Proceedings of CONF-FMCE 2026 Symposium: Smart City and Infrastructure Engineering
DOI: 10.54254/2755-2721/2026.CH37508

Digital Twins for Predictive Governance and Government Decision-Making in Smart Cities

Yiman Wu

College of International Tourism and Public Administration, Hainan University, Haikou, China
yimanwu@asu.edu

Abstract. Urban governance problems in transport, public safety, infrastructure, and emergency management often change quickly and involve several connected systems. Governance based mainly on complaints, periodic reports, and action after an event may therefore delay risk identification and policy adjustment. This paper examines how digital twins can support predictive governance and government decision-making in smart cities through a literature review and case analysis. The analysis focuses on problem identification, scenario simulation, and feedback after policy implementation. The findings show that digital twins can combine historical records, real-time monitoring data, and spatial information to identify emerging risks and areas requiring attention. Scenario simulation can also help decision-makers compare possible outcomes before selecting a response. In addition, updated data collected after implementation can support the evaluation and adjustment of existing measures. However, the usefulness of digital twins depends on data quality, model reliability, clear responsibilities, and sufficient technical capacity within government agencies. Digital twins should therefore be used as decision-support tools rather than substitutes for public decision-making. Appropriate data governance and regular model assessment are also necessary for responsible use in urban governance.

Keywords: digital twin, smart city, predictive governance, government decision-making, urban governance

1. Introduction

Urban digitalisation has increased the connections among transport, environmental management, public safety, infrastructure, and other urban systems. A problem in one system can affect the operation of several other systems. Extreme weather, for example, may disrupt transport networks and infrastructure while also increasing pressure on emergency services and public resources. However, urban governance often depends on citizen complaints, administrative reports, periodic statistics, and action after a problem becomes visible. This approach may create a delay between the emergence of a risk and government intervention. Digital twins connect physical systems with digital representations that can be updated as real-world conditions change. When combined with data analysis, scenario simulation, and feedback mechanisms, digital twins can support risk identification and the assessment of governance options [1]. Applications have gradually expanded

© 2026 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2755-2721/2026.CH37508

from individual buildings and infrastructure to transport management, disaster risk reduction, infrastructure operation, and public safety.

Research on digital twins has followed two main directions. The first direction concerns technical foundations, including data exchange between physical systems and digital models, model construction, and integration with building information modelling (BIM), the Internet of Things, and artificial intelligence. Sacks et al. emphasised the continuous exchange of information between physical systems and corresponding digital models [1]. Deng et al. described the transition from static BIM models to digital systems supported by real-time data, simulation, and intelligent prediction [2]. The second direction concerns applications in transport management, disaster risk reduction, infrastructure monitoring, and urban planning. Existing studies show that digital twins can support risk analysis, scenario simulation, and decision-making in addition to representing urban conditions. However, technical capability does not always lead to practical governance value. Azadi et al. reviewed 88 peer-reviewed studies and found that many expected contributions to urban planning and decision-making had not been fully achieved [3]. One reason was the limited connection between technical functions and actual planning or decision processes. Further analysis is therefore needed to explain how risk identification, scenario comparison, and real-time feedback can be incorporated into government decision-making. Data bias, accountability, and technological dependence also require attention.

This study examines the role of digital twins in predictive governance and government decision-making through a literature review and case analysis. The analysis covers three stages of the decision process. These stages include problem identification and risk sensing, scenario simulation and policy selection, and real-time feedback after implementation. Cases from public safety, transport, flood risk management, and urban operations are used to examine the practical use of digital twins in different governance settings. The study also considers data quality, model transparency, decision-making responsibility, government technical capacity, and technological dependence. The purpose is to assess the governance value of digital twins and identify the conditions that may limit practical application.

2. Digital twins and predictive governance in smart cities

2.1. The concept and core characteristics of digital twins

Digital twin is the link between a real-world object and its virtual model, and it is continually updated. Unlike traditional 3D models, digital twins can be updated with new information about changes in the real world. Sensors, Internet of Things (IoT) devices and information platforms are employed to gather data and construct a digital model of the current environment in a more systematic way [1].

The first kind of digital twin is a connection between real-world objects and virtual models; it does not need to look like them. Through data integration and analysis, digital twins can be used for condition monitoring, change detection, and performance evaluation. Therefore, the above can be employed to study and regulate the complicated system technically [1].

Digital twins are not the same thing as traditional Building Information Modelling (BIM). BIM mainly refers to the geometry and building information of a construction project, and is used for design, construction and operation. The old BIM models are not updated automatically according to changes in reality. With the help of BIM technology, real-time data, sensors, analysis technology, a digital twin will be constructed and operational data will be continuously collected for monitoring and prediction [2].

DOI: 10.54254/2755-2721/2026.CH37508

Digital twins of smart cities aggregate heterogeneous data from multiple sources—such as transportation systems, buildings, and the environment—into a single platform. Such integration provides a comprehensive understanding of the current urban situation and supports informed decision-making. These capabilities consequently enable the application of digital twins to the predictive governance of smart cities.

2.2. From reactive governance to predictive governance

Generally speaking, the traditional form of urban governance is to look at what has occurred in the past, hear what the people have to say, and periodically conduct surveys to identify problems. Although it can solve the current problem, it is not always feasible to provide all-weather information on changes in urban risks in a timely manner. Events such as traffic accidents, disasters, infrastructure and public security problems are constantly occurring in different areas at various times and require continuous observation and analysis.

Predictive governance is about using information in advance to foresee problems. It does not mean that what will happen in the future can be known for sure. Instead, it will provide some data on the risk and help the decision-makers know how to respond. Predictive governance will be able to collect information proactively and address problems in time, but it is no longer the previous model of governance.

The digital twin continuously collects and processes data and makes corrections. Sensors and the urban operating system provide current information from the real world to the digital model. The government office will know about the change in time. Digital models can also see how the risk will change with different parameters and boundary conditions. It will show what happens in different areas after implementing various governance measures. A new operation has been carried out, and the model now has new data. The better model will be chosen for evaluation and then improved [1, 4].

Therefore, the functions of digital twins are risk identification, scenario analysis and feedback on the implementation.

A digital twin should not be used to replace the government in making decisions. The results of a digital model depend on the quality of the data, the parameters of the model and where it will be used. Based on the above results, the main uses of digital twins are risk assessment and monitoring; they do not make many predictions about future events.

3. Digital twin applications and case analysis

3.1. Problem identification and risk sensing

The risks in urban areas, such as public security, traffic and the environment, are not the same everywhere and at all times. However, the corresponding information is often collected by different departments and stored in separate systems. It is therefore not possible to obtain all the risk information from individual data. A digital twin will collect the historical data, current monitoring data and location information of the city to show how it has changed over time.

Warner Robins, Georgia has begun to use digital twins for public safety management. Pan et al. have used crime data, deep learning and simulation models to study the distribution of crime in space and time [5]. These models enable the identification of risk-prone areas and the simulation of alternative traffic routes in the event of an accident. Based on the above results, the deployment of

DOI: 10.54254/2755-2721/2026.CH37508

license plate readers can be changed according to changes in risk [5]. Therefore, all kinds of data can be stored in a digital twin, and this will be used to guide the allocation of resources.

The same way was used for transport safety. Sohail et al. have combined transportation, weather, crime, emission and traffic data in the urban digital twin of Sydney [6]. Machine learning is employed to study the relationship between the urban environment and the risk of traffic accidents. Therefore, there are some places that are relatively high-risk in certain situations. The above analysis still has errors in the data, range of area and model factors. Most of the risks and other kinds of future events cannot be predicted by digital twins.

3.2. Scenario simulation for policy decision-making

Based on the above risks, decision-makers should know how different situations will affect the urban system. However, it is often difficult to conduct the actual experiment due to high costs or other reasons. Instead, a digital twin can simulate how different policies will affect the urban system in the future.

FlowsDT-Galveston by Mandal et al. is a typical case of the application of digital twins in flood control [7]. The rainfall study obtained the following return period data: 2-year, 10-year, 25-year, 50-year and 100-year values. Flood depth, range, flow velocity and damage to buildings and roads were observed. According to the above data, the proportion of buildings with an inundation depth exceeding 0.3 metres was 5.7 per cent higher in the 100-year return period than in the 2-year return period, and the increase for roads was 6.7 per cent [7]. The above results have provided some information on areas needing flood control attention.

Another example is the urban flood digital twin developed in Waterloo, Iowa. Kaynak et al. have built a general flood forecasting system for transportation networks and important facilities [8]. A model will be built to study the impact of a flood on the accessibility of roads, hospitals, and other medical facilities. The first is to consider the consequences of various options in advance before choosing one.

Digital twins can help researchers understand the problems better, but the results will still be affected by errors in the model, data and other reasons. Therefore, the digital twin will be used to support the evaluation of policy, not to determine the best course of action directly.

3.3. Real-time feedback and dynamic governance

The first function is to identify risks and develop scenarios before the government acts. However, the urban situation will still change after the introduction of policies and measures. Therefore, one should continue to observe whether the above measures have the desired effect. The digital twin will gather the latest operating data and then show this information for analysis and correction.

Punggol Digital District in Singapore is a representative case of this. The Open Digital Platform has collected all sorts of urban services, such as facilities, energy, security and parking [9]. Data on building usage, environmental conditions, energy consumption, and facility operation can be gathered from the platform [10]. The above data will be used to monitor the operation and revise the facility management plan accordingly.

Digital twins are being employed in emergency response now. Situational Awareness for Emergency Response in Frisco, Texas is the combined information of the police, fire department, etc. In case of an emergency, all departments will be informed promptly and work together. Traffic lights can be changed based on the current traffic situation to help emergency vehicles and other resources move more smoothly [11].

DOI: 10.54254/2755-2721/2026.CH37508

The above cases show that updating the data in real time can help identify problems in time and determine whether the results of the management measures taken so far are satisfactory. Feedback is only useful if the updated information can affect the government's future decisions and management. Digital twins have also been employed to connect and manage the technical system of the government in practice. However, the data and models currently available are insufficient for effective management. The digital twin platform therefore needs to be integrated with the existing management system, so that the information generated by the platform can support daily operations. To realise the practical advantages of digital twins, technology should be introduced in the work of the government.

4. Governance challenges and safeguards

4.1. Data quality and representativeness

Digital twins rely on data collected from sensors, urban platforms, and administrative systems. Therefore, the quality of data directly affects the reliability of analysis results. In practical applications, urban data may have problems such as incomplete information, inconsistent standards, outdated records, and uneven spatial coverage. These limitations may influence risk assessment and scenario simulation [12].

Digital data will not cover all the cases in the city. Some areas or groups are not well represented in the current monitoring system and administrative data. Kitchin has pointed out that urban data are not entirely objective reflections of social conditions [13]. Digital twins are based on available data and cannot represent all the conditions of a city. The government should normalise the data, improve its quality, and spread the information within the department to enhance the reliability of digital twins. Decision-makers should take into account local knowledge and actual conditions in applying the results of the model.

4.2. Algorithmic transparency and decision-making accountability

If the digital twin is based on machine learning and prediction, it is necessary to know how this result is obtained and how reliable it is. The model's output is determined by the data source, parameter settings, etc. Therefore, they should not be considered entirely objective conclusions.

Haraguchi et al. have pointed out that urban digital twin governance should be transparent and accountable [14]. Decision-makers should know the main sources of data, application conditions and potential uncertainties of the model. Some people find the technical results difficult to understand.

Digital twins can provide the data for risk assessment and policy comparison, but the government will not carry out this work. Decisions that affect the public interest, society and the law still need human judgment. The different parties need to clarify their responsibilities for the good governance of the city.

4.3. Government digital capacity and technological dependence

The components of a digital twin system are sensors, a data platform, cloud computing and analysis models. Often, the government office will work with outside technology companies to build and run a system. Cooperation can provide technical support, but if it is too close, the government will not be able to manage and supervise the system independently.

DOI: 10.54254/2755-2721/2026.CH37508

If one vendor is responsible for the main data, model and operation process, it will be difficult to carry out later maintenance and system modifications. Therefore, the government office should have a basic knowledge of external services to monitor them and exercise administrative supervision.

Open data standards, clear data ownership and regular system audits will reduce the need for technology. At the same time, the government staff should have some knowledge of digital twin technology for system management and decision-making.

5. Conclusion

This study examined how digital twins can support predictive governance and government decision-making in smart cities through a literature review and case analysis. The findings show that the integration of historical records, real-time monitoring data, and spatial information can improve the identification of urban problems and emerging risks. Scenario simulation can help government agencies compare possible consequences under different risk conditions before action is taken. Continuous data updates can also support the evaluation and adjustment of governance measures after implementation. These functions allow digital twins to support government decision-making at different stages, from early risk identification to policy assessment and post-implementation adjustment. However, the practical value of digital twins depends on data quality, model transparency, clear accountability, and sufficient government digital capacity. Digital twins should therefore be used as decision-support tools rather than as substitutes for government judgement. Effective data governance, model oversight, and technical capacity are necessary for the responsible and long-term use of digital twins in urban governance. Several limitations of this study should be noted. The analysis relies on published literature and documented cases, and the conditions of each city may differ from those described in the sources, so the findings are indicative rather than directly generalisable. The costs of building and maintaining digital twins, data security, and staff training are not examined in detail and deserve further study. Future work may quantify the effect of digital twins on governance efficiency through longitudinal data, examine how smaller cities with limited budgets can adopt the technology at lower cost, and study how responsibilities should be divided among departments when digital twins are introduced into existing administrative processes.

References

[1] Sacks, R., Brilakis, I., Pikas, E., Xie, H. S., & Girolami, M. (2020). Construction with digital twin information systems. *Data-Centric Engineering, 1*, e14. https://doi.org/10.1017/dce.2020.16

[2] Deng, M., Menassa, C. C., & Kamat, V. R. (2021). From BIM to digital twins: A systematic review of the evolution of intelligent building representations in the AEC-FM industry. *Journal of Information Technology in Construction, 26*, 58–83. https://doi.org/10.36680/j.itcon.2021.005

[3] Azadi, S., Kasraian, D., Nourian, P., & van Wesemael, P. (2025). What have urban digital twins contributed to urban planning and decision making? From a systematic literature review toward a socio-technical research and development agenda. *Smart Cities, 8*(1), Article 32. https://doi.org/10.3390/smartcities8010032

[4] Hetherington, J., & West, M. (2020). *The pathway towards an information management framework: A "commons" for Digital Built Britain*. Centre for Digital Built Britain. https://doi.org/10.17863/CAM.52659

[5] Pan, X., Mohammadi, N., & Taylor, J. E. (2022). Smart city digital twins for public safety: A deep learning and simulation-based method for dynamic sensing and decision-making. In *2022 Winter Simulation Conference (WSC)* (pp. 808–818). IEEE. https://doi.org/10.1109/WSC57314.2022.10015527

[6] Sohail, A., Shen, B., Cheema, M. A., Ali, M. E., Ulhaq, A., Babar, M. A., & Qureshi, A. (2025). Beyond data, towards sustainability: A Sydney case study on urban digital twins. *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science, 93*(4), 365–377. https://doi.org/10.1007/s41064-025-00337-y

[7] Mandal, D., Zou, L., Wadhwa, A., Wilkho, R. S., Cai, Z., Zhou, B., Ye, X., Newman, G., Gharaibeh, N., & Güneralp, B. (2026). FlowsDT: A geospatial digital twin for navigating urban flood dynamics. *Computers,*

DOI: 10.54254/2755-2721/2026.CH37508

Environment and Urban Systems, 126, Article 102414. https://doi.org/10.1016/j.compenvurbsys.2026.102414

[8] Kaynak, S., Kaynak, B., Mermer, O., & Demir, I. (2025). City-scale digital twin framework for flood impact analysis: Integrating urban infrastructure and real-time data analytics. *Urban Climate, 64*, Article 102640. https://doi.org/10.1016/j.uclim.2025.102640

[9] Government Technology Agency of Singapore. (2020, February 5). Building an operating system for Punggol Digital District. *GovTech Singapore*. https://www.tech.gov.sg/technews/building-an-operating-system-for-punggol-digital-district/

[10] JTC Corporation. (2026, July 10). Punggol Digital District: A blueprint for sustainable mixed-use development. *JTC Corporation*. https://www.jtc.gov.sg/punggoldigitaldistrict/story-articles/punggol-digital-district-a-blueprint-for-sustainable-mixed-use-development

[11] Lanclos, R., & Thomas, C. (2023, May 11). Frisco, Texas finds success with a public safety digital twin. *Esri*. https://www.esri.com/about/newsroom/blog/frisco-texas-public-safety-digital-twin

[12] Lei, B., Janssen, P., Stoter, J., & Biljecki, F. (2023). Challenges of urban digital twins: A systematic review and a Delphi expert survey. *Automation in Construction, 147*, Article 104716. https://doi.org/10.1016/j.autcon.2022.104716

[13] Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal, 79*, 1–14. https://doi.org/10.1007/s10708-013-9516-8

[14] Haraguchi, M., Funahashi, T., & Biljecki, F. (2024). Assessing governance implications of city digital twin technology: A maturity model approach. *Technological Forecasting and Social Change, 204*, Article 123409. https://doi.org/10.1016/j.techfore.2024.123409