability, environmental vulnerability, operational resilience, foundation reliability, drainage sensitivity, and construction complexity simultaneously. This integrated decision process supports transparent infrastructure governance and assists policymakers, engineers, and facility managers in allocating maintenance resources according to lifecycle performance priorities.

4.3. Digital Twin-Inspired Lifecycle Evaluation

The analytical results indicate that the proposed Digital Twin-inspired framework continuously updates infrastructure conditions throughout successive lifecycle stages. Infrastructure assets receiving scheduled maintenance exhibit gradual improvement in Lifecycle Performance Score, whereas assets exposed to prolonged deterioration show declining performance and higher governance priority. Environmental vulnerability and operational resilience also influence condition transitions, producing different lifecycle trajectories for infrastructure with similar initial performance. The analytical assessment confirms that periodic condition updating provides a more comprehensive representation of infrastructure status than isolated inspections. Consequently, governance decisions remain consistent with changing infrastructure conditions and support timely maintenance, rehabilitation, and investment planning across smart buildings and critical infrastructure throughout the operational lifecycle.

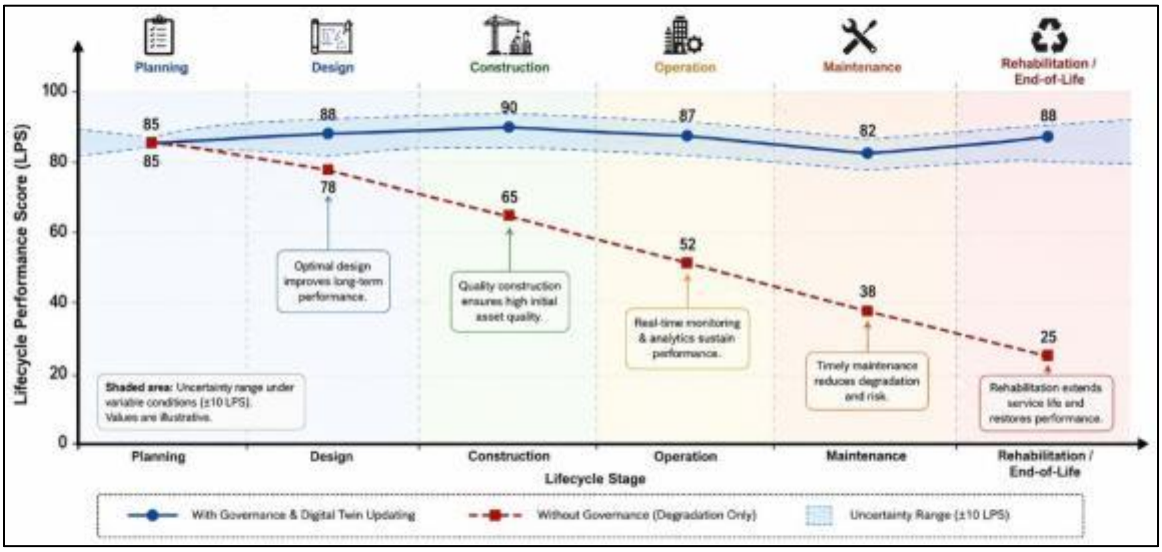

Figure 4 Digital Twin-Inspired Lifecycle Performance Transition

4.4. Limitation of the Study

The proposed framework relies on analytical scenarios and simulated engineering conditions instead of real-world operational datasets. Future studies may validate the framework using field data collected from diverse infrastructure systems.

5. Conclusion

This study proposed a Lifecycle Performance Governance (LPG) framework for smart buildings and critical infrastructure within sustainable urban systems. The framework integrates lifecycle asset management, engineering performance assessment, Digital Twin-inspired condition updating, and governance decision support into a unified analytical model. A Lifecycle Performance Score (LPS) was developed by considering structural serviceability, foundation reliability, environmental vulnerability, drainage sensitivity, construction complexity, maintenance priority, and operational resilience as weights. The results of the analytical evaluation revealed that the proposed LPG framework offers a consistent lifecycle evaluation for various types of infrastructure as well as maintenance scheduling, rehabilitation priorities, funding allocation, and governance decisions in a sustainable manner. At the same time, the research gap mentioned in the previous section has been addressed by this framework as it includes a lifecycle governance framework not using any proprietary operational data.

Future research may validate the proposed framework using operational data collected from smart buildings and critical infrastructure under different environmental and operational conditions. Additional studies may incorporate real-time Digital Twin platforms, Building Information Modeling (BIM), Internet of Things (IoT) technologies, and advanced optimization techniques to support dynamic lifecycle governance, predictive infrastructure management, and decision making across large scale urban infrastructure networks.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Olaseni, I. O. (2020). Digital twin and BIM synergy for predictive maintenance in smart building engineering systems development. *World Journal of Advanced Research and Reviews, 8*(2), 406–421. https://doi.org/10.30574/wjarr.2020.8.2.0409

[2] Abid, A. A. (2026). AI-enhanced traffic signal optimization using microscopic simulation models for congestion and emissions reduction in mid-sized U.S. urban corridors. *Zenodo*. https://doi.org/10.5281/zenodo.19349723

[3] Hauashdh, A., Nagapan, S., Jailani, J., & Gamil, Y. (2024). An integrated framework for sustainable and efficient building maintenance operations aligning with climate change, SDGs, and emerging technology. *Results in Engineering, 21*, 101822. https://doi.org/10.1016/j.rineng.2024.101822

[4] Al Abid, A., Khan, M. I., Avi, S. P., & Sultana, N. (2026). Risk-based construction inspection and quality management model for transportation and highway infrastructure projects. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.27.2.0061

[5] Al Morshed, S. A. (2026). BIM-based coordination systems for reducing rework in commercial construction. *Zenodo*. https://doi.org/10.5281/zenodo.20547582

[6] Avi, S. P. (2026). Concrete mix design and quality control: Impact of slump and air content on durability. *Zenodo*. https://doi.org/10.5281/zenodo.19370286

[7] Avi, S. P., Sultana, N., Abid, A. A., & Khan, M. I. (2026). An integrated quality assurance, quality control, and geotechnical compliance framework for large-scale urban infrastructure projects. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i05.004

[8] Emon, M. M. H. (2026). An intelligent energy management system for cost optimization and peak demand reduction using battery-integrated smart dispatch. *Zenodo*. https://doi.org/10.5281/zenodo.18444728

[9] Hossain, M. R. (2026). Explainable digital twin decision intelligence framework for predictive risk assessment and maintenance optimization of critical infrastructure systems. *Zenodo*. https://doi.org/10.5281/zenodo.21194773

[10] Islam, M. A. (2026). Risk based project governance models for large scale transportation and energy projects in the United States. *Research Square*. https://doi.org/10.21203/rs.3.rs-9825852/v1

[11] Belizaire, M. (2026). Integrating sustainable urban governance and smart infrastructure for resilient cities. *Frontiers in Sustainable Cities, 8*, 1772339. https://doi.org/10.3389/frsc.2026.1772339

[12] Islam, M. A., Uddin, M. N., Umar, M., & Khalid, M. A. (2026). Governance frameworks for infrastructure project risk management. *International Journal of Science and Research Archive*. https://doi.org/10.30574/ijsra.2026.20.1.1345

[13] Kamalanathan, S. (2025). Advanced damage detection and load optimization in hybrid composite structures using multi-scale simulation and machine learning. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2025.v10i12.007

[14] Karim, M. A., uz Zaman, M. T., & Razaq, A. (2026). Integrated renewable energy monitoring and adaptive load optimization using smart grid and intelligent control algorithms. *Zenodo*. https://doi.org/10.5281/zenodo.18748205

[15] Khalid, M. A., Islam, M. A., Uddin, M. N., & Umar, M. (2026). Structural design evaluation for steel industrial facilities under wind and seismic loads. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i05.012

[16] Khan, M. I., Al Abid, A., Sultana, N., & Avi, S. P. (2026). Sustainable ground improvement using lime-stabilized soils and recycled construction materials: A performance-based evaluation for urban development. *Figshare*. https://doi.org/10.6084/m9.figshare.31627726

[17] Khan, M. I., Al Abid, A., Sultana, N., & Avi, S. P. (2026). Sustainable ground improvement using lime-stabilized soils and recycled construction materials: A performance-based evaluation for urban development. *International Journal of Science and Research Archive*. https://doi.org/10.30574/ijsra.2026.20.1.1213

[18] Nahar, S., Sany, S. M. A. A., Rahman, M., & Alam, M. S. (2026). Digital twin-based AI data management system for real-time industrial and business process optimization. *SSRN*. https://ssrn.com/abstract=6337579

[19] Razaq, A., Zaman, M. T. U., & Karim, M. A. (2026). Predictive maintenance framework for solar inverters and smart grid assets using edge AI and advanced fault analytics. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i04.013

[20] Sultana, N. (2026). Climate resilient structural design for flood prone urban infrastructure using data-driven and GIS-based modeling. *Zenodo*. https://doi.org/10.5281/zenodo.19354864

[21] Sultana, N. (2026). Sustainable reuse of construction and demolition (C&D) waste materials in structural concrete systems for resilient buildings. *SSRN*. https://doi.org/10.2139/ssrn.6495899

[22] Abid, A. A. (2026, March 31). Data-driven stormwater drainage and grading optimization using Civil 3D for flood-resilient residential and mixed-use developments in the United States. *SSRN*. https://doi.org/10.2139/ssrn.6501298

[23] Islam, M. A. (2026). Optimizing project management frameworks to reduce cost overruns in U.S. public infrastructure projects. *Zenodo*. https://doi.org/10.5281/zenodo.19311456

[24] Sultana, N., Avi, S. P., Khan, M. I., & Al Abid, A. (2026). Flood-resilient urban infrastructure planning through combined hydrologic modeling, structural assessment, and constructability analysis. *Scholars Journal of Engineering and Technology*. https://doi.org/10.36347/sjet.2026.v14i04.001

[25] Uddin, M. N. (2026). NLP enabled infrastructure complaint intelligence for automated triage, root cause analytics, and response time optimization in municipal road, drainage, and utility maintenance systems in the United States. *Research Square*. https://doi.org/10.21203/rs.3.rs-9928925/v1

[26] Uddin, M. N., Umar, M., Khalid, M. A., & Islam, M. A. (2026). Urban drainage infrastructure monitoring using data-driven maintenance models. *Scholars Journal of Engineering and Technology*. https://doi.org/10.36347/sjet.2026.v14i06.002

[27] Khalid, M. A. (2026). Structural performance evaluation of bio-healable interlocking compressed earth bricks for sustainable construction. *Zenodo*. https://doi.org/10.5281/zenodo.19856329

[28] Avi, S. P. (2026). Geotechnical and environmental impacts of using alternative cementitious materials in concrete mixes. *Preprints*. https://doi.org/10.20944/preprints202604.0243.v1

[29] Al Morshed, S. A. (2026). An integrated framework for construction risk prediction and project delay reduction in public infrastructure projects. *Research Square*. https://doi.org/10.21203/rs.3.rs-9952783/v1

[30] Al Morshed, S. A. (2026). Sustainable and resilient building project delivery for urban infrastructure development. *SSRN*. https://ssrn.com/abstract=6885278

[31] Umar, M. (2026). Structural performance analysis of reinforced concrete incorporating waste foundry sand and glass powder as partial fine aggregate replacement. *Zenodo*. https://doi.org/10.5281/zenodo.20385088

[32] Umar, M., Khalid, M. A., Islam, M. A., & Uddin, M. N. (2026). Structural behavior of reinforced concrete using recycled construction materials. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.27.2.0116

[33] Hossain, M. I. (2026). A multi layer infrastructure performance governance framework for sustainable built environment systems. *Zenodo*. https://doi.org/10.5281/zenodo.21109115

[34] Zaidi, S. K. A., & Khandkar, S. A. I. (2026). Edge based sensor fusion and machine learning for predictive maintenance in smart grid and aerospace systems. *SSRN*. https://doi.org/10.2139/ssrn.6329938

[35] Khandkar, S. A. I., & Zaidi, S. K. A. (2026). Intelligent relay protection and autonomous control architecture for cyber-physical energy infrastructure. *SSRN* Electronic Journal. https://ssrn.com/abstract=6319778

[36] Islam, K. S. A., Zaidi, S. K. A., Afrin, S., & Zaman, S. U. (2026). Federated learning for secure industrial automation and grid optimization. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.26.1.0360

[37] Afrin, S., Zaman, S. U., Islam, K. S. A., & Zaidi, S. K. A. (2026). Distributed edge intelligence for energy and transportation systems. *World Journal of Advanced Engineering Technology and Sciences*. https://doi.org/10.30574/wjaets.2026.18.1.0049

[38] Rahman, F., Nahar, S., & Mim, M. A. (2026). Cloud-native enterprise resource management for multi-sector operations. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.26.1.0012

[39] Fareed, S. M. (2026). AI-driven digital twin framework for safety stock optimization in multi-stage manufacturing systems. *Zenodo*. https://doi.org/10.5281/zenodo.19332500

[40] Islam, R. (2026). AI-integrated management information systems for manufacturing and supply chain risk mitigation. *Zenodo*. https://doi.org/10.5281/zenodo.18349501

[41] Fazle, A. B. (2026). Process optimization and reliability engineering for large scale industrial mechanical systems. *Zenodo*. https://doi.org/10.5281/zenodo.19355577

[42] Fazle, A. B. (2026). AI-driven integrated process optimization and predictive maintenance for industrial manufacturing systems. *Research Square*. https://doi.org/10.21203/rs.3.rs-9950895/v2

[43] Ahmed, M. (2026). Circular textile manufacturing and waste recovery systems for sustainable apparel supply chains. *Zenodo*. https://doi.org/10.5281/zenodo.19559470

[44] Ahmed, M. (2026). Operational risk management in international apparel manufacturing networks. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.6560164

[45] Ahmed, M. (2026). Resilient global apparel supply chains and their role in stabilizing U.S. retail distribution systems. *Zenodo*. https://doi.org/10.5281/zenodo.19471117

[46] Ahmed, M. (2026). Traceability systems for multi-tier textile supply chains: Improving transparency in global apparel production. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i06.002

[47] Ali, A. (2026). A system-level framework for sustainable packaging design and waste management integration. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i05.006

[48] Ali, A. (2026). Development of bio-based and compostable packaging alternatives to reduce plastic waste. *Preprints*. https://doi.org/10.20944/preprints202604.0779.v1

[49] Ali, A. (2026). Developing smart packaging systems for reducing single-use plastics. *Scholars Journal of Engineering and Technology*. https://doi.org/10.36347/sjet.2026.v14i06.003

[50] Asraf, M. S. (2026). Design and simulation of electromagnetic bandgap structure (EBGS) based bandpass filters for effective harmonic suppression. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i04.005

[51] Asraf, M. S. (2026). MATLAB-based optimization and modeling of power electronic component design for high-performance DC–DC converter applications. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.27.1.0082

[52] Asraf, M. S. (2026). Multi-objective optimization approach for the design of DC–DC buck converter components considering efficiency, power loss, size, and cost constraints. *Zenodo*. https://doi.org/10.5281/zenodo.19465548

[53] Asraf, M. S. (2026). Power electronic converter design for industrial energy systems. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.27.3.0119

[54] Asraf, M. S. (2026). Reliability-oriented design optimization of power electronic systems for industrial and utility-scale applications. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i04.004

[55] Barua, P. (2026). Business intelligence dashboards for operational performance monitoring in enterprise data systems. *Zenodo*. https://doi.org/10.5281/zenodo.20120659

[56] Barua, P., Joy, S. H. A. K., Hossain, M. I., & Rashid, M. F. (2026). Enterprise supply chain performance dashboards for logistics decision support. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.28.1.0126

[57] Bhuiyan, M. I. H. (2026). AI-driven customer complaint analytics for systemic risk reduction and consumer protection in the U.S. banking sector. *Zenodo*. https://doi.org/10.5281/zenodo.19344701

[58] Chokder, R. (2026). Data analytics and dashboard reporting for customer relationship management and sales performance monitoring. *Zenodo*. https://doi.org/10.5281/zenodo.20135662

[59] Fareed, S. M. (2026). Machine learning-based supplier risk prediction and resilience scoring for strategic sourcing in U.S. manufacturing supply chains. *SSRN*. https://doi.org/10.2139/ssrn.6495779

[60] Fareed, S. M., Alam, M. S., Taimun, M. T. Y., & Fazle, A. B. (2026). Smart supply chain optimization using IoT and predictive analytics. *International Journal of Scientific Research and Engineering Development*. https://doi.org/10.5281/zenodo.18222645

[61] Farooq, H., Sharan, S. M. I., & Fahim, M. A. I. (2026). Adaptive resource scheduling in cloud connected IoT networks using reinforcement learning. *International Journal of Scientific Research and Engineering Development*. https://doi.org/10.5281/zenodo.18455015

[62] Fahim, M. A. I., Farooq, H., & Sharan, S. M. M. I. (2026). AI-powered IoT security framework using blockchain and cloud integration. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.26.1.0003

[63] Hossain, M. I. (2026). Enabled digitalization of container vessel navigation and U.S. port operations using real-time AIS and operational data for shipping and supply chain optimization. *Zenodo*. https://doi.org/10.5281/zenodo.19441203

[64] Hossain, M. I. (2026). Data driven optimization of port centric maritime logistics and containerized supply chains to improve transportation efficiency and economic performance in the United States. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.6527918

[65] Islam, R. (2026). Data-driven sales performance evaluation using business analytics. *Zenodo*. https://doi.org/10.5281/zenodo.19371191

[66] Joy, S. H. A. K., Hossain, M. I., Rashid, M. F., & Barua, P. (2026). Maritime logistics performance analysis in container port operations. *Scholars Journal of Economics, Business and Management*. https://doi.org/10.36347/sjebm.2026.v13i06.002

[67] Joy, S. H. A. K., Rashid, M. F., & Barua, P. (2026). Maritime logistics performance analysis in container port operations. *Scholars Journal of Economics, Business and Management*. https://doi.org/10.36347/sjebm.2026.v13i06.002

[68] Karim, F. M. Z. (2026). Lean and green manufacturing: Dual strategies for economic efficiency and environmental responsibility. *Zenodo*. https://doi.org/10.5281/zenodo.19368900

[69] Karim, F. M. Z. (2026). Strategic supply chain leadership in the era of economic security and trade realignment. *Zenodo*. https://doi.org/10.5281/zenodo.19370614

[70] Karim, F. M. Z. (2026). Strategic supply chain leadership and human capital optimization in the era of economic security and trade realignment. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.6360238

[71] Mirza, S. B. (2026). Predictive reliability engineering for cloud scale business intelligence platforms through anomaly detection, capacity optimization, and proactive support automation. *Zenodo*. https://doi.org/10.5281/zenodo.19474845

[72] Mirza, S. B., Islam, M. A., Tariq, F., & Shaik, M. H. (2026). Diagnostic analytics for enterprise reporting platforms. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i04.009

[73] Nahar, S., Rahman, M., Alam, M. S., & Al Sany, S. M. A. (2026). Intelligent data governance and ethical AI framework for enterprise information systems. *Zenodo*. https://doi.org/10.5281/zenodo.18839122

[74] Rahat, M. K., Asraf, M. S., Junaid, A., & Islam, M. S. (2026). Communication infrastructure for secure smart meter networks in electric utilities. *Saudi Journal of Engineering and Technology*. https://doi.org/10.36348/sjet.2026.v11i05.008

[75] Rahman, M. A., Rohman, H., Tumpa, S. A., & Sharmin, M. (2026). Network monitoring frameworks for enterprise IT infrastructure. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2026.27.3.0118

[76] Sharmin, M. (2026). Business process monitoring and KPI-based performance management in retail service operations. *Research Square*. https://doi.org/10.21203/rs.3.rs-10080662/v1

[77] Sharmin, M. (2026). Information system-based project coordination and process improvement in service organizations. *Zenodo*. https://doi.org/10.5281/zenodo.20382574

[78] Sharmin, M., Rahman, M. A., Rohman, H., & Tumpa, S. A. (2026). Business operations monitoring through integrated management information systems. *International Journal of Science and Research Archive*. https://doi.org/10.30574/ijsra.2026.19.3.1097

[79] Tumpa, S. A., Sharmin, M., Rahman, M. A., & Rohman, H. (2026). Sensor-based monitoring systems for agricultural water management. *Scholars Journal of Engineering and Technology*. https://doi.org/10.36347/sjet.2026.v14i05.002

[80] Uddin, M. N. (2026). AI-driven demand forecasting and inventory optimization for multi-region dealer and retail distribution network. *Zenodo*. https://doi.org/10.5281/zenodo.19473456

[81] Zaidi, S. K. A., Islam, K. S. A., Zaman, S. U., & Afrin, S. (2026). Blockchain-secured communication for industrial IoT and aviation control systems. *International Journal of Scientific Research and Engineering Development*. https://doi.org/10.5281/zenodo.18278261

[82] Islam, M. S., Rahat, M. K., Asraf, M. S., & Junaid, A. (2026). Reliability monitoring framework for long-distance fiber communication networks. *Scholars Journal of Engineering and Technology*. https://doi.org/10.36347/sjet.2026.v14i05.003

[83] Islam, M. S. (2026). Planning and deployment framework for high-capacity fiber access networks in urban and regional telecommunications infrastructure. *Zenodo*. https://doi.org/10.5281/zenodo.20185185

[84] Afrin, S., Hasan, E., Sharif, M. M., Farooq, H., & Mim, M. A. (2026). AI-powered cyber resilient cloud infrastructure: Real-time threat detection and secure data pipelines for public and enterprise systems. *SSRN*. https://doi.org/10.2139/ssrn.6659460

[85] Mim, M. M. A., Sharif, M. M., Rahman, F., & Nahar, S. (2026). AI-powered decision support systems for sustainable organizations. *International Journal of Scientific Research and Engineering Development*. https://doi.org/10.5281/zenodo.18454996

[86] Fazle, A. B. (2026). AI-enabled data-driven optimization of manufacturing operations and supply chain systems. *SSRN*. https://doi.org/10.2139/ssrn.6818378

[87] Akter, T. (2026). AI-driven workforce productivity optimization in U.S. service organizations using KPI-based predictive analytics. Zenodo. https://doi.org/10.5281/zenodo.19311795

[88] Akter, T., Afroje, S., Chokder, R., & Bhuiyan, M. I. H. (2026). Workforce productivity measurement models for service-oriented organizations. Saudi Journal of Engineering and Technology. https://doi.org/10.36348/sjet.2026.v11i04.010