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DATA FOR POLICY CONFERENCE PROCEEDINGS PAPER

A socio-technical perspective on digital twins as GovTech solutions: the case of WiseTown

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Abstract

This article examines the implications of adopting a socio-technical perspective on the design and implementation of GovTech solutions. To observe the phenomenon, it adopts a case study approach focusing on the WiseTown solution and its City Digital Twin (CDT), developed by the Italian company TeamDev. The article investigates how integrating social factors, such as urban governance, with technical elements, like data analysis and modeling, can enhance the conceptualization, design, and implementation of user-centric, data-driven digital solutions as part of a broader digital transformation strategy. The article explores an Italian best practice that is developing four dimensions of the GovTech socio-technical framework: Governance Structures, Institutional Arrangements, User and Context Understanding, and Technological Development. It critically examines and discusses the challenges and opportunities associated with the adoption of CDTs and their impact on public policy implementation. The analysis is centered on two main aspects that emerged from the case study: data integration and sharing within CDTs, and the social implications associated with data usage for decision-making. Ultimately, the article explores the role of stakeholder collaboration (public-private partnerships) and the creation of innovation ecosystems—GovTech ecosystem in this specific case—to inform and steer policy-making through and beyond the adoption of CDTs.

Policy Significance Statement

This study showcases the potential of City Digital Twins (CDTs) as powerful tools for urban management and policymaking. By integrating real-time data with urban models, CDTs help policymakers understand complex city dynamics and make informed decisions that are pivotal for sustainable urban development. The research highlights the importance of a socio-technical approach that combines governance, technology, and stakeholder engagement within the GovTech framework to effectively implement these digital solutions. It underscores the necessity of addressing both technological challenges and social considerations, such as data privacy and public participation, to ensure that CDTs serve the diverse needs of urban communities effectively. Insights for policymakers concern leveraging technology for better governance and enhanced public services, providing a relevant case of successful CDT implementation with first-hand insights into the opportunities and challenges across multiple levels—governance, institutional arrangements, contextual understanding, and the technological landscape.

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1. Introduction

How does the adoption of a socio-technical perspective, rather than a strictly technical one, affect the design and implementation of GovTech technologies?

This question is addressed by examining the concept of City Digital Twins (CDTs) as advanced digital models representing urban areas. Focusing on WiseTown, a CDT application by the Italian company TeamDev, the study explores how integrating social aspects (such as urban governance) with technical factors (like data analysis and modeling) can facilitate the conceptualization, design, and implementation of user-centered and data-driven digital solutions within a wider digital transformation strategy.

CDTs provide a solution to the increasing complexity of urban decision-making, which requires analytical tools able to leverage the advantages of data-informed policymaking. Their simulative aspect makes them more than mere digital replicas of urban environments. CDTs are interactive and responsive platforms capable of bringing several advantages, from informing the conceptualization and testing of innovative ideas in cities to providing tools for the collection, use, and sensemaking of data for policy. Further, CDTs offer an infrastructure for broadening the scope of contemporary planning methods as they support city officials in leveraging data strategically for the design, implementation, and evaluation of public policies, as emphasized in recent literature (van Veenstra and Kotterink, 2017; Aragona and De Rosa, 2019; Brunswicker et al., 2019; Verstraete et al., 2021).

However, despite advantages, empirical studies of the uptake of CDTs within the policy realm remain limited. There are notable instances of empirical research in this area (Nochta et al., 2021), yet the academic discourse often overlooks the challenges of applying CDTs in policymaking, particularly beyond engineering and technological aspects. The conversation surrounding CDTs shows a predominantly technology-centric focus, showcasing technical capabilities and functionalities. Drawing from research that examines cities' digital transformation through the lens of socio-technical innovations and transitions (Carvalho, 2015; Kitchin, 2015; Mora and Deakin, 2019), it is clear how achieving benefits is neither straightforward nor inevitable, particularly given the technological origins of CDT. Instead, defining roles and values of CDTs requires interdisciplinary and cross-sectoral collaboration, also using participatory methods to engage not only those who plan and manage cities but also their prospective users—namely, residents and workers, researchers, and technology providers (Ku and Kwok, 2015). This interdisciplinary perspective might help move beyond the technology hype that currently surrounds government digital transformation and technological uptake (Verbong et al., 2008; Carvalho, 2015).

The socio-technical approach needed refers to GovTech as "socio-technical solutions—that are developed and operated by private organizations—intertwined with public sector components for facilitating processes in the public sector" (Bharosa, 2022, p. 3). Similarly, the GovTech concept underscores the integration of advanced technologies within government functions to enhance service delivery, policymaking, and value creation (Mergel et al., 2019; Ubaldi et al., 2019), thus providing a strategic orientation to the integration of technologies like CDTs into government. By depicting key areas of intervention into four pillars—governance structures, institutional arrangements, technological development, and user and context understanding—GovTech offers a valid lens to investigate the challenges and opportunities that CDTs bring to city governance and policymaking.

Using this approach, the article explores an Italian best practice that is developing CDTs through the GovTech framework, critically examining and discussing the challenges and opportunities of CDTs adoption and their impact on the implementation of public policy. The article identifies critical areas and persistent challenges that need to be taken into account when dealing with CDTs. Ultimately, it explores the role of stakeholder collaboration (public-private partnerships) and the creation of innovation ecosystems—the GovTech ecosystem in this specific case—to inform and steer policymaking through and beyond the adoption of CDTs.

2. CDTs for policymaking

A CDT is a dynamic virtual model that captures both the physical characteristics and behaviors of urban environments. The idea of a Digital Twin (DT) was to create a model that could predict and simulate the

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life cycle of a system. The primary utility of DTs lies in their ability to predict how a system will perform under various conditions using data-driven analytics and simulations, which can be applied either in real situations or hypothetically (Cioara et al., 2021).

The rise in computing power, the ubiquitous nature of data, and the growing interest in DTs have progressively broadened their application from physical object modeling to complex socio-technical systems. One of the most ambitious applications is indeed modeling cities, where CDTs can simulate dynamic modeling of urban infrastructure and service interactions, relying upon data for providing valuable insights into sustainable development and planning, possibly even anticipating and mitigating events proactively (Papyshev and Yarime, 2021). In these cases, CDTs aim to enhance policy and service design by integrating real-time and historical data, forecasting service demands and responses, thereby informing their development, while also steering policy decisions (Mohammadi and Taylor, 2017). This enables ongoing monitoring by identifying areas needing attention and supporting the development of targeted solutions (Soe, 2017). Francisco et al. (2020) note that CDTs are now developed to delve into the complexities of urban environments over various scales and periods. Mohammadi and Taylor (2017) point out that they are virtual replicas of cities, constantly updated by real-time data reflecting urban life. In these cases, CDTs can even scale down to neighborhood or district levels, integrating extensive data sets into sophisticated mathematical models, empowered by machine learning and other advanced Artificial Intelligence (AI) techniques (Ruohomäki et al., 2018).

Against the backdrop of increasing urbanization, coupled with rapid technological advancements like the Internet of Things (IoT), the Internet of Everything, and the increasingly powerful data analytics software, CDTs have raised increasing interest from both the practice and the theory. The technology behind CDTs, in fact, integrates real-time data into three-dimensional city models (Shahat et al., 2021), useful for monitoring various urban domains (Dou et al., 2020). In practice, thus, cities like Singapore, Glasgow, Helsinki, and Boston are already working with CDTs for various applications. From disaster management to urban planning, this technology can help city officials prioritize actions during emergencies (Fan et al., 2021; White et al., 2021), manage traffic, energy, and resources more effectively (Bliss, 2019; Francisco et al., 2020), and monitor health using personal device data (Laamarti et al., 2020). Furthermore, CDTs facilitate the simulation of future urban scenarios, such as traffic patterns under various conditions (Dembski et al., 2020), and aid in integrating different city aspects into a cohesive platform, although this integration remains a challenging endeavor (Shahat et al., 2021).

In theory, scholars started underscoring the critical role of the data generated by digital services in urban management (Soe, 2017; Fuller et al., 2020). Deren et al. (2021) and Deng et al. (2021) discuss how the relentless generation of urban data, propelled by IoT and 5G technologies, necessitates DTs for steering digital transformation in cities, although Nochta et al. (2021) caution that it may be premature to claim CDTs have revolutionized urban modeling. Deren et al. (2021) define four primary characteristics of CDTs: accurate mapping, virtual-real interaction, software definition, and intelligent feedback, facilitating early warnings and preventive measures against potential hazards. Shahat et al. (2021) categorize CDT applications into five thematic areas: data management, visualization, situational awareness, planning and prediction, and integration and collaboration. Here, effective data management is crucial, reliant on the integration and standardization of diverse data sources (Ruohomäki et al., 2018), while visualization techniques, especially those illustrating social processes, pose significant challenges, yet are fundamental for CDT effectiveness (Shahat et al., 2021).

Despite the experimental nature of current CDTs, their potential as effective urban management tools is increasingly recognized (Batty, 2018). Nochta et al. (2021) suggest that early-stage policy development could greatly benefit from CDTs, aiding in identifying policy inconsistencies, supporting cross-disciplinary policy design, and enhancing the efficiency of urban modeling. CDTs can also simulate disaster scenarios, evaluate urban planning impacts on climate, and explore traffic management solutions (Dembski et al., 2020; Ham and Kim, 2020; Schrotter and Hürzeler, 2020), showcasing how their potential in transforming urban policymaking is vast, although requiring further empirical investigation.

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2.1. A socio-technical perspective: Key areas and descriptions

This article draws on the elaboration of the socio-technical framework of the GovTech design and governance by Mortati et al.'s (2025), originally outlined by Bharosa (2022), which proposes four key pillars for the analysis and development of effective GovTech solutions, such as CDTs (Figure 1): (1) **Governance structures** involve analyzing how decisions are taken and stakeholders mobilized for the implementation of solutions; (2) **Institutional arrangements** focus on depicting the norms, regulations, and mechanisms necessary to procure and implement solutions; (3) **User and context understanding** emphasize the importance of analyzing co-creation mechanisms to develop solutions that cater to diverse user groups; and (4) **Technological development** aims at understanding the adoption of interoperable and scalable technological components.

In light of this socio-technical framework (Mortati et al., 2025), this article investigates critical areas and persistent challenges of a CDT as one GovTech solution, and reflects on the mechanisms for creating local GovTech ecosystems to inform and steer policymaking.

This study answers the primary research question of: *How does the adoption of a socio-technical framework influence the design, implementation, and effectiveness of GovTech solutions, particularly in the context of City Digital Twins?*

3. Methodology: An in-depth qualitative analysis of one case study

This study is centered on an in-depth case analysis of WiseTown (wise.town/en), a solution developed by the Italian company TeamDev (teamdevecosystem.it/en), which focuses on implementing CDTs to support urban innovation. WiseTown offers an integrated suite of modules designed to improve urban management and citizen engagement. These include CitiVerse, a CDT for city modeling; urban dashboards for analyzing georeferenced data; issue managers to handle citizen reporting; crowd planning for participatory city planning; situation room for real-time event monitoring and management; and custom solutions that provide specialized urban consultancy and tailored solutions for cities.

WiseTown was chosen as the subject of this case study due to its pioneering role in the development and deployment of CDT solutions within the Italian GovTech ecosystem. It stands out for its socio-

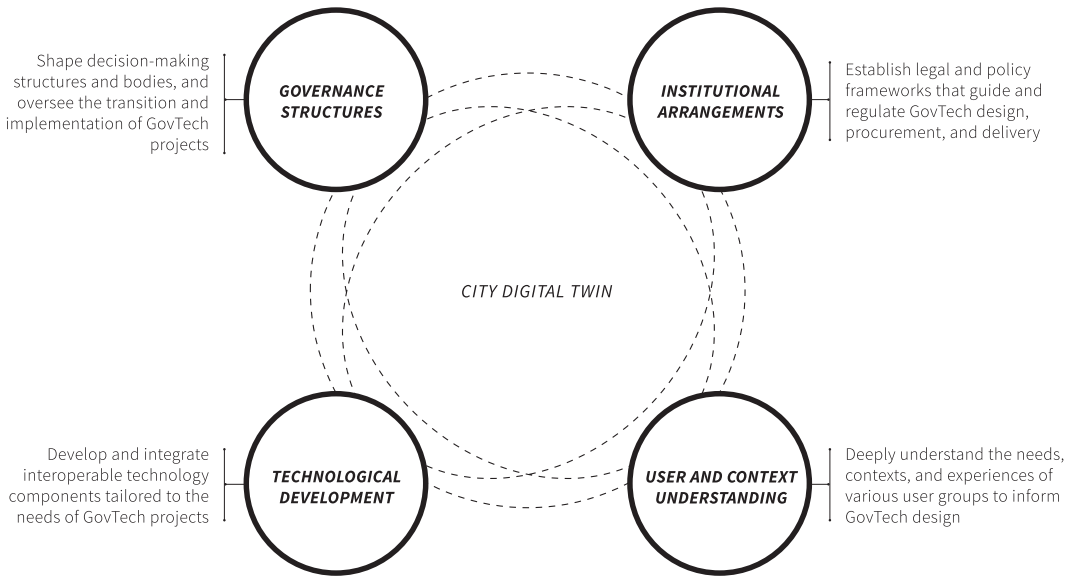


Figure 1. *Adaptation of the conceptual framework for the GovTech design and governance—initially presented in Bharosa (2022) and further elaborated in Mortati et al. (2025).*

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technical approach to smart city innovation, explicitly aligning with the principles of civic technology and data-driven governance. Already recognized as Best Civic Tech Startup by the South Europe Startup Awards in 2019—an initiative honoring high-impact startups advancing civic innovation across Southern Europe—and then winner of the prestigious national Top of the Pid 2023 award by Unicamere, WiseTown is steadily consolidating its role as a key actor at both national and European levels. It has also been actively engaged in European Commission initiatives, such as the GovTech BootCamps of the GovTech Connect project created under DG CONNECT. These recognitions reflect WiseTown's maturity, socio-technical orientation, and replicability as a CDT model, making it a highly suitable case for exploring the challenges and opportunities of DTs in public sector innovation and policymaking.

In line with calls in the literature to expand empirical research on the adoption and impact of GovTech solutions in urban environments (Nochta et al., 2021), TeamDev was selected as a representative case of a company that has successfully implemented full CDT solutions in multiple Italian cities—most notably Perugia and Parma (since 2022), as well as integrated solutions (Narni, Calcinato, and San Fermo Della Battaglia) with further projects underway.

Following a qualitative case study methodology aimed at gaining a nuanced, context-sensitive understanding of real-world phenomena (Yin, 2011), the analysis draws on multiple sources of data. Primary data have been extracted through a 2.5-h semi-structured interview conducted in January 2025 with Irene Provvidenza, Business Developer in TeamDev (interview structure in Annex I). The interview was designed to capture a comprehensive understanding of WiseTown's CDT, including both strategic and operational dimensions. To strengthen and contextualize the primary data, additional documentation and publicly available materials produced by the company were consulted as secondary sources. These materials include project reports, promotional content, technical descriptions, and municipal case study data (Table 1).

Data extracted from both primary and secondary sources have been coded for analysis. **First**, we open-coded all transcribed data by iteratively (authors individually first, and cross-checking and merging annotations afterwards) annotating transcriptions. Through this process, we read through the text and made annotations on segments identified as significant. This allowed us to organically identify themes, patterns, and interesting points that emerge directly from the data, without a predefined coding scheme. Significant statements and themes were marked and grouped into clusters reflecting the central topics discussed during the interview. In particular, this thematic clustering involved three steps: (1) grouping annotations, to cluster commonalities in content or context and distilling raw data into manageable and analyzable segments; (2) theme development, to refine groups into coherent themes; (3) iterative

Table 1. *Overview of data sources and use in the analysis*

Data source	Type of data	Use in the analysis
Semi-structured interview	A 2.5-h interview with Irene Provvidenza, Business Developer in TeamDev/WiseTown. Recorded and transcribed, 16 pages, 9,470 words verbatim.	Gaining a deep understanding of the solution in terms of processes, methods, and data used. Exploring the different types of challenges encountered in the development and strategies adopted for improvement.
Archival data	Public documentation Reports, articles, and descriptions of applicative projects published online by the company and describing WiseTown (47 pages, 9,906 words).	Supporting, integrating, and cross-checking interview-based insights. Supporting further understanding of WiseTown, and understanding better the technology.

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refinement, to adjust themes into insights. **Second**, published information was cross-checked and integrated using online reports and other sources made public by the company. **Third**, once the themes were defined, we referred them back to the four conceptual dimensions of GovTech—(1) Governance structures, (2) Institutional arrangements, (3) User and context understanding, and (4) Technological development—to further organize the data into critical areas and persistent challenges of CDTs, thus advancing empirical understanding of this technology through a socio-technical lens.

The qualitative analysis was conducted employing MAXQDA to assist in systematic organization, evaluation, and interpretation of data. Thematic codes are applied to the interview transcript, categorizing relevant quotes as data segments, and extracting direct insights. The selected quotes are provided in Annex II for reference, while a summarized version is presented in Table 2. Ultimately, the authors conducted a thorough identification of critical areas and persistent challenges for each code, pinpointing specific obstacles and opportunities within the GovTech framework that could influence the implementation of the WiseTown DT. In the discussion, these elements are generalized to provide learning for all researchers and policymakers exploring the benefits and challenges of adopting GovTech solutions for city management.

4. Case introduction: Wise Town DT

WiseTown is a comprehensive software platform designed to support the digital transformation of cities by creating a virtual environment that accurately replicates urban realities (Sartoretti and Minascurta, 2024). WiseTown is an ecosystem of applications built on geospatial technology that collects and analyzes large volumes of data from the physical city. This data is then transformed into actionable insights, providing urban decision-makers with advanced tools to analyze, monitor, simulate, and plan urban dynamics more effectively.

Far from merely offering access to technologies and data, WiseTown emphasizes the meaningful application of technology to support evidence-based decision-making and promote sustainable urban development. WiseTown's features are particularly geared toward embedding sustainability as a foundational value for cities. It equips cities with digital tools to optimize green spaces, monitor the environmental impact of policy decisions, and evaluate the sustainability of urban growth strategies. As cities and communities worldwide face the dual pressures of resource optimization and climate change, WiseTown provides the necessary tools to reduce waste, lower pollution, and create more inclusive, resilient urban environments. This is also done by offering support for data-driven policy-making and tailored solutions for human-centered urban planning.

Given its capabilities, WiseTown has been adopted by various cities, serving as a critical enabler for aligning with global smart city standards. A prominent example of implementation is the city of Perugia (https://wise.town/portfolio-items/perugia-smart-city), which adopted WiseTown to enhance urban management and citizen engagement.

Key components deployed in Perugia included WiseTown Geoanalytics, which supports municipal decision-making through spatial data analysis, and the WiseTown Situation Room, which monitors critical events to enhance emergency response. Additionally, the WiseTown Issue Manager facilitated citizen reporting of urban issues, transforming reports into actionable tasks managed by city departments.

In practice, WiseTown aggregates data from a wide range of sources to build tools that support public administrators. These sources include the city's Geographic Information System, IoT sensors, citywide monitoring systems, Open Data repositories, historical data, and datasets Available at both internal public administration applications and external contributors. Central to this ecosystem is a fully functional CDT, one of the few in Italy, which simulates the behavior of the real city in three dimensions and in real time, providing municipal departments with up-to-date information across various domains. The model was developed through a comprehensive data collection campaign involving drones, ground-penetrating radar (georadar), and advanced Mobile Mapping technologies. Territorial monitoring and urban planning are

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Table 2. *Association of GovTech dimensions with interview codes, insights from the interview, critical areas, and challenges*

High-level dimensions	Derived code from the interview	Alignment of code with high-level dimensions	Direct insights from the interview (full quotes in Annex II)	Critical areas and persistent challenges
Governance structures	Engagement process	Aligns with adapting decision-making structures to allow co-creation, as it details specific engagement techniques and participatory approaches used to involve stakeholders during the DT development phases.	• Begins with technical offices • Utilizes workshops and training to build trust	• Time-consuming engagement • Expanding influence to political levels
	Power dynamics influence	Relates to governance structures as it investigates the power dynamics between public and private actors that impact the design and implementation of technological solutions, influencing the governance model of projects.	• Involves strategic alliances • Public-private influences on project outcomes	• Resistance from established suppliers • Adapting to entrenched public sector interests
	Conflict resolution strategies	Understanding and managing conflicts among stakeholders is crucial for adapting governance structures to support co-creation and collaborative decision-making.	• Manages conflicts between data privacy and transparency	• Balancing privacy with transparency needs
	Future challenges and interests	Identifies future challenges and interests that WiseTown aims to address, focusing on governance-related technological, strategic, and market-oriented goals that will influence decision-making and governance structures.	• Adapting to tech trends • Integrating AI and expanding market presence	• Keeping pace with technology advancements • Managing scalability and resource allocation

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Table 2. *Continued*

High-level dimensions	Derived code from the interview	Alignment of code with high-level dimensions	Direct insights from the interview (full quotes in Annex II)	Critical areas and persistent challenges
Institutional arrangements	Institutional influence on adoption	Examines the arrangements needed to legitimize GovTech procurement and delivery, as it focuses on how institutional norms and priorities shape the adoption process of the Digital Twin technology.	• Shaped by institutional norms • Enhanced by recent regulations and funding	• Aligning new technology with institutional frameworks • Overcoming departmental resistance
	Barriers	Discusses barriers such as procurement rules and legacy systems, which are directly related to institutional arrangements that need to be managed for successful GovTech implementation.	• Includes resistance to change and bureaucratic processes	• Preexisting supplier relationships • Adapting to slow bureaucratic procedures
	Strategies for adaptation and scaling	Describes strategies that enable WiseTown's solution to adapt and scale across different contexts and institutions, which is crucial for creating flexible institutional arrangements that can accommodate new technologies and methods.	• Modular platform design • Phased implementations tailored to municipal needs	• Diverse municipal contexts without compromising platform integrity
	Lessons learned and improvements	Discusses how insights from previous implementations are used to refine and enhance solutions, informing both technological development and cross-departmental institutional arrangements.	• Importance of real-time data integration • Regulatory changes impact adoption and scalability	• Incorporating feedback in evolving regulatory environments
	Potential synergies and growth opportunities	Explores potential synergies with other networks and public/private bodies that could be relevant for WiseTown's future growth and innovation, aligning with institutional strategies to enhance GovTech procurement and delivery.	• Networks and public bodies drive growth • Collaborative platforms for territorial management	• Building and maintaining collaborations across diverse networks

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Table 2. *Continued*

High-level dimensions	Derived code from the interview	Alignment of code with high-level dimensions	Direct insights from the interview (full quotes in Annex II)	Critical areas and persistent challenges
User and context understanding	Adaptive mechanisms for evolving needs	Outlines mechanisms to ensure solutions remain flexible and responsive to stakeholders' and end-users' evolving needs, essential for centering the development of solutions on user needs.	• Modular, adaptable platform approach • Focuses on user feedback to evolve solutions	• Maintaining flexibility to meet evolving needs while ensuring stability
	Balancing complexity with usability	Discusses how WiseTown balances technical complexity with the usability needs of nonexpert users, aligning with the necessity to co-create solutions that address various user groups.	• User-friendly interfaces for nonexperts • Simplification strategies	• Ensuring intuitive use for all users, requiring ongoing education and support
	Factors for adapting to new settings	Discusses factors considered by WiseTown when adapting their solution to new institutional or geographic settings, emphasizing the importance of understanding user and contextual needs to ensure the effectiveness of solutions.	• Local contexts and regulatory requirements • Stakeholder engagement to tailor solutions	• Diverse local regulations and stakeholder priorities to customize solutions effectively
	Feedback mechanisms from users	Focuses on how feedback from users is incorporated into ongoing development and refinement, crucial for understanding and responding to user and context specifics.	• Feedback informs solution refinement • Mechanisms for collecting user input	• Accessible feedback mechanisms to capture user insights effectively
Technological development	Tailoring to requirements	Describes how WiseTown's Digital Twin technology is customized to meet local government needs, serving the technological development that supports all other areas.	• Customization to meet local needs • Emphasizes flexibility and scalability	• Customizing digital tools to diverse requirements while ensuring scalability

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Table 2. *Continued*

High-level dimensions	Derived code from the interview	Alignment of code with high-level dimensions	Direct insights from the interview (full quotes in Annex II)	Critical areas and persistent challenges
	Challenges in public setting integration	Identifies challenges in integrating new technologies into public systems, addressing technological development needs to ensure interoperability.	• Integrating new tech with existing systems • Overcoming institutional inertia	• Resistance to traditional practices • Integrating solutions into public settings
	Open data and third-party access	Explores data democratization through open data access, a key aspect of technological development in GovTech solutions.	• Offers open data access • Focuses on data democratization	• Managing open data access while ensuring privacy and security compliance
	Lessons learned and improvements	Regards using past experiences to inform ongoing technological developments, ensuring that lessons learned are integrated into the continuous improvement of technological solutions.	• Real-time data integration is crucial • Regulatory changes impact solution scalability	• Adapting lessons to new projects involves balancing innovation with practical design

further enhanced by the WiseTown's Thematic Dashboards, interactive and queryable platforms that visualize geospatial data and reveal relationships between events on a map. These dashboards are powered by spatial analysis conducted on both Open Data and proprietary datasets, offering a broad array of functions—from management of urban green spaces, urban planning, service development for public welfare and economic activities, as well as real-time analysis of traffic patterns and tourist flows. These tools equip city administrators with a comprehensive overview of city operations, enabling smarter planning and more effective delivery of services aimed at improving the quality of life for residents.

Through these tools, Perugia improved service delivery, increased public administration efficiency, and fostered greater transparency and community trust. This integration showcases how WiseTown can drive urban transformation in cities of varying sizes and complexities.

5. Results

Our analysis suggests that critical areas and challenges are persistent across all four pillars of our socio-technical framework, even in successful cases like the one explored. We found two aspects having particular relevance: the aspects of data integration and sharing in CDTs, and the social aspects linked to the use of data for decision-making. These two aspects are consistent across all four key areas of the GovTech framework. Their significance and critical challenges are described in the following, according to our framework.

5.1 Data integration and sharing in CDTs

Data integration involves combining data coming from various municipal departments into a unified system in order to enable a holistic view of the city, while data sharing refers to the ability of different stakeholders (e.g., municipal departments) to access and utilize the integrated data for various purposes, such as decision-making, planning, and service implementation. Below, the challenges related to data integration and sharing are discussed across the four dimensions of the socio-technical framework and in the context of the case analyzed.

In the domain of **governance structures**, numerous challenges arise, primarily revolving around the establishment of policies and regulatory frameworks that not only facilitate data integration and sharing but also protect data security and privacy. Our analysis emphasizes how establishing appropriate governance structures is crucial to determining how data are collected, stored, accessed, and used across different public functions. These structures are a prerequisite for aligning administrative activities under a coherent strategy that respects both the priorities of a municipality and the privacy and security of the data involved.

Against this backdrop, WiseTown's approach adopts co-creation with municipal technical offices that hold stakes in administrative and political decision-making. The collaboration often starts with the involvement of technical officers who understand the digital tools and can bridge the gap to the broader administration, ensuring a smoother transition and greater acceptance of new technologies. Technical offices are indeed identified as key initiators of changes due to their direct impact on administrative and political decision-making. WiseTown's approach involves identifying and addressing the immediate practical needs of these technical stakeholders—such as requirements for detailed calculations, precise mapping, or comprehensive reporting capabilities—while providing continuous technical support and consultancy. This interaction opens upskilling and capacity-building opportunities to municipal technicians, keeping them informed of technological advancements emerging from TeamDev's ongoing research and development. This dual strategy not only meets urgent operational needs by demonstrating the broader benefits of their CDT solutions but also builds long-term digital competencies within public administrations, thereby establishing a relationship that facilitates subsequent stages of a sustained engagement.

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If this has proven a successful strategy, expanding engagement to include a wider range of stakeholders—from political leaders to the general public—has demonstrated to be often been more demanding (Par19, Par21, Par31–32, and Par34–35). Beyond the need for establishing ongoing trust and transparent communication, inherent difficulties persist in maintaining effective communication across different phases of development and throughout the life cycle of CDT. Power dynamics within municipalities further complicate this picture, with conflicts arising particularly around issues of data privacy, resource allocation, and development priorities. The introduction of new technologies like CDTs, thus, proves difficult because it can disrupt established relationships and hierarchies, while entrenched interests might resist the introduction of novelties that threaten their control. Further, challenges remain in aligning interests across governance levels and ensuring that data integration supports informed decision-making. Overcoming these challenges requires a governance model that supports open communication and shared decision-making frameworks (Par19 and Par30). Additionally, governance structures need to become adaptive to the rapidly evolving technological landscape and sensitive to the socio-political context, thus presenting a continuous challenge (Par44–45). In this regard, WiseTown largely relies on aligning digital tools and local strategic priorities (Par19, Par29–30, and Par42–43). Proactive strategies to conflict prevention are also used, such as developing platforms that allow for transparent data sharing and the integration of feedback mechanisms where stakeholders can voice concerns.

Additional challenges are posed by existing **institutional arrangements**. Here, the integration and sharing of data encounter obstacles like varying data standards and a lack of interoperability among systems. Each institution may have established its data protocols and systems, leading to data silos that hinder effective CDT operations. The integration of data essential for CDTs requires not only technological alignment but also institutional agreements on data ownership (Par21). In addition, the presence of legacy systems (Par56) and the struggle for inter-departmental collaboration (Par44) highlight the barriers that persist in fully integrating and deploying CDTs. Norms, regulations, and public incentives shape the procurement and operationalization of these technologies. For instance, national funding programs, such as the Recovery and Resilience Plan, have played a significant role in driving digitalization efforts at the municipal level, favoring the switch to cloud and thus benefiting CDT implementation (Par42). However, aligning regulatory frameworks with the procurement and operationalization of CDT technologies remains a challenge. To face this, WiseTown facilitates dialogues that emphasize the mutual benefits of data sharing, such as enhanced capability for predictive analytics and improved resource management. Their approach also highlights the complex work needed for harmonizing efforts across departments, which is addressed by personalizing approaches, focusing on helping institutions overcome data silos, and facilitating data sharing across departments. Also in this case, WiseTown addresses the challenge through a strategic engagement process that begins with outreach to technical officers, identified as key enablers within the administration. Their expertise and institutional influence are leveraged to promote collaboration and overcome resistance to innovation. A central concern highlighted by WiseTown is the cost and inefficiency associated with repeatedly gathering data in different formats—an issue that consumes both time and money. Instead, WiseTown emphasizes the value of sharing and analyzing data to build layered insights that can be interpreted in a unified and coherent manner (Par21, Par31–32, Par34–35, and Par37). The process starts by migrating data from traditional formats like Excel or paper records to advanced digital systems, providing a foundation for further scaling. Particularly effective is reaching the integration of diverse datasets—such as traffic and health data—which allows for better-informed policies and improved city planning. Through continuous dialogue with municipal departments, WiseTown actively works to break down data silos and foster interdepartmental collaboration. Nevertheless, persistent challenges remain, especially in overcoming institutional inertia, where data are often compartmentalized within departments, and in addressing lingering skepticism toward the adoption of new technologies.

Our analysis underlines that shifting institutional mindsets toward embracing new technologies like CDTs is a significant hurdle. This challenge is possibly magnified by the Italian landscape, which often suffers from a lack of understanding regarding the value of data-driven decision-making within municipal

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authorities, as well as the lack of the skills necessary to handle large datasets. The required transition necessitates significant investments in infrastructure and training, which can be additional substantial barriers. Recognizing the importance of enhancing data literacy to overcome institutional inertia, the company leverages events, workshops, and training opportunities as strategic platforms for increasing awareness about the value of data.

User and context understanding refers to the need of analyzing users and adapting the technology to their needs (Par55 and Par47–48). WiseTown employs a user-centric approach to configure solutions for the specific needs and priorities of each municipality, engaging users through hands-on workshops, and feedback mechanisms. Specifically, they do not always use the same technique when approaching cities because each territory is unique and each municipality has different dynamics (Par44). Therefore, WiseTown focuses on context-specific needs to ensure that the data integrated into the CDTs reflects user requirements (Par47 and Par68). Further, they continuously engage users to recalibrate solutions (Par47) according to the unique dynamics, priorities, and organizational structures (Par44–45).

Moving to the needs of citizens, the challenge identified concerns managing the expectations and apprehensions of residents—for instance, regarding privacy and the potential misuse of data. Engaging with the community through regular feedback mechanisms (e.g., crowd-planning) and ensuring that the benefits of CDTs are communicated and understood can mitigate these concerns (Par65–68).

In terms of **technological development**, the integration and sharing of data within CDTs require advanced systems capable of handling data from diverse sources. However, challenges in this case extend beyond technical integration to ensuring systems are resilient and scalable. Technologies must allow interoperability among disparate urban systems and process real-time data effectively. WiseTown's modular and microservices-based architecture exemplifies an approach to tackle this, enabling flexibility and incremental integration of various data streams (Par47–48).

Data protection in WiseTown is embedded at both the technological and organizational levels, ensuring privacy and security are integral to the platform's design and implementation, with robust safeguards from the outset. This is achieved through the use of certified cloud infrastructures and strict adherence to cybersecurity and accessibility guidelines (Par29–30 and Par97–98), in compliance with national and EU regulations, including GDPR. The company also aligns its development with national guidelines such as those from AGID (Agenzia per l'Italia Digitale), which set standards for digital services in public administration (Par97–98). In interactions with public administrations, these commitments to regulatory compliance and standardization are thoroughly framed as added values rather than obstacles. The company emphasizes how adhering to these standards serves as a quality assurance mechanism, reinforcing the reliability, integrity, and trustworthiness of its solutions (Par82–83). At the system level, specific components—such as FIWARE IDM Keyrock and PEP Proxy Wilma—are employed to manage identity and ensure secure, authorized access to data. Furthermore, WiseTown integrates participatory tools within a broader data governance framework that complies with public administration standards. For instance, feedback and participatory tools like Issue Manager and Crowd Planning are designed with privacy-aware workflows and are provided to municipalities to enable citizens to report issues or contribute to planning initiatives via secure and transparent platforms. Through these solutions, citizens are empowered to submit issues and participate in planning initiatives through controlled, transparent platforms that limit the exposure of personal information and ensure data are handled responsibly throughout the life cycle.

However, the rapid pace of technological advancements and the need for continuous updates pose a challenge in keeping the system up-to-date and secure. The technological backbone of CDTs involves interoperable systems that can scale and adapt without sacrificing usability (Par47–48). WiseTown's efforts to balance the technical complexity of DT solutions with user-friendly interfaces illustrate this challenge. The company has developed a platform that integrates a comprehensive array of data (Par31)—such data on municipal infrastructure and services, citizen-generated reports, and geospatial mapping of assets—allowing municipalities to optimize interventions based on comprehensive, integrated insights.

Yet, the technological sophistication required to maintain and scale such a system poses further challenges, particularly in ensuring that different municipal departments can share and analyze data to

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fully leverage the benefits of CDTs (Par21, Par31–32, and Par35–37). Additional issues arise from "varying technological competencies across municipalities," which constitute a persistent gap to be tackled.

5.2 Social aspects related to data use for decision-making

The social aspects of data use in CDTs highlight several key areas of concern, including privacy and ethical use of data, stakeholder engagement, institutional resistance, and the balancing of technological innovation with user-centric designs.

A critical challenge in the **governance** of CDTs involves establishing transparent decision-making processes that respect the privacy and rights of individuals while leveraging data for urban planning and management. The integration of different data in CDT, such as traffic and health data, can significantly enhance policymaking but at the same time raises concerns about privacy and data security (Par65 and Par67–68). As highlighted in the interview, WiseTown can integrate "traffic data with the health data, understand the quality of the air, that is, there are so many insights that can emerge to help optimize an intervention policy" (Par37). However, this also needs rigorous frameworks to ensure that data handling processes are not only compliant with legal standards but also ethically sound (Par65). Another prevalent issue in governance structures is the ambiguity about "who has the authority to make decisions based on the insights derived from data, which can lead to power imbalances and misuse of data" (Par82–83). This condition underscores the necessity to develop governance models that incorporate robust data protection measures and clear accountability mechanisms. It is also noted that "data is a good counselor, but a bad decider" (Par39): data alone are not enough; rather, interpretations are needed by skilled personnel to inform decision-making.

Moving to **institutional arrangements**, there is often resistance to adopting new technologies that fundamentally change data handling and decision-making processes. Public administrations are now obliged to deal with digital solutions, which raise questions about their transparency and accountability, while they may lack the agility to adapt to an ethical use of digital tools. For instance, the WiseTown case testifies how different municipal departments are often protective of their own data, hindering digital transformation (Par21). In addition, individuals who have used the same tools for 20 or 30 years find it difficult to adopt new technologies (Par81), thus slowing down adoption and questioning the integrity and confidentiality of data.

The WiseTown case also illustrates the relevance of mobilizing specific stakeholders to address institutional barriers. This hinges on the presence of decision-makers who possess technical backgrounds or understand the value of data and CDT. These individuals lead by example and encourage other officers to adopt new technologies. Conversely, environments with less data literacy often show a greater reluctance to embrace new tools (Par44). Consequently, WiseTown tailors its engagement approach to the specific context, sometimes leveraging technically proficient staff or politically progressive leaders who are receptive to novel digital solutions. This approach underscores the necessity for continuous negotiation to align with the diverse institutional dynamics.

Several social challenges emerge in the domain of **user and context understanding**. The first is ensuring that digital solutions, such as WiseTown's CDT, are accessible and relevant across diverse user groups (Par13). In particular, key players include local governments and city planners who utilize CDT insights for urban development; public administration employees who interact with the system for daily city operations; and citizens and community groups, whose feedback is vital for refining the system. The needs and priorities of these stakeholders vary significantly, which underscores the importance of understanding them to develop tailored solutions. Across these stakeholders, technical parties often have very practical needs, such as calculations, mapping, and report creation, while administrative and political ones have needs that span from improving efficiency, transparency, and accountability to informing decision-making (Par19). This diversity highlights the importance of participatory approaches and feedback mechanisms to incorporate a wide range of perspectives and needs. To embed user and context understanding in their solution, WiseTown opted for integrating innovative tools like the above-

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mentioned crowd-planning, which allows for the publication of projects and the collection of feedback from residents (Par66–68). Still, this opens the need to educate and empower users to understand and utilize digital tools effectively. Recognizing and integrating local needs into the design and implementation of CDTs is crucial for ensuring that these technologies are more likely to be accepted by the community of users. However, there is a delicate balance between adapting solutions to fit specific local contexts and developing fully-tailored solutions that may not be scalable or economically viable. WiseTown opts for adaptation, considering specific needs and contexts without committing to fully customized solutions. This approach allows WiseTown to maintain the scalability and generalizability of its platform: while the core functionality remains consistent, it can still accommodate the unique dynamics and requirements of different communities.

Technologically, the challenge lies in designing systems that are both advanced enough to provide meaningful insights and intuitive enough for nonexpert users to operate (Par82–83). WiseTown addresses the issue of simplifying complex data analysis by trying to mediate user needs while keeping a high quality (Par83). The CDT is seen as a tool to support the government and management of the territory and not as a substitute for human decisions (Par71 and Par73–74). The social aspects of technology also raise important questions about data access, information sharing, and their impact on democracy and citizen rights. An example of how these ideas are being applied in practice is the development of new models that combine governance with data services, enabling collaboration among citizens, service providers, and researchers to drive systemic change. Additional reflections concern the integration of data from multiple sources to limit potential for biases, thus attempting not to skew decision-making.

6. Discussion

The literature frequently emphasizes the potential benefits of CDTs in urban governance, particularly their ability to create virtual environments that mirror real-world cities (Mohammadi and Taylor, 2017; Jones et al., 2020; Deren et al., 2021). These environments allow policymakers to develop and test new policies and services in controlled yet realistic settings, reducing the risks associated with direct implementation (Papyshev and Yarime, 2021). However, several risks and barriers—both technical and social—persist, complicating the widespread adoption of CDTs.

Our analysis of the WiseTown case illustrates how a socio-technical approach can enhance the development and deployment of CDTs for public value creation. WiseTown's CDTs go beyond static, three-dimensional city models by serving as interactive ecosystems. These ecosystems leverage geospatial technologies to collect, analyze, and transform large volumes of urban data into actionable insights, supporting urban planners and policymakers in real-time monitoring, simulation, and decision-making. This integration of high-quality, interoperable data is essential for creating a cohesive and meaningful digital representation of a city. A significant insight is how WiseTown blends technical functionalities with social dynamics, emphasizing multi-stakeholder engagement for data-driven decision-making (van Veenstra and Kotterink, 2017; Aragona and De Rosa, 2019). Continuous engagement with diverse stakeholders ensures the relevance and usability of CDT solutions throughout their life cycle. By incorporating participatory methods, WiseTown addresses critiques of technology-centric approaches to CDTs (Carvalho, 2015; Kitchin, 2015) and highlights the importance of integrating technical and societal dimensions to achieve successful socio-technical innovations.

Under the GovTech framework, WiseTown demonstrates the necessity of embedding technological adoption within broader transformations of government structures and processes. As emphasized by Mergel et al. (2019) and Ubaldi et al. (2019), a holistic approach to CDT development is crucial for adapting to local governance conditions and fostering GovTech ecosystems. The role of stakeholder collaboration, particularly through public-private partnerships, is paramount for such ecosystems, serving as a foundation for innovation and informing policymaking beyond the mere CDT adoption. WiseTown shows how these collaborations that engage government entities, private sector participants, academia, and civil society deeply guide the development of GovTech solutions, which are not only technologically advanced but also socially desirable. To support this, WiseTown's case shows how using workshops,

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forums, and co-creation events can help establish partnerships to drive public sector innovation and advance discussions on the potential of digital tools in government settings (Klievink et al., 2017). These engagement initiatives also address the challenges of bureaucratic inertia and resistance to technological change—common barriers in GovTech adoption (Bharosa, 2022). By promoting data literacy and fostering innovation, WiseTown bridges the gap between technological potential and practical applications. This aligns with adaptive management strategies that leverage DTs to proactively monitor and respond to urban dynamics (Mohammadi and Taylor, 2017; Soe, 2017).

Finally, it is relevant to reflect on how WiseTown addresses long-term sustainability and scalability challenges. As urban environments grow and evolve, CDTs must adapt to shifting data requirements, technological progress, and the dynamics of urban development. WiseTown's modular architecture exemplifies a scalable solution that can accommodate growing complexity without compromising performance. This modularity enables cities to progressively expand their systems by integrating new data streams and analytical tools over time. Additionally, WiseTown's sustainable business model allows cities to invest in new modules incrementally, aligning with budget constraints and evolving urban needs. This approach represents a practical model for scaling GovTech solutions while ensuring long-term adaptability. In parallel, the GovTech ecosystem that WiseTown contributes to nurturing through its collaborations and engagement practices acts as a catalyst for continuous innovation, ensuring that the technologies developed are relevant and meaningful, and capable of driving long-term policy improvements.

WiseTown's case offers a relevant example to researchers and policymakers, demonstrating the importance of socio-technical integration in developing GovTech solutions like CDTs. By embedding technical advancements within participatory governance frameworks and promoting long-term adaptability, WiseTown exemplifies how CDTs can transform urban governance and policymaking, and highlights the need for continued research and innovation in GovTech to fully realize the potential of data-driven, sustainable, and inclusive urban environments.

7. Conclusions

This article explores how the adoption of a socio-technical perspective can enhance the design and implementation of GovTech solutions, focusing on CDTs and their integration into urban management and policymaking. Using WiseTown as a case study, we examined the interplay between social and technical factors and how they influence the conceptualization, development, and deployment of CDT solutions.

Our analysis identified four critical areas within the GovTech framework—governance structures, institutional arrangements, user and context understanding, and technological development—each presenting unique challenges and opportunities for the effective adoption of CDTs. Data integration and sharing emerged as key challenges across all areas, requiring robust governance models to balance data privacy, security, and accessibility. Institutional arrangements also pose barriers, such as data silos and legacy systems, which hinder cross-departmental collaboration. WiseTown addresses these challenges through personalized engagement approaches and efforts to enhance data literacy and promote data-driven decision-making. The social aspects of data use were also highlighted, including privacy concerns, stakeholder resistance, and the ethical use of data in decision-making. WiseTown's participatory approach demonstrated the importance of continuous stakeholder engagement and transparent communication to foster trust and inclusivity. Tailoring solutions to local contexts while ensuring scalability was critical to overcoming adoption barriers and ensuring the long-term sustainability of the platform.

Overall, this study demonstrates the importance of integrating technical capabilities with socio-political dynamics to maximize the benefits of CDT adoption. The case of WiseTown shows how GovTech solutions, when designed through a socio-technical lens, can enhance public sector innovation, support data-informed policymaking, and create more sustainable and inclusive urban environments. Future research should further explore the long-term impacts of such solutions and continue to refine strategies for fostering adaptive, stakeholder-driven approaches to urban governance.

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While this article offers an in-depth examination of a single case, future research should consider comparative studies of multiple CDT implementations across different cities and governance models to better understand context-specific dynamics and identify scalable best practices—a gap still under-explored in the literature. Additionally, evaluating the impact of CDTs on urban efficiency, service delivery, and citizen engagement would provide a more systematic understanding of their effectiveness, particularly from a long-term perspective that considers how these tools evolve in response to technological change and shifting urban priorities. Further exploration into the integration of artificial intelligence and predictive analytics within CDTs is also area in need of further exploration, particularly to assess how these technologies can enhance forecasting, resource allocation, and real-time decision-making. Although these directions fall beyond the scope of this article, they represent critical avenues for advancing research and practice in the fields of GovTech and smart urban governance.

Abbreviations

CDT city digital twin
DT digital twin

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