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Policy and Institutional Frameworks for City Information Modeling (CIM) Adoption in Bahrain: A Pathway to Achieving Sustainable Urban Development Goals

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Abstract

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City Information Modeling integrates Building Information Modeling (BIM), Geographic Information Systems (GIS), and real-time data analysis to enhance urban planning. While CIM has a lot to offer in sustainable urban development, its application in Bahrain is hampered by policy and institutional limitations. This study examines the impact of policy platforms and institutional frameworks on integrating CIM to align with Bahrain's Economic Vision 2030 and United Nations' Sustainable Development Goals. Using a mixed-methods approach, the study combines policy analysis, stakeholder interviews, and comparative case studies to ascertain barriers, including fragmented regulations, poor inter-agency coordination, and capacity limitations. The main findings highlight the CIM potential to enhance infrastructure efficiency, urban resilience, and public engagement subject to surmounting such barriers. The research proposes a policy-led roadmap for targeting standardized data protocols, cross-sector collaboration, and capacity building. With an emphasis on institutional and policy reforms, this research presents prescriptive outcomes for the application of CIM to enhance sustainable urban development in Bahrain and other places.

Keywords: City Information Modeling (CIM); Policy Frameworks; Institutional Barriers; Sustainable Urban Development; Bahrain Economic Vision 2030; SDGs.

1. Background

Urbanization across the Gulf region has accelerated exponentially over the last two decades, exerting tremendous pressure on environmental, infrastructural, and land systems. Similar to most of its regional peers, Bahrain is confronted with multifaceted urban issues, such as heightened land demand, resource limitations, fragmented planning, and limited integration between urban systems. These are augmented by the geographical limitations, desert climate, and population growth in Bahrain, which impose challenging requirements for creative solutions in planning and city management.

City Information Modeling (CIM) is increasingly becoming a ground-breaking tool for integrating city data, optimizing resource utilization, and enabling planning transparency. Evolved from the foundation of Building Information Modeling (BIM) and Geographic Information Systems (GIS), CIM broadens digital modeling from buildings to urban systems. By synthesizing multidimensional information, CIM facilitates real-time simulation, analysis, and decision-making to aid sustainable urban planning objectives (Xu et al., 2021; Göçer et al., 2016). At the global level, CIM has been used to enhance infrastructure performance, reduce climate risks, and enhance public engagement, such as in Singapore, Helsinki, and New York cities (Sabri et al., 2019; Usman, 2020). Despite these global improvements, Bahrain's institutionalization of CIM is still inadequate. Urban development in Bahrain now relies on stand-alone data systems, volatile policy regimes, and under-developed policy coordination between municipal and national institutions. Bahrain Vision 2030 envisions sustainability, innovation, and diversification of the economy, but there is a wide policy and institutional gap in repositioning CIM as a strategic instrument for the achievement of these visions. The previous research has touched, at most, the technical capacity of CIM. It has not yet addressed holistically the aspects of governance, regulation, and institution that are required for its implementation in Bahrain to succeed.

The above gap will be addressed by this research as it investigates the policy and institutional frameworks necessary to enable the adoption of CIM in Bahrain. It investigates how CIM can be harmonized with national priorities and the SDGs through a mixed-methods study involving policy analysis, stakeholder interviews, and comparative case studies. It aims to determine the major enablers and inhibitors within Bahrain's urban governance framework that

affect CIM institutionalization and provide evidence-based policy recommendations for policymakers, planners, and technological stakeholders.

Urbanization Challenges

Urbanization has reshaped the socio-spatial dynamics of cities, leading to complex, densely populated environments.

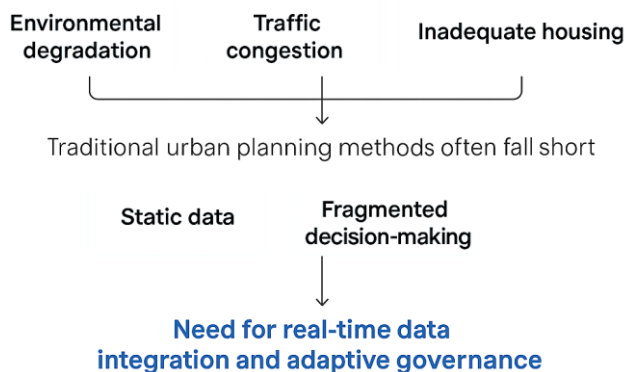


Figure 1. Urbanization Challenges. (By Author).

2. Research question

This study examines CIM's strategic contribution to Bahrain's urban planning system evolution from institutional and policy perspectives. The implementation of digital planning tools like CIM becomes obligatory when Bahrain needs to respond to complex challenges posed by rapid urbanization, environmentality, through limited land and water resources. However, success in the adoption of such technology will not only be a function of technical feasibility but also a reflection of whether consistent governance structures, policy support, and inter-agency collaboration exist. To this end, this research is guided by the following general questions that will aim to establish the institutional and policy needs for effective CIM adoption and its alignment with the SDGs and the visions of Vision 2030 in Bahrain.

Primary Research Question

What are the policy and institutional tools required to execute and successfully apply City Information Modeling (CIM) in the urban planning process of Bahrain, namely to achieve sustainable development targets?

This master research question encapsulates the knowledge gap regarding how governance frameworks, policy instruments, and institutional alignment influence the capacity of cities to integrate new technologies into formal planning systems, especially in the Global South. It captures the intention of the research to place CIM as a technical innovation and governance and policy instrument for sustainable urbanization.

Secondary Research Questions

1. To what extent do existing urban governance structures, legal orders, and administrative practices in Bahrain facilitate or impede the rollout of CIM into urban planning business processes?

The question touches on inter-agency coordination, regulatory coherence, and institutional capacity in CIM adoption. It draws from institutional theory and urban governance studies, emphasizing the salience of coherent institutional constellations in facilitating digital Planning reforms.

2. What are the perceptions of the most important stakeholders in government planners, policymakers, engineers, and private sector actors of the significant technological, organizational, and policy barriers and facilitators to CIM implementation in Bahrain?

This one requires exploring multidimensionality of adoption concerns by including perspectives of stakeholders into questionnaires and interviews. It draws on technology adoption and policy diffusion theory as it tries to take into account the process through which innovations become adopted—or refused—within complex policy systems.

3. How can Bahrain gain from successful international CIM experience, in light of its own city size, natural conditions, and administrative capacity?

This comparative question addresses the imperative of context-sensitive policy learning. It weaves case stories of global cities such as Singapore, New York, and Helsinki together to identify lessons and practices of application to the context of Bahrain, with its inward urban sprawl, climatic constraints, and development requirements.

4. How do CIM application support Bahrain's Vision 2030 goals and associated Sustainable Development Goals (SDGs) such as urban sustainability, infrastructure, innovation, and institutional capacity (e.g., SDG 11; SDG 9; SDG 16)?

This activity links operations work by CIM with strategic policy agendas. It balances CIM implementation with national and global contexts, providing opportunities for measuring CIM's value towards evidence-based planning, resilience, and digital city management.

3. Objectives

In responding to the questions raised by the study, the study is keen to explore the policy and institutional requirements in Bahrain's successful implementation of City Information Modeling (CIM) against sustainable urbanization. The study aims to contribute theoretically to the realm of urban governance and lead Bahrain's digital revolution in planning with actionable advice that aligns with Vision 2030 and the Sustainable Development Goals (SDGs).

Primary Objective

To critically evaluate and recommend a policy and institutional setup that supports fruitful integration of City Information Modeling (CIM) into Bahrain's urban development system for sustainable urban development.

This overall objective directly addresses the main research question while paying rightful attention to governance, regulatory, and institutional arrangements for CIM mainstreaming in urban decision-making. It places CIM as a technological tool but as well an instrument of reform in strategic planning.

Secondary Objectives

1. To examine Bahrain's existing urban governance and regulatory frameworks with a view to establishing institutional strengths, weaknesses, and gaps influencing the adoption of CIM.

This addresses Research Question 1 in assessing the ability and readiness of Bahrain's urban planning institutions, contributing to the literature in digital planning governance in the Global South.

2. To determine the views of the key stakeholders, that is, government, urban planners, engineers, and private sector, regarding what facilitates and impedes CIM adoption.

This is consistent with Research Question 2, linking empirical results and conceptual frameworks of technology adoption and stakeholder participation in innovation planning.

3. To contrast and synthesize global CIM case studies (e.g., Helsinki, Singapore, New York) and test the generalizability of the same to Bahrain's environmental, spatial, and administrative contexts.

This is addressed by Research Question 3 through relating best practice from overseas to localized action plans and providing a comparative context for adaptive policy transfer.

4. To establish how the implementation of CIM can assist in delivering Bahrain's Vision 2030 goals and relevant Sustainable Development Goals (for instance, SDG 9; SDG 11; SDG 13; SDG 16) with an emphasis on sustainability, infrastructure, innovation, and the efficiency of institutions.

This leads to Research Question 4 by pitting CIM technological capability against strategic planning outcomes and country development plans.

5. To facilitate a data-driven, stakeholder-centered framework to examine Bahrain's CIM readiness and deployment strategies.

This integration goal combines qualitative and quantitative evidence to build functional policy recommendations and institutional reforms, increasing the worth and utility of the research.

3. Literature review

3.1 City Information Modeling (CIM) as a New Paradigm

City Information Modeling (CIM) is a new paradigm that is expected to advance Building Information Modeling (BIM) and Geographic Information Systems (GIS) to the city level, to enable multidimensional modeling, simulation, and management of cities (Melo et al., 2019; Xu et al., 2021). CIM enables data-intensive representation of cities that makes planning, design, operations, and policymaking for different urban sectors feasible.

The scholars have positioned CIM as a techno-platform and as a strategic governing tool, capable of achieving sustainable urban development, infrastructure life cycle management, and live city monitoring (Kolbe, 2017; Göçer et al., 2016). However, literature is not in consensus regarding whether CIM needs to be understood as a new discipline or digital urbanism tools converging into a broader set. This kind of ontological uncertainty is a barrier towards shared use of institutions, particularly in emerging environments.

CIM as a Global Approach: How and Why

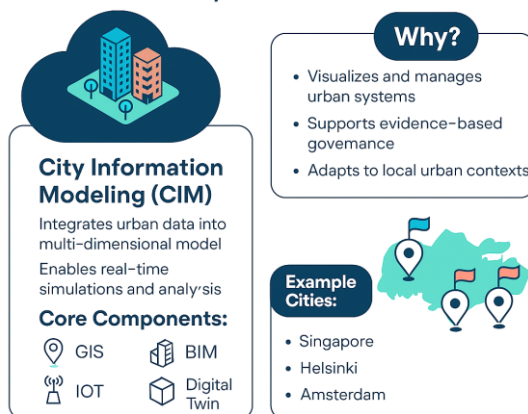


Figure 2. CIM as a Global Approach. (By Author).

3.2 CIM and Urban Governance: Theoretical Foundations

Theoretically, CIM implementation is increasingly debated in urban governance, digitalization, and institutional theory. Institutional theory views technological innovation in public planning as dependent on formal rules, organizational culture, and inter-agency coordination (North, 1990; March & Olsen, 2008). CIM adoption here is not merely a technical upgrade but a change in governance that requires institutional alignment, policy coherence, and the backing of stakeholders.

Innovative city models also lead CIM literature as CIM provides the spatial and data infrastructure for implementing smart mobility, energy efficiency, and adaptive urban services (Batty et al., 2012). Synergy between CIM and innovative governance patterns emphasizes transparency, interoperability, and participatory planning (Chourabi et al., 2012). There is nevertheless limited empirical analysis of how these models are being implemented in environments like the Gulf, where top-down planning culture prevails.

3.3 Policy Transfer and Diffusion of Innovation

Use of CIM can also be described applying the theory of diffusion of innovation (Rogers, 2003), where relative advantage, compatibility, and complexity are emphasized as key factors in determining the dissemination of new technologies across institutional frameworks. Models of technological adoption emphasize the need for readiness at the user's end, leadership, and external pressures like international standards or donor pressure (Venkatesh et al., 2003). Policy diffusion in urban planning is when cities copy effective overseas models, e.g., Singapore's Virtual City or Finland's CIM-facilitated energy dashboards. But the literature lacks a picture of how these policies are carried out—or confronted with opposition—based on situational conditions such as scale, political environment, and digital maturity. Bahrain, for example, has been targeted by international smart city discourses but lacks a systematic framework for local adaptation and institutional capacity building.

Chourabi et al. (2012) posited that key success factors in innovative city governments encompass institutional leadership, collaboration among stakeholders, and technology infrastructure. As a location and data backbone, CIM directly supports these aspects by enabling cross-sectoral integration, transparency, and real-time responsiveness. Incorporating CIM into innovative urban models reinforces multi-level governance and citizen engagement. Dolowitz and Marsh's (2000) policy diffusion model is also relevant to CIM adoption. The model explains how policy innovations are diffused across boundaries based on learning, coercion, or emulation. In the Gulf context, CIM must be understood as part of a broader smart city policy diffusion, where cities try to approximate more general models like Singapore or Helsinki, but subject to certain political and institutional limitations.

3.4 Institutional Barriers and Opportunities in Developing Contexts

In the Global South, institutional fragmentation, weak digital infrastructure, and siloed data governance are constant issues in CIM implementation (Dantas et al., 2019; Souza & Bueno, 2022). Studies across South America, the Middle East, and parts of Asia emphasize the need for central data platforms, inter-agency coordination directives by law, and clear performance metrics. Precisely for this reason, little research exists to date on how small nations like Bahrain can overcome institutional challenges through CIM integration in novel governance programs.

Limited analysis of public-private partnerships (PPPs) as enablers of CIM also exists, despite empirical examples in cities such as New York and Berlin, where PPPs formed a core part of CIM financing, data standardization, and operationalization (City of Berlin, 2019; NYC Open Data Portal, 2020). This lack of analysis represents a key research gap in digital governance and market-based collaboration.

3.5 Gaps Summary and Relevance to Bahrain

In sum, the literature emphasizes the development potential of CIM in enhancing urban governance, sustainability, and resilience. However, there are still significant gaps regarding how CIM can be institutionalized in countries like Bahrain, where digital infrastructure is expanding but inter-agency integration and regulatory frameworks are nascent. This study attempts to fill that gap by (1) placing CIM adoption within the policy and institutional

environment in Bahrain, (2) drawing on global cases for adaptive strategies, and (3) outlining policy and governance innovations that can facilitate CIM as a tool for urban transformation that is sustainable.

4. Methodology

This study employs a mixed-methods research design, combining qualitative and quantitative approaches to comprehensively analyze the policy and institutional frameworks shaping City Information Modeling (CIM) adoption in Bahrain. This design is well-suited for unpacking complex governance dynamics, institutional readiness, and stakeholder perspectives across multiple urban systems. The methodology is structured around five core components: (1) policy document analysis, (2) stakeholder interviews, (3) a national survey, (4) comparative case study analysis, and (5) a data synthesis framework.

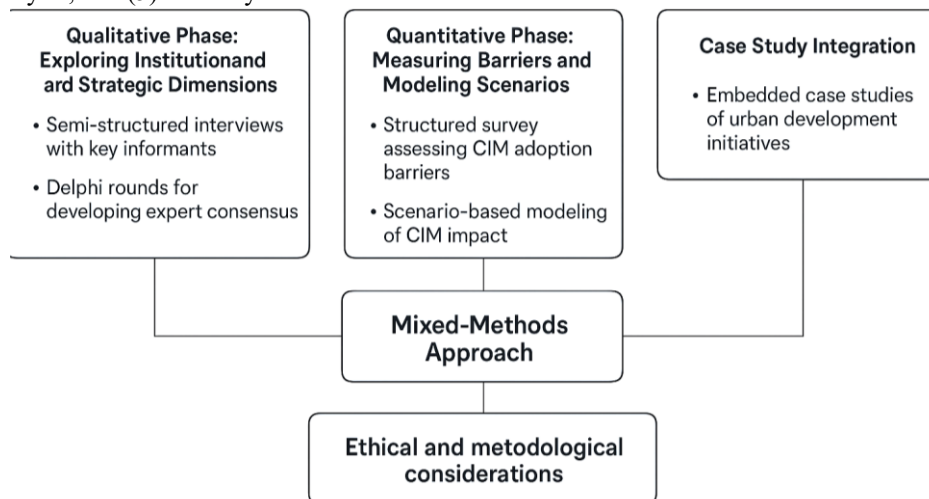


Figure 3. Research Methodology Design (By Author).

4.1 Policy Document Analysis

In order to address Research Question 1, a qualitative content analysis of national urban planning policies, regulations, strategies, and guidelines related to urban sustainability, digital transformation, and spatial planning was conducted. Reports were selected based on theme similarity to CIM-related subject matters, including data governance, innovative city initiatives, infrastructure projects, and regulatory environments. Certain primary sources including Bahrain's Vision 2030, National Planning and Development Strategy, municipal law, eGovernment initiatives, and environmental sustainability reports were used.

- Inclusion Criteria: Official planning documents published or endorsed by national or municipal governments from 2000 onwards.
- Analytical Framework: Thematic coding with NVivo, based on institutional theory and digital urbanism principles. This stage analysed policy coherence, institutional alignment, and regulatory gaps for CIM implementation.

4.2 Semi-Structured Interviews

In order to follow Research Question 2, semi-structured interviews were conducted with purposively sampled stakeholders from government departments, municipalities, planning consultancies, engineering firms, and universities.

- Stakeholder Selection Criteria:
 - Urban planning, digital transformation, or infrastructure development role
 - Institutional affiliation with organizations relevant to CIM (e.g., Survey and Land Registration Bureau, Ministry of Municipalities, Information & eGovernment Authority)
 - Sample Size: 120 participants
 - Interview Structure: Guided by themes such as digital governance, data interoperability, regulatory constraints, institutional capacity, and perceived value of CIM.
 - Data Analysis: Thematic analysis was used to reveal patterns, contradictions, and institutional narratives.
- Interview findings yielded data on the enablers, barriers, and political-institutional processes affecting CIM adoption.

4.3 Quantitative Survey

Provide a structured web-survey administered to more planning professionals, engineers, and municipal officials to supplement qualitative data and provide stakeholder attitude triangulation.

- Sample: 400 respondents
- Sampling Technique: Snowball sampling and professional network invitations.
- Surveys: question topics: institutional capacity, regulatory hindrances, inter-agency collaboration, technological preparedness, and CIM advantages.
- Data Analysis: Descriptive statistics and cross-tabulations using SPSS.

The survey evaluated readiness indicators of an institution and stakeholder awareness in the Bahrain planning context.

4.4 Comparative Case Study Analysis

In response to Research Question 3, five foreign CIM case studies—Singapore, New York, London, Helsinki, and Berlin—were selected based on the following criteria:

- Maturity and variety of CIM adoption
- Publicly available data and documentation
- Applicability to Bahrain's scale, climate, and governance context

A cross-case comparison model analyzed policy mechanisms, technology infrastructures, stakeholder engagement models, and lessons learned. Adjustability to Bahrain was examined with contextual analysis of environmental, institutional, and socioeconomic determinants.

4.5 Data Synthesis Framework

Thematic analysis followed Braun and Clarke's (2006) six-step guide to thematic analysis: familiarization with the data, generation of initial codes, searching for themes, reviewing the themes, defining and naming the themes, and producing the report. NVivo software supported qualitative coding, while SPSS was used to examine quantitative data, such as cross-tabulations and descriptive statistics. To reconcile methodological rigor and synthesize findings across methods, a two-level synthesis framework was used:

1. Thematic Synthesis (Qualitative): Policy documents, interviews, and case studies were deductively and inductively coded following Braun and Clarke's (2006) thematic analysis.
2. Comparative Synthesis (Quantitative): Survey results were statistically examined, and the qualitative data were triangulated to enhance main trends and institutional patterns.

Findings were organized along five thematic dimensions of CIM adoption: (1) regulation and governance, (2) stakeholder participation, (3) institutional capacity, (4) technological infrastructure, and (5) alignment of strategy with sustainability objectives.

Mixed-Methods Integration Framework

Phase	Data Source	Method	Purpose
Phase 1	Policy Documents	Qualitative Content Analysis	Identify gaps in regulation, thematic trends
Phase 2	Interviews	Thematic Analysis (Braun & Clarke)	Capture stakeholders' views and contradictions
Phase 3	Surveys	SPSS Statistical Analysis	Quantify awareness, readiness, institutional trends
Phase 4	International Case Studies	Comparative Analysis	Identify relevant best practices
Phase 5	Synthesis	Triangulation	Synthesize findings to create a policy roadmap

4.6 Overcoming Methodological Limitations

Reflexivity was maintained through routine journaling, peer debriefing, and routine critical self-reflection throughout all phases of data collection and analysis. By doing so, the researcher's assumptions and positionality were kept from affecting stakeholder narrative or policy interpretation. Any potential biases in policy interpretation were resolved through stakeholder validation during interviews and cross-checking policy documents against international planning norms. Reflexivity as a researcher was exercised at all times to ensure objectivity while interpreting data. Ethical clearance was obtained, and informed consent was received from all the participants.

5. Results

The results of this study are drawn from a triangulated analysis of policy documents, stakeholder interviews, survey responses, and international comparative case studies. They reveal multidimensional insights into Bahrain's current institutional landscape for City Information Modeling (CIM) adoption, including perceived barriers, enablers, and areas of alignment or conflict between policy ambitions and operational capacity. Results are categorized into five key thematic areas aligned with the research objectives.

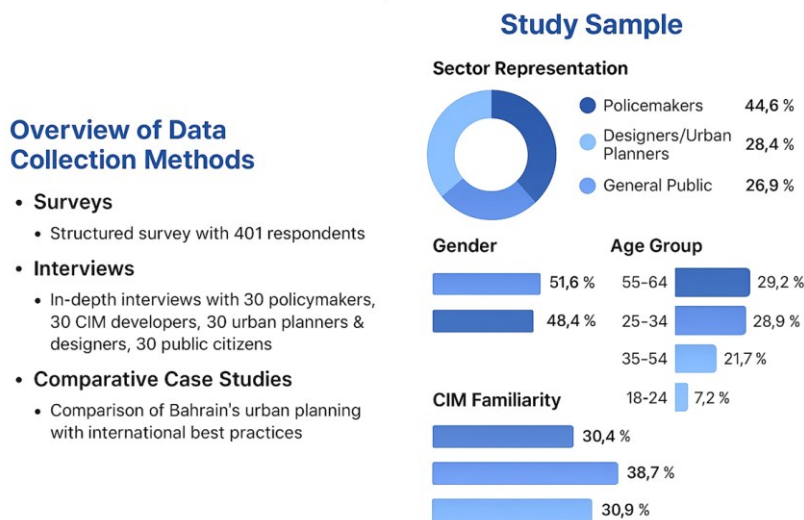


Figure 4. Overview of Results (By Author).

5.1 Fragmentation in Urban Governance Structures

A prominent finding across policy review and stakeholder interviews is the fragmentation of roles and responsibilities in Bahrain’s urban governance system. While entities such as the Ministry of Municipalities and Agriculture Affairs, the Information and eGovernment Authority (iGA), and the Electricity and Water Authority (EWA) have begun digital transformation initiatives, these efforts are mainly siloed and lack interoperability. Stakeholders noted the absence of a centralized data-sharing platform or a legal mandate to coordinate cross-sector digital planning, constraining the adoption of integrated urban modeling frameworks such as CIM.

For example, survey responses showed that only **32% of respondents** from government agencies agreed that their departments regularly share spatial data with other agencies. This fragmentation leads to inefficiencies in planning processes, duplicated infrastructure efforts, and missed opportunities for integrated sustainability strategies—an issue that CIM could directly address if adequately institutionalized.

5.2 Absence of a Dedicated CIM Policy or Legal Framework

Despite Bahrain’s strong alignment with smart city objectives and the Sustainable Development Goals (SDGs), there is currently no policy framework or regulation that directly supports the deployment of CIM. Analysis of national development documents, such as the Bahrain Economic Vision 2030, the Fourth National Communication to the UNFCCC, and the Urban Planning Law, revealed implicit support for digital urbanism but no explicit articulation of CIM or similar data-driven urban platforms.

Stakeholders emphasized that the absence of a policy framework results in limited institutional commitment to data integration, platform investment, and capacity building. Moreover, legal ambiguity regarding data ownership, security, and interdepartmental access emerged as a critical concern during interviews with municipal and national planners.

5.3 Perceptions of CIM Benefits and Risks

Stakeholder interviews and surveys identified a strong recognition of CIM’s potential benefits. Over 78% of surveyed urban professionals agreed that CIM could significantly enhance planning transparency, improve infrastructure coordination, and optimize public service delivery. Interviewees highlighted its usefulness in simulating flood risks, modeling traffic flows, and facilitating evidence-based zoning decisions.

However, concerns were also raised. Several stakeholders, particularly from the public sector IT departments, cited the high upfront costs of platform development and uncertainty about return on investment. Others raised questions about digital readiness, noting that the existing GIS infrastructure and municipal staff training levels are insufficient for immediate CIM implementation.

5.4 Institutional Readiness and Capacity Gaps

The survey indicated mixed levels of institutional readiness. While 65% of respondents confirmed the presence of GIS tools within their institutions, only 28% reported using integrated BIM-GIS platforms. The capacity gap is particularly evident at the municipal level, where reliance on outdated CAD-based systems and a lack of spatial analytics expertise are prevalent.

Interview responses highlighted that no national roadmap or institutional training program is currently dedicated to CIM, nor is there a standardized protocol for spatial data collection or model interoperability. This finding aligns with broader regional studies emphasizing the need for capacity development and standardization in digital urban governance.

5.5 Lessons from International Case Studies: Relevance and Adaptability

The comparative case studies of Singapore, New York, London, Helsinki, and Berlin demonstrated several adaptable practices that Bahrain can adopt. These include:

- Singapore’s centralized 3D city database and BIM-GIS integration enable real-time traffic and energy simulations (Sabri et al., 2019).
- Berlin’s open data policy promotes transparency and citizen participation.
- Helsinki’s use of CIM for building energy performance monitoring aligns with its climate goals.

While the study focused on global cases, emerging GCC initiatives also offer valuable lessons. The NEOM megacity project in Saudi Arabia incorporates digital twin technology and integrated urban modeling as core planning tools. Similarly, Dubai’s Digital Twin Strategy envisions a real-time 3D model of the city to optimize services and simulate future development scenarios. These cases highlight the regional momentum toward CIM-aligned technologies and underscore the urgency for Bahrain to adopt a tailored, scalable approach suited to its own governance and spatial scale.

Bahraini stakeholders expressed interest in these models but emphasized the need for contextual adaptation. Bahrain’s smaller geographic scale and top-down planning culture offer a unique opportunity to pilot CIM initiatives within a more contained urban system, particularly in Manama, before scaling nationally.

However, the research also identified the absence of regional case studies or benchmarks, highlighting a gap in GCC-specific CIM research and emphasizing the need for Bahrain to become a regional pioneer in this domain.

Summary of Results

Thematic Area	Key Finding
Urban Governance Fragmentation	Lack of data sharing and inter-agency coordination undermines integrated planning.
Policy and Legal Framework Gaps	CIM is not explicitly supported in Bahrain’s current legislative or strategic documents
Perceived Value vs. Implementation	Stakeholders recognize CIM’s benefits but cite financial and technical constraints.
Institutional Capacity	Low BIM-GIS integration; training gaps persist, especially at the municipal level.
International Lessons	Global models offer applicable insights but require adaptation to Bahrain’s scale and context.

6. Discussions

This study offers critical insights into the institutional and policy challenges that shape the potential adoption of City Information Modeling (CIM) in Bahrain’s urban planning sector. The findings reveal structural limitations and transformative opportunities, emphasizing the importance of context-sensitive adaptation of global CIM practices. This section discusses the implications of the results about the broader theoretical frameworks of urban governance, digital transformation, and sustainable development while addressing key gaps identified in existing literature.

6.1 Fragmented Governance and the Need for Institutional Coherence

The fragmentation of urban governance in Bahrain—evidenced by siloed departmental operations and the absence of a national data-sharing framework—reflects broader challenges identified in digital urbanism literature. Scholars argue that digital technologies such as CIM require institutional alignment, legal interoperability, and robust governance ecosystems to be effective (Joss et al., 2019; Söderström et al., 2014). Bahrain’s situation aligns with these challenges, demonstrating how institutional fragmentation impedes coordinated planning and limits the integration of CIM into national urban strategies.

This finding suggests structural reform, including establishing a centralized urban data authority or an inter-agency coordination mechanism. Developing shared protocols, common data standards, and legally binding mandates could enhance interoperability, aligning with recommendations in institutional theory for fostering organizational alignment in innovation diffusion (Tolbert & Zucker, 1996).

6.2 Policy Gaps and the Absence of a Legal CIM Mandate

Despite Bahrain’s commitments to sustainable urban development through Vision 2030 and the Sustainable Development Goals (SDGs), the lack of an explicit policy framework for CIM adoption represents a significant institutional gap. This concerns the literature about the disconnect between high-level smart city visions and on-the-ground implementation strategies (Paskaleva, 2019). While Bahrain has adopted digital governance in sectors such as e-government and utilities, urban planning remains loosely regulated regarding data-driven methodologies. This gap reinforces the importance of formalizing CIM through national legislation or regulatory instruments. Legal clarity on data ownership, interdepartmental access, and integration requirements is crucial for institutionalizing CIM in the urban planning process. Doing so would also align with global trends, where regulatory frameworks have accelerated the adoption of CIM, as seen in Singapore’s Building and Construction Authority and Helsinki’s digital twin governance model (Sabri et al., 2019; Jylhä et al., 2020).

6.3 Evaluating Institutional Readiness and Capacity

The study highlights uneven institutional readiness, particularly at the municipal level, where reliance on outdated CAD systems and a lack of GIS-BIM integration prevail. This aligns with technological adoption theories, such as Rogers’ Diffusion of Innovations model, which emphasizes organizational capacity and perceived complexity as key barriers to the uptake of innovation (Rogers, 2003). Bahrain’s case reflects these dynamics, where CIM is acknowledged as valuable but perceived as technically and financially demanding.

The findings underscore the importance of a phased implementation strategy, beginning with capacity-building programs and pilot projects in high-priority areas, such as the Capital Governorate. Technical training, institutional restructuring, and procurement reform can lay the groundwork for the long-term deployment of CIM. Moreover, targeted investments in digital infrastructure could address disparities across planning agencies.

6.4 Opportunities for Policy Learning and Contextual Adaptation

International case studies underscore the importance of adapting to local contexts. Singapore and Helsinki demonstrate how CIM can support urban sustainability through energy optimization, mobility planning, and disaster resilience; however, Bahrain's smaller scale, centralized decision-making, and distinct climatic conditions present constraints and opportunities.

Bahrain's compact urban geography may facilitate more controlled CIM implementation, particularly in pilot cities like Manama. Moreover, pressing challenges such as water scarcity, saline intrusion, and rapid urban expansion provide fertile ground for CIM-enabled modeling of infrastructure, environmental systems, and public service delivery. This supports policy diffusion theory, which posits that innovation adoption improves when aligned with local institutional, environmental, and socio-political realities (Dolowitz & Marsh, 2019).

6.5 The Role of Public-Private Partnerships and Stakeholder Collaboration

The study also identified a significant gap in private sector engagement and civil society participation in the CIM ecosystem. This is consistent with critical urban studies literature, which highlights the importance of inclusive digital transformation strategies (Kitchin, 2015). CIM's participatory potential—through interactive 3D models and stakeholder co-creation platforms—has been underutilized in Bahrain.

Engaging private technology firms, academic institutions, and NGOs can provide essential technical expertise and promote innovation. Public-private partnerships (PPPs) have proven instrumental in implementing CIM in cities such as London and New York, particularly in platform development and data management. Establishing clear public-private partnerships (PPPs) frameworks in Bahrain could help mobilize resources and integrate corporate integrity management (CIM) into the national urban planning agenda.

6.6 Bridging the Theory-Practice Gap in Bahrain's Urban Digitalization

This study's empirical findings highlight a broader theoretical concern: the limited localization of digital urban planning frameworks in Gulf cities. While the literature on smart cities and digital twins is expanding, research remains sparse on how these concepts are translated into practice in rentier states with centralized governance structures.

This study bridges that gap by providing grounded, context-specific insights into how CIM can be institutionalized in Bahrain. It also suggests developing a localized theoretical framework incorporating regional governance characteristics, environmental constraints, and cultural priorities for CIM adoption. Such a framework can guide both policy and academic efforts moving forward.

7. Conclusions and Future Recommendations

This study critically examined the policy and institutional frameworks influencing the adoption of City Information Modeling (CIM) in Bahrain to identify a pathway for integrating CIM into the country's sustainable urban development agenda. Drawing on a mixed-methods approach—including policy analysis, stakeholder interviews, and comparative case studies—the study revealed significant institutional fragmentation, legal ambiguity, and capacity gaps that currently hinder the adoption of CIM. At the same time, it identified valuable opportunities for Bahrain to localize and adapt CIM practices aligned with its Vision 2030 objectives and the UN Sustainable Development Goals (SDGs).

While CIM offers transformative potential for enhancing resource efficiency, participatory planning, and climate resilience, its implementation in Bahrain requires a coherent policy mandate, institutional reform, and sustained investment in digital capacity. The comparative case studies of Singapore, Helsinki, and New York demonstrated that successful CIM integration depends on technological readiness and governance structures that support cross-sectoral collaboration, public-private partnerships, and regulatory innovation.

The findings reaffirm the need to bridge the gap between CIM's theoretical benefits and the practical realities of planning institutions in Bahrain. As such, the study contributes to emerging scholarship on digital urbanism in the Gulf region, offering one of the first in-depth assessments of CIM from a governance and policy integration lens.

Future Recommendations

1. Develop a National CIM Policy Framework

A formal national policy should be established to mainstream CIM within Bahrain's urban planning system. This framework must define standards for data integration, mandate inter-agency collaboration, and delineate responsibilities among government actors. Legal backing is essential to ensure that CIM is not treated as a peripheral tool but embedded into the regulatory fabric of planning practices.

2. Establish a Centralized Urban Data Authority

A national urban data governance body should coordinate geospatial and planning data collection, management, and dissemination. This institution would promote interoperability, oversee platform development, and support data ethics and privacy regulations, addressing a critical institutional void identified in this study.

3. Initiate CIM Pilot Projects in Strategic Urban Zones

Bahrain should launch pilot programs in high-priority areas such as Manama's central district or proposed innovation zones to build momentum and demonstrate CIM's value. These projects can focus on transportation optimization, energy modeling, or water resource planning, generating local knowledge and supporting evidence-based scaling.

4. Invest in Institutional Capacity Building

The digital transformation of urban planning requires targeted capacity-building efforts across all levels of government. Training programs on GIS-BIM integration, data analytics, and CIM software should be institutionalized in collaboration with universities, international organizations, and private sector experts.

5. Foster Public-Private Partnerships and Knowledge Exchange

Bahrain should develop structured public-private partnership (PPP) frameworks to mobilize private sector investment and innovation in CIM platforms. Knowledge exchange with international cities and academic institutions should be encouraged to facilitate policy learning, adaptation, and innovation transfer.

6. Promote Civic Engagement Through CIM Visualization Tools

CIM's potential to enhance transparency and public engagement must be fully leveraged. Interactive platforms that enable citizens to visualize and comment on proposed urban projects can enhance participatory planning and foster trust in planning decisions. Such approaches are increasingly vital in ensuring socially inclusive and responsive urban development.

7. Align CIM Implementation with Bahrain's SDGs Monitoring

The government should integrate CIM indicators into Bahrain's national SDG monitoring and reporting mechanisms. Doing so will support data-driven policymaking and enhance Bahrain's ability to track and report progress toward global sustainability goals. This research provides a foundation for further academic inquiry and practical experimentation on CIM in the Gulf. Future studies should expand empirical data collection through broader stakeholder engagement, assess the scalability of pilot projects, and explore region-specific CIM governance models that balance centralization with local responsiveness. By institutionalizing CIM within its urban development processes, Bahrain can position itself as a regional leader in sustainable, innovative, and inclusive city planning.

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Conflict of Interests

The Author(s) declares that there is no conflict of interest.

References

- Al Furjani, Z., Younsi, A., Abdulalli, et al. (2020). Enabling the City Information Modeling (CIM) for urban planning with OpenStreetMap (OSM). *The Fourth International Conference for Geospatial Technologies—Libya GeoTec 4*.
- Amen, Mustafa Aziz, and Hourakhsh A. Nia. 2021. "The Effect of Cognitive Semiotics on The Interpretation of Urban Space Configuration."
- Aziz Amen, Mustafa. 2017. "The Inspiration of Bauhaus Principles on the Modern Housing in Cyprus." *Journal of Contemporary Urban Affairs* 1(2):21–32. doi:10.25034/ijcua.2017.3645.
- Aziz Amen, Mustafa, and Hourakhsh Ahmad Nia. 2018. "The Dichotomy of Society and Urban Space Configuration in Producing the Semiotic Structure of the Modernism Urban Fabric." *Semiotica* 2018(222):203–23. doi:10.1515/sem-2016-0141.
- Bahrain Voluntary National Review (2023). (2023). Government of Bahrain. https://www.sdgs.gov.bh/PDFfiles/EN/EN_DESIGNED%20REPORT%20V17%20-%20Single%20Page_compressed.pdf
- Bentley Systems. (2025). Bentley Systems | Infrastructure Engineering Software. <https://www.bentley.com/>
- Biljecki, J., Stoter, H., Ledoux, S., Zlatanova, S., Çöltekin, A. (2015). Applications of 3D city models: state-of-the-art review. *ISPRS Int. J. Geo-Inf.*, 4, 2842–2889. <https://doi.org/10.3390/ijgi4042842>
- Dantas, H.S., Sousa, J.M.M.S., & Melo, H.C. (2019). The importance of City Information Modeling (CIM) for cities' sustainability. *IOP Conference Series: Earth and Environmental Science*, 225, 012074. <https://doi.org/10.1088/1755-1315/225/1/012074>
- From Regional Pioneer to Global Contender: The Economic Vision 2030 for Bahrain. (2008). Government of Bahrain. https://www.bahrain.bh/wps/wcm/connect/cc20ef28-552d-44b5-8af5-95566fdbe9f9/Vision%2B2030%2BEnglish%2B%28low%2Bresolution%29.pdf?MOD=AJPERES&CV_ID=kTtAKxR
- Gil, J. (2020). City Information Modeling: A conceptual framework for research and practice in digital urban planning. *Built Environment*, 46(4), 501–527. <https://doi.org/10.2148/benv.46.4.501>

- Ho, S., & Rajabifard, A. (2016). Towards 3D-enabled urban land administration: Strategic lessons from the BIM initiative in Singapore. *Land Use Policy*, 57, 1–10. <https://doi.org/10.1016/j.landusepol.2016.05.011>
- International Electrotechnical Commission (IEC). (2021). City information modeling and urban digital twins. <https://www.iec.ch/basecamp/city-information-modelling-and-urban-digital-twins>
- ISO (2018). ISO 19650—organization and digitization of information about buildings and civil engineering works, including building information modeling (BIM)—information management using building information modeling—Part 1: Concepts and principles.
- Najafi, M., Mohammadi, P., van Wesemael, P.M., Le Blanc, P.M. (2023). A user-centered virtual city information model for inclusive community design: state-of-the-art. *Cities*, 134, 104203. <https://doi.org/10.1016/j.cities.2023.104203>
- Omrany, H., Ghaffarianhoseini, A., Ghaffarianhoseini, D.J., Clements-Croome, R. (2022). The uptake of City Information Modelling (CIM): A comprehensive review of current implementations, challenges, and future outlook. *Smart and Sustainable Built Environment*. <https://doi.org/10.1108/SASBE-06-2022-0116>
- Pereira, A.P., & Procopiuck, M. (2022). The path to implementing and institutionalizing CIM: A systematic literature review. *Revista Brasileira Planejamento e Desenvolvimento*, 11(1), 236–265. <https://doi.org/10.3895/rbpd.v11n1.14586>
- Rossiter, G., Cotterill, H., Zhang, J., Turner, J., Gil, J., Lieberman, J., Zhu, R., Ferris, S., Wei, S., Le, V., Patterson, W., Jian, Y. (2021). City Information Modelling and Urban Digital Twins. <https://www.iec.ch/basecamp/city-information-modelling-and-urban-digital-twins>
- Schaufler, C., & Schwimmer, E. (2020). City Information Modeling – an expedient tool for developing sustainable, responsive, resilient cities? *IOP Conference Series: Earth and Environmental Science*, 588(3), 032005. <https://doi.org/10.1088/1755-1315/588/3/032005>
- Smart Nation Singapore. (2025). Smart city initiatives in Singapore. <https://www.smartnation.gov.sg/>
- Wang, Y., Tian, Y. (2021). Research on key technologies of City Information Modeling. *IOP Conference Series: Earth and Environmental Science*, 693(1), 12129. <https://doi.org/10.1088/1755-1315/693/1/012129>
- Xu, Z., Qi, M., Wu, Y., Hao, X., & Yang, Y. (2021). City Information Modeling: State of the Art. *Applied Sciences*, 11(19), 9333. <https://doi.org/10.3390/app11199333>