

Smarter participation: Co-governance Protocol utilizing the urban digital twin and design thinking

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Abstract

This article presents the Smart Participation Protocol (SPP), a socio-technical methodology designed to support participatory urban governance by integrating design thinking with Social Urban Digital Twin (SUDT) technologies. Developed through action research in Hadar, a historically aging and socioeconomically challenged neighborhood in Haifa, Israel, the SPP addresses the urgent need to align smart city tools with social and welfare priorities in vulnerable urban settings.

The protocol unfolds through five milestones, aligned with the phases of design thinking, and involves immersive, collaborative engagement with local stakeholders. The SUDT component integrates spatialized data from municipalities, civil society, and residents, enabling shared analysis of complex urban conditions.

This paper focuses on two key insights from the reflexive phase of the study. First, it unpacks the power dynamics and negotiations of authority that surfaced during the formation of the cross-sectoral partnership. Second, it examines how participants' initial resistance to unfamiliar technologies evolved into meaningful engagement as they recognized the embedded social-scientific logics behind the tools.

These findings demonstrate the transformative potential of digital technologies when embedded in co-creative, place-based urban policymaking. The SPP offers a model for grounding smart city innovation in local knowledge and inclusive governance, particularly in underrepresented urban contexts.

Key words: Smart participation, social digital twin, urban aging, design thinking, co-governance, urban decision making.

Introduction

Cities around the world are increasingly striving to become "smarter" (Sadowski & Bendor, 2019). Yet, researchers and practitioners alike have noted the limited integration of socio-technical approaches in urban co-governance and decision-making (Jiang et al., 2020; Meijer & Thaens, 2018; Ruohomäki & Santala, 2023). This study addresses a critical gap: the disconnect between smart city technologies and their application in social welfare policymaking. Specifically, it develops and tests a methodology that integrates urban digital twins with participatory design to address challenges related to urban aging.

Despite the growing body of literature on smart cities and digital twin technologies, social welfare concerns remain notably absent from these frameworks. Urban digital twin models tend to focus on infrastructure, mobility, energy efficiency, and crisis management, often overlooking the pressing needs of aging populations, social inequality, and public health services (Cardullo & Kitchin, 2019; Sadowski & Bendor, 2019). This omission reflects a technocratic bias in urban innovation discourse, wherein welfare considerations are either abstracted or relegated beneath economic and physical priorities (Vanolo, 2014; Kitchin et al., 2015). Bridging this gap is essential for developing inclusive digital tools that respond not only to spatial and technical demands, but also to the lived experiences and vulnerabilities of diverse urban communities.

This article introduces an innovative protocol for advancing urban co-governance in line with smart city development. The proposed protocol combines urban digital twin technology—a data-driven, three-dimensional modeling system (Batty, 2018)—with design thinking, a participatory methodology for collaborative problem-solving.

The article has a dual aim: first, to present the Smart Participation Protocol (SPP) developed in this study, and second, to demonstrate its impact and practical implications. In doing so, it contributes to both applied urban research and methodological innovation, completing the research cycle by reporting on the protocol's development, implementation, and outcomes.

In recent years, the urban digital twin has emerged as a transformative tool in urban governance, showcasing advanced data analytics and predictive modeling capabilities. Often heralded as the "holy grail" of smart city technologies (Deren et al., 2021; Ruohomäki et al.,

2018), it creates three-dimensional computerized representations of urban environments by integrating real-time monitoring data into dynamic simulations. However, despite significant progress in data-driven urban modeling, its use in collaborative governance remains underdeveloped, with few established frameworks, methods, or real-world applications (Lember et al., 2019). Scholars attribute this gap to the absence of “sociotechnical” applications—tools that integrate both social and technological dimensions. Originally geared toward tangible urban domains such as energy monitoring and infrastructure management (Marai et al., 2021; Park et al., 2019; Schrotter & Hürzeler, 2020), digital twin tools rarely engage with human-centered or welfare-related concerns.

The central research question guiding this study is:

How can participatory digital twin protocols be developed and applied to co-govern urban aging?

In addressing this question, we also examine the implications of our proposed model and its influence on urban policy design for older residents.

This question foregrounds the structural elements of the Smart Participation Protocol, which integrates the urban digital twin’s 3D data infrastructure with design thinking’s participatory framework. We applied the SPP in the Hadar neighborhood of Haifa, iteratively refining it into a transferable and adaptable methodology. Beyond its development, we also assess the broader policy and governance implications of implementing this model.

The SPP consists of five distinct milestones, each aligned with a phase of the design thinking process. These milestones structure a preparatory approach that synthesizes insights from the global urban agenda and localizes them through a digital twin lens. Each phase concludes with a formal workshop, ensuring stakeholder engagement and reflective iteration. The SPP functions as a coherent framework in which each stage builds upon the last, culminating in a data-driven urban co-governance policy. In this article, we both conceptualize the socio-technical protocol and illustrate its application through our case study on urban aging in Hadar.

We conclude by demonstrating how the SPP addresses the absence of participatory digital twin applications in current smart city practices. It does so via two key strategies: It foregrounds social issues—such as urban aging—as central to the digital modeling process. It

employs a participatory governance model, engaging both local government and civil society, as exemplified in the collaboration between the Haifa Municipality and Hadar residents.

The final discussion reflects on the strengths and limitations of the SPP, highlighting its potential to support data-driven, inclusive co-governance practices in urban settings.

Role of technology in collaborative decision making

The rapid digitization of everyday life coupled with traditional information and participation channels which are considered to be difficult or unrewarding to use (Lundman, 2016) has naturally led to changes in how technology is used in collaborative settings. The joining of the terms collaboration and technology vaguely refers to the involvement of external stakeholders in a process or work task. This involvement of external stakeholders typically entails them donating data or information and as such the relationship between stakeholders and organisations is often considered one of the pillars of success of contemporary technology industries (Lember, 2018).

This new wave of technology induced collaboration has supposedly enabled comfortable and efficient implementation of democratic values as institutional bodies can communicate with the public through online platforms (Hennen et al., 2020; Kingston, 2002; Kneuer, 2016). This shift is coined E-democracy, an umbrella term which is characterised by an attempt to democratise public participation and communication via technological and internet means. In more recent decades there have been more complex technological developments which allow the public to lead participation and take more of an active rather than passive approach. Such tools include platforms which allow the users to upload their own content (Cui et al., 2014), Facebook and second life (Evans-Cowley & Hollander, 2010) and more sophisticated tools such as participatory GIS or bottom-up GIS which aims to allow stakeholders to better articulate themselves (Kahila & Kyttä, 2009; Talen, 2000) as well as 3D models and virtual environments (Jutraz & Zupancic, 2015). Many of these tools have been commended for transforming collaboration due to their ability to increase accessibility of citizens to the processes and offer more diverse ways for citizens to understand projects and plans.

One of the recurring characteristics of technology-based collaboration tools is visualization. Visualization techniques are deemed to be useful as they provide a visual

language through which both technical and nontechnical experts can communicate and allow people to envision their everyday lives as information is brought to the real environment (Al-Kodmany, 2000; Lundman, 2016). Participants can express their opinions more coherently as they see ideas in 3D, often being actively incorporated as opposed to having to imagine contexts and work from memory (Jutraz & Zupancic, 2015; Slotterback, 2011). A study which assessed citizens preferences of urban form in growing urban areas using an ICT (information and communications technology)-based participation tool found that there is a stark difference between projects that citizens, as opposed to the planner, suggested, concluding that ICT can play a significant role in enabling any person to bring their opinion and views to the forefront (Levy et al., 2015). Furthermore, the use of visualization methods has been found to reduce the gap between scientific literature and local knowledge.

The nature of technology-based collaboration tools encourages and enables participation of a broad spectrum of stakeholders. As opposed to traditional tools of urban governance and decision-making processes, technology-based tools enable a much larger scale interaction between planners, designers, residents, and communities, emphasizing and promoting dialogue between local and professional knowledge (Al-Kodmany, 2001b). Jutraz & Zupancic's (2015) study of virtual worlds and immersive technological spaces for engagement find that such tools, which often incorporate numerous visual, text and other characteristics, serve as a sphere for interdisciplinary collaboration and as such can function as an interface for knowledge transfer from the professional sphere to the public sphere. This opportunity is significant, as traditional public participation is often critiqued for its inability to 'speak' to diverse audiences with differing backgrounds. Despite recent developments in stakeholder participation technological tools, such tools principally deal with gathering information from the public or providing information to the public and as such are a one-sided platform which does not foster collaborative decision-making environments. In contrast, this research studies a protocol which does not fall into the traditional category of technology-based collaboration as its emphasis is on the co-location of participants who utilize technology together to reach decisions and craft policy.

Methodology: Development and Research

In this article, we present key findings from a broader research project conducted at the Smart Social Strategy Lab (see Figure 1). The lab is dedicated to developing immersive

environments for urban policy design and three-dimensional computer-based urban models grounded in social data, serving as new platforms for both research and action. Established as a living lab embedded within the neighborhood it engages with, the lab was founded through a partnership between the Municipality of Haifa and local civil society organizations.



Figure 1. Smart Social Strategy Lab.

A Sociological and Geographical Case Study: Hadar as an Aging Neighborhood

Our research addresses the sociological phenomenon of urban aging by examining the relationships among older populations, urban transformation, and the urgent need for supportive urban communities (Joost van Hoof et al., 2018). For over a decade, national and international discourse has emphasized the importance of “aging in place”—the ability of older adults to live safely and independently in their own homes, regardless of age, income, or ability. Successful aging in place is strongly associated with social connection, community participation, and meaningful engagement with the built and cultural environment.

Our case study site—the Hadar neighborhood in Haifa—exemplifies the complexities of urban aging. One of the city's oldest areas, Hadar features dense housing stock from the 1920s and is home to approximately 40,650 residents, of whom 16.7% are aged 65 and older (Komemi & Yavelberg, 2015; see Figure 2). Notably, about 30% of this older population consists of immigrants from the former Soviet Union, many of whom face language barriers and a lack of social support.

The neighborhood's physical environment further complicates daily life for its older residents. Hadar's steep topography requires navigating countless stairs between levels. Most residential buildings are three to five stories tall and lack

elevators (see Figure 2), intensifying the challenge for older adults. This results in a harsh daily reality: navigating both the neighborhood's terrain and its inaccessible housing.

During the COVID-19 pandemic, Haifa's municipal Welfare Department recorded a 32% increase in inquiries from older residents seeking assistance. A particularly alarming phenomenon that emerged—and has continued since—is that of older residents dying alone in their apartments, sometimes remaining undiscovered for extended periods (see Figures 3 and 4).

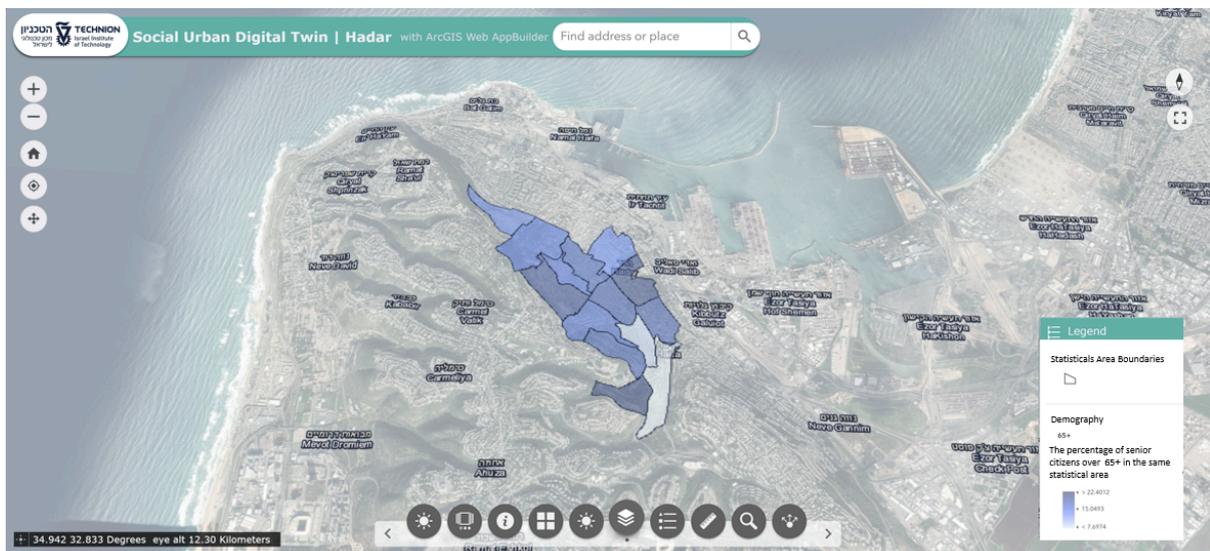


Figure 2.

Although the average percentage of residents aged 65+ in Hadar stands at 16.7%, internal variation is significant across sub-areas of the neighborhood.

Source: Hadar Social Urban Digital Twin.

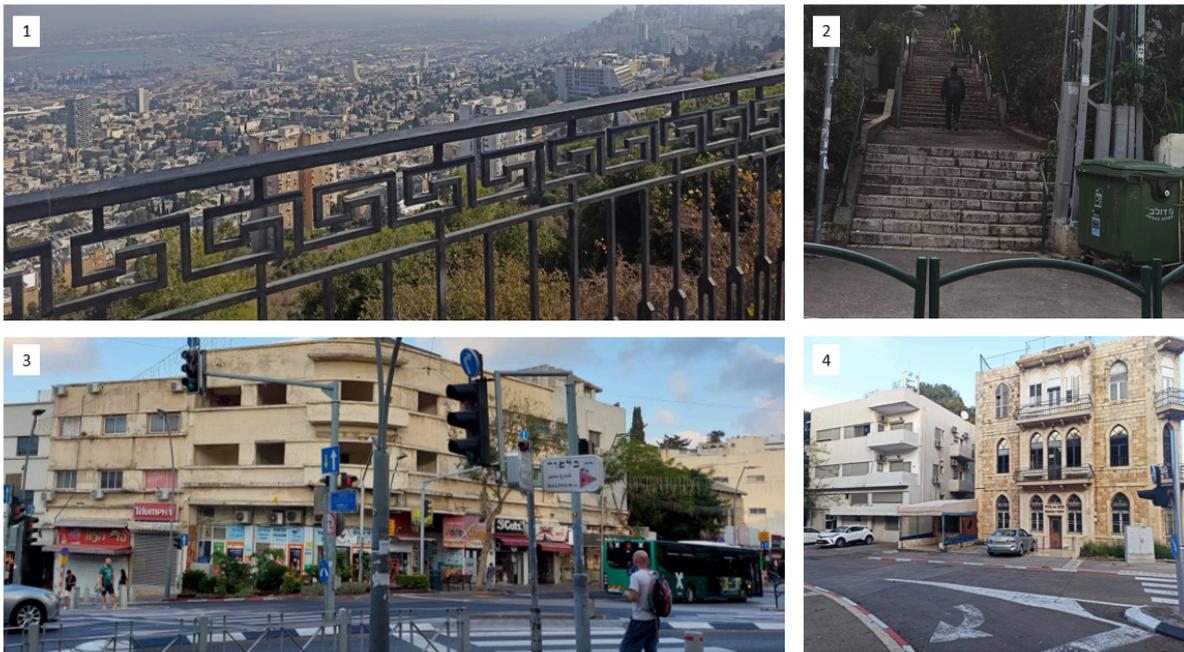


Figure 3. Photographs of Hadar, taken by the authors:

Photo 1: View from the top of Mount Carmel overlooking Hadar and the port of Haifa.

Photo 2: A typical stairway connecting Hadar's topographical levels.

Photo 3: A central intersection surrounded by long-abandoned buildings.

Photo 4: Two contrasting building styles: on the left, an eclectic structure characteristic of Arab architecture; on the right, an international-style building associated with early Jewish development. Both are three-story buildings without elevators.



Figure 4.

The socioeconomic ranking of Hadar. Most of the neighborhood falls within the lowest socioeconomic clusters (1–2). These areas correspond almost exactly with the locations where decaying bodies of older residents were found (highlighted in red). Source: Hadar Social Urban Digital Twin.

Co-governance: The stakeholders

The co-governance structure includes various entities such as the Municipality of Haifa, local civil society NGOs in Hadar, and other local residents and volunteers. Each entity is familiar with the neighborhood and brings different levels of responsibility to the collaborative effort (Yossef Ravid, 2023). The participatory design theory guided the engagement of relevant stakeholders, involving them as active participants and partners in the project. The co-location of stakeholders is vital for crafting the partnership model. When stakeholders with previous knowledge and experience come together, it fosters interactions between individuals and practices, leading to the generation of additional knowledge (Spinuzzi, 2005). The stakeholders in this applied study were carefully selected, and provide both tacit knowledge acquired through lived experiences and explicit knowledge derived from professional and organizational responsibilities. Figure 5 illustrates the relationship of responsibility among stakeholders with regard to their knowledge contributions. Appendix 1 outlines the roster of stakeholders and their association with the issue of urban aging in the Hadar case study.

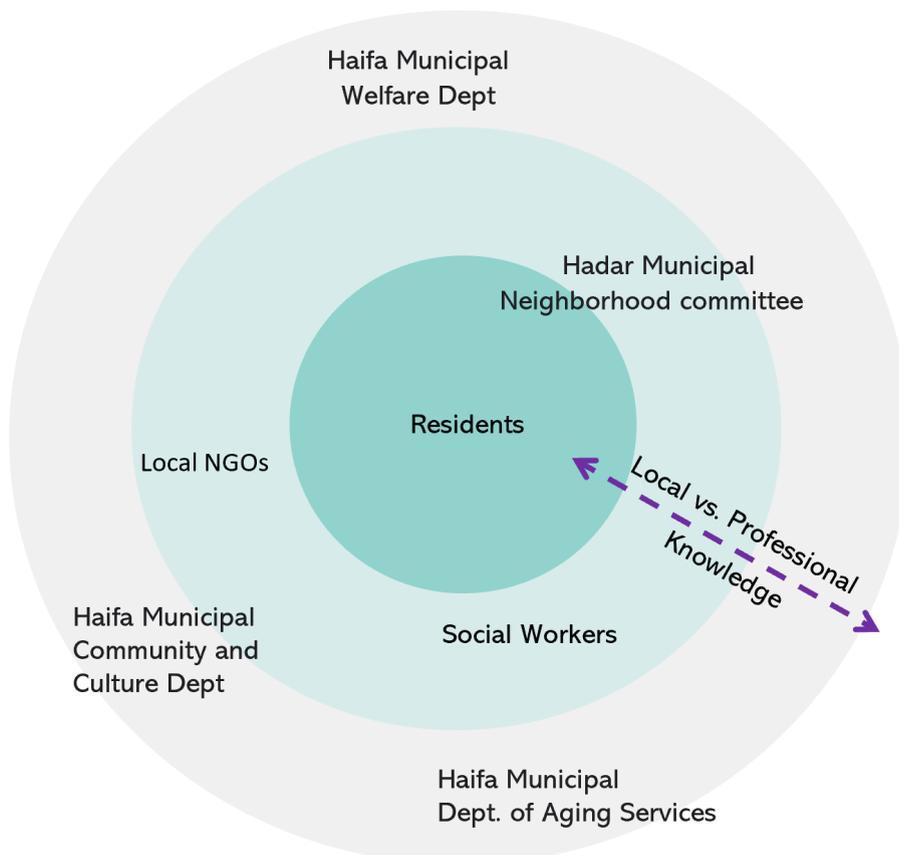


Figure 5

Depicts the relationship of responsibility among stakeholders. At the center of the circle, the organization possesses tacit knowledge, while the outer circle represents explicit knowledge.

Stage One: Foundational Components for Co-Designing the Protocol

The first phase is the preparatory stage: it involves acquiring knowledge and preparing several key components that will play a significant role in shaping the Smart Participation Protocol (see Figure 6),:

- A. A **Social Digital Twin**, which serves as both the medium and the empirical foundation for the partnership.
- B. Learning the principles of **design thinking**, and
- C. Acquiring knowledge in the field of **age-friendly cities**, including key concepts and core indicators in this domain.

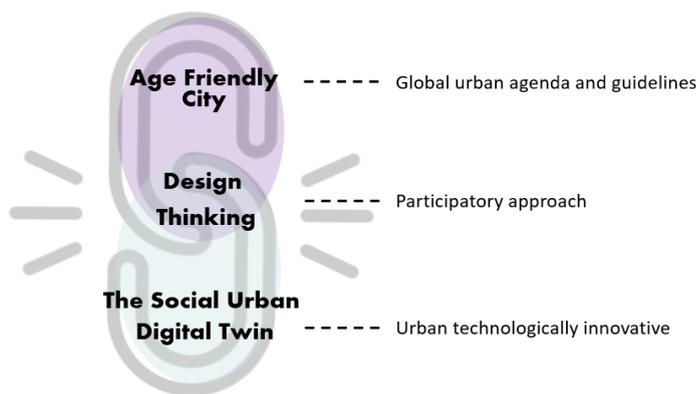


Figure 7: The Socio-Technical Co-governance Protocol – Conceptual Methodologies

The Social digital twin

We developed the Social Urban Digital Twin (Yossef Ravid & Aharon-Gutman, 2022), designed to address the specific case study of urban aging in Hadar. The Social Urban Digital Twin (SUDT) is imbricated with the development and advancement of the urban digital twin, linked with the concepts, strategies, and techniques of smart city models, and integrating tools, methodologies, and protocols from the field of urban sociology. A six-phase approach is essential for the SUDT, as it establishes connections between the social fabric and the physical urban environment of the neighborhood (see Figure 7).

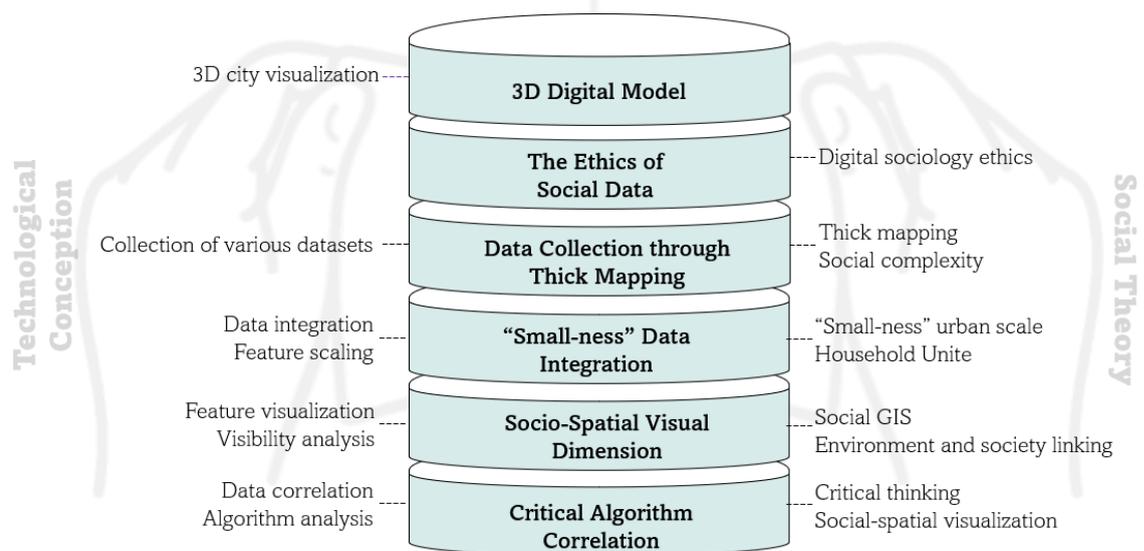


Figure 7
The Six Phases of the Social Urban Digital Twin, Integrating Technological Concepts and Urban Sociological Methods.

The co-governance partnership research not only manifests in the structure of stakeholders involved in urban decision-making processes, but also influences the methodology of assembling and producing the database for the SUDT. The SUDT model draws information from four key sources: open central government data, datasets from various departments within the Municipality of Haifa, data from select civil society NGOs, and the civic monitoring of data collection. Appendix 2 provides a comprehensive list of database resources utilized in establishing the SUDT that supported this research protocol for co-governance based on the urban digital twin.

The objective of this study was to establish a comprehensive Smart Participation Protocol (SPP) using the urban digital twin to address urban social challenges. This generic protocol was developed through the examination of a specific case study focusing on urban aging in the neighborhood of Hadar. Design thinking is a participatory methodology for collaborative problem-solving (Mendonça de Sá Araújo et al., 2019). Integrating the steps of this method with the technologically innovative urban digital twin enabled us to produce the protocol. By integrating the global urban agenda of "age-friendly city" indicators and guidelines provided by the World Health Organization (WHO), we produced a SUDT model for Hadar, which served as a tool for analyzing the age-friendly city indicators within a specific locality. The following sub-section of the current methodology section delves into

the concept and the stages of design thinking and the age-friendly city indicators and guidelines.

b. Design thinking: A problem-solving approach

Design thinking, when applied in the context of governance, offers a potentially progressive approach to tackling the complex challenges of modern societies (Allio, 2014). It utilizes user-centered methods, aiming to involve a diverse range of stakeholders and develop innovative and flexible policy solutions. Inspired by techniques used in the private sector, design thinking aims to improve decision making within the public sector. Its methodology, outlined in Figure 8, involves a step-by-step process for the scope and needs of governance project, starting with immersion and exploration. This includes analyzing collected information to identify specific problems, proposing and examining multiple solutions, creating a prototype for evaluation, and ultimately testing and refining the prototype (Mendonça de Sá Araújo et al., 2019).

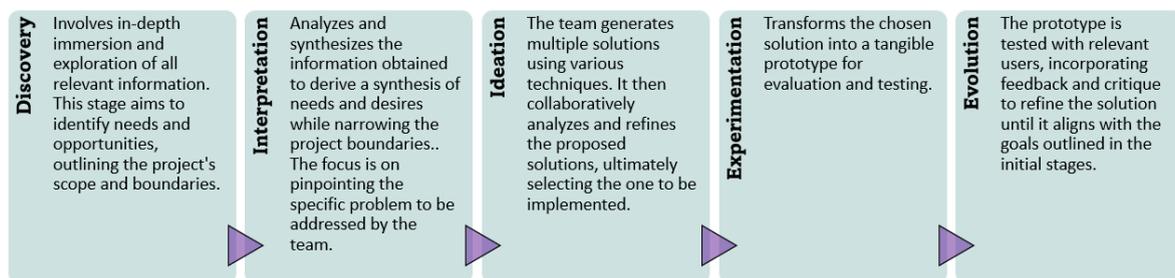


Figure 8

Design thinking methodology.

Source: Mendonça de Sá Araújo et al., 2019

Introducing design thinking into government processes aims to streamline decision making and reduce the chances of duplication or inconsistencies in urban government policies. However, implementing design thinking, deeply rooted in bureaucratic structures, presents significant challenges, such as requiring specific expertise that is not common in the public sector (Schliwa, 2019). Integrating the design thinking method into urban government structures involves navigating numerous bureaucratic and systemic barriers, presenting significant challenges to successful adoption.

Perhaps due to design thinking's prominent role in technological innovation (Dam & Teo, 2022), its application in smart-city contexts is more frequent. Various initiatives have sought to transform the smart city into a human-centered model (Cardullo et al., 2019). Terms like design thinking and human-centered design promise solutions tailored to citizens' needs. Research that mapped governance through design thinking in Manchester and Amsterdam (between 2014 and 2019) reflects that these initiatives engage in "designing the social" rather than "for the social," indicating that citizen participation and civil society participation remain largely excluded from urban government decision-making processes (Schliwa, 2019).

In the context of the urban digital twin, there is a lack of evidence supporting the application of design thinking as a socio-technical approach for urban government decision-making. However, digital twin technology is widely recognized as a valuable tool for generating and enhancing design. The burgeoning opportunities provided by the digital twin in bridging the physical and virtual realms, and in refining product design, have attracted substantial interest across multiple industries (Tao et al., 2019).

c. The age-friendly city: A global urban agenda and guidelines

To comprehend the social challenge of urban aging, we leveraged the Age-friendly City project established by the World Health Organization (WHO) in 2007, which focuses on the relationship between aging and the built environment (WHO, 2007). This project defined the age-friendly city as one that promotes "active aging by optimizing health opportunities, participation, and security to enhance life quality as individuals age" (WHO, 2007, p.1). The project produced a guide that identified key characteristics in three primary areas: service provision, the built environment, and social aspects.

In 2015, the WHO issued a report outlining a protocol with key indicators aimed at evaluating and enhancing the age-friendliness of urban environments (J. van Hoof et al., 2021; WHO, 2015). The indicators were organized around three core principles: equity, accessibility of the physical environment, and inclusiveness of the social environment (WHO, 2015). Each principle encompassed several indicators, enabling a comprehensive assessment of age-friendliness. These indicators played a vital role in shaping our SUDT model, revealing various elements within Hadar and integrating them into our model as new layers. The digitization and localization of the age-friendly city indicators transformed the general

understanding of what defines an age-friendly city, which had previously been viewed as a vague policy. The transition established an inclusive digital tool for assessing and examining the neighborhood context of Hadar vis-à-vis urban aging.

Notably, although localizing age-friendly city indicators is not a new initiative, various past projects, like that of the City of Unley in Australia, identified 25 indicators by focusing on group consultations for localizing age-friendly indicators (Zaman & Thornton, 2018). However, these cases did not incorporate digital tools for mapping and analyzing the indicators. For instance, initiatives that address aging in order to further strategic priorities (Marston & Van Hoof, 2019; J. van Hoof et al., 2021) and smart city interventions focused on meeting the needs of older citizens and enhancing tailored digital solutions (Ivan et al., 2020). Our intervention is unique, as it integrates the urban digital twin with the localization of age-friendly city indicators, thereby providing a comprehensive understanding of inclusive age-friendly city indicators within a specific geographical location.

Stage Two: The Protocol

The SPP comprises five distinct milestones, each of which begins with a preparation stage and involves an in-depth review and study of the global urban agenda and guidelines. These are then integrated into a localized urban digital twin model. Each milestone concludes in a formal workshop event (typically lasting approximately three hours), which provides a platform for stakeholders to convene, discuss, and collectively develop urban co-governance policies. Figure 10 shows the milestone structure. The protocol functions like interlocking roof tiles, with each milestone building upon the foundations of the preceding one. Design thinking acts as the cohesive element, connecting these components seamlessly and resulting in a data-driven urban co-governance policy (see Figure 11).



Figure 10
The milestone structure: Preparation and the culminating workshop.

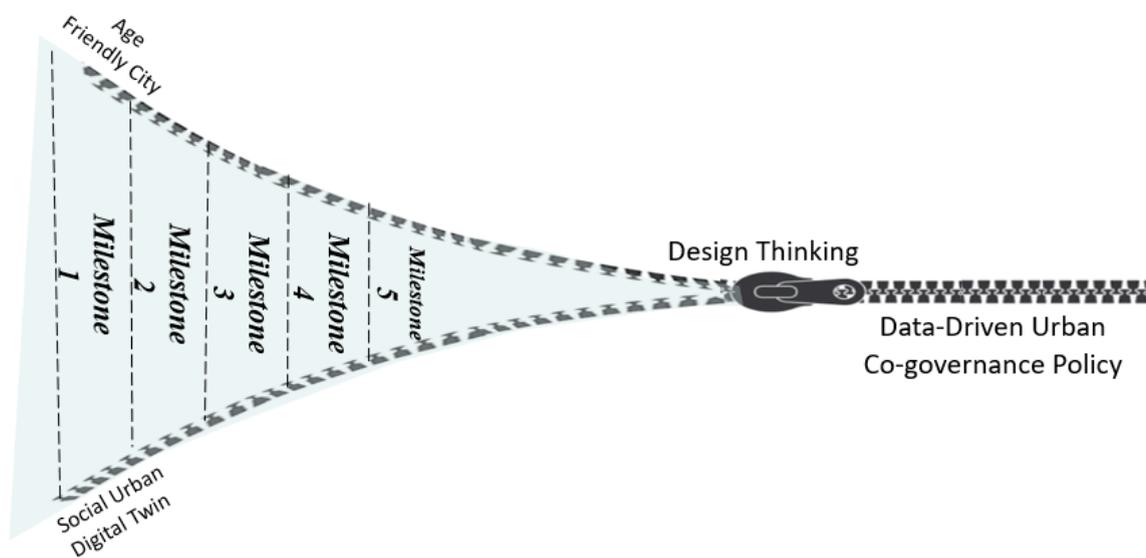


Figure 11

Design thinking acts as the cohesive element, seamlessly connecting these components into a data-driven co-governance urban policy.

The following section delineates each milestone, providing detailed insights into the generic socio-technical protocol and its practical application in our case study on urban aging in Hadar.

The first milestone: Urban thick mapping

Conceptual basis of the generic protocol

This stage corresponds to the design thinking phase of "discovery," which emphasizes immersion in relevant information to identify needs and opportunities (Mendonça de Sá Araújo et al., 2019). The primary objective of this stage is to explore the goals of urban co-governance and engage stakeholders. To this end, we advocate the utilization of thick mapping, derived from the field of urban sociology (Geertz, 1973). Thick mapping facilitates a structured organization of comprehensive collaborations without sacrificing their meaning or significance. This mapping is never truly finished, encouraging ongoing participation and leaving room for future developments (Presner et al., 2014).

The preparation stage of the protocol is essential for initiating fundamental steps like team building with stakeholders, introducing urban governance guidelines

and indicators, and gathering applicable data for the urban digital twin. This stage plays a crucial role in the overall process and may require more time in comparison to other stages. The aim of the first workshop is to introduce the stakeholders to the concept of the urban digital twin and its role in localizing global urban guidelines and indicators.

Implementation of the protocol in the case study

Preparation stage: The goal of this milestone was to facilitate the collaboration and the stakeholder engagement, in accordance with the global urban age-friendly city agenda. Rich, diverse data was collected, including information about locales of the elderly, such as day-care centers, cultural sites, and public facilities. The SUDT played a crucial role in illustrating this formal data, continuously updating the neighborhood's narrative and providing policymakers with an evolving holistic view of the community in order to prevent biased analyses.

Workshop: The first workshop, held on March 17, 2021, sought to introduce the SUDT to co-governance stakeholders while highlighting the global age-friendly city agenda. With access to 170 data layers of the SUDT, participants gained comprehensive insights into the neighborhood. Exploring the SUDT independently, they fostered new perspectives and challenged their existing perceptions (Figure 12). The workshop concluded with collaborative discussions centered around intriguing or unexpected data about the neighborhood. Stakeholders identified missing data not represented in the SUDT that could enhance their understanding of the neighborhood with regard to age-friendly city aspects. They deliberated on the SUDT's potential to support inclusive urban co-governance aging policy.



Figure 12

Photo from the first milestone workshop.

The second milestone: Collective analytical interpretation

Conceptual basis of the generic protocol

The second milestone corresponds with the design thinking phase of interpretation, with its goal of analyzing and synthesizing gathered information, shaping the project's boundaries, and aligning needs and desires (Mendonça de Sá Araújo et al., 2019). This phase emphasizes leveraging explicit knowledge from reputable research and formal institutions to understand the urban guideline agenda concerning specific co-governance locations (Spinuzzi, 2005). The key aim is to transform the global urban agenda into a site-specific approach, which requires deep understanding of the global urban agenda to identify the specific issues relevant to the urban policy protocol.

The preparation stage focuses on creating a core list of issues and indicators from the urban agenda, with the aim of applying them comprehensively to the local context. The urban digital twin functions as a platform for testing and visualizing these global indicators in relation to specific locations. The final workshop aims to

present and discuss how the global urban agenda aligns with the local geography and sociology and the targeted urban co-governance location.

Implementation of the protocol in the case study

Preparation stage: The principal objective of this milestone was to delve into the principles of the age-friendly city, establishing the foundation for aggregating and linking data. Our study focused on the age-friendly city's three core principles: equity, accessibility of the physical environment, and inclusiveness of the social environment (WHO, 2015). We adapted these principles to create distinct domains within the SUDT, emphasizing the unique characteristics of the neighborhood of Hadar (Figure 13). The domains fashioned – accessibility, housing, and demography – each had specific SUDT scene models. These models comprised relevant data layers consistent with the age-friendly city criteria, shedding light on the challenges and lived experiences of older residents in the area.

Workshop: The second workshop, held on April 13, 2021, began with an insightful introduction to the age-friendly city protocol, outlining its historical context, significant characteristics, and current applications. It then introduced three models of the SUDT: accessibility, housing, and demography. The participants delved into each model, focusing on the domain they considered to be most crucial to the everyday experiences of older residents. The subsequent feedback session addressed key concerns: participants identified major issues within the explored domain and determined the core age-friendly city principals most pertinent to addressing challenges in Hadar. They also noted the absence of certain data layers in the SUDT, which, if included, could offer more comprehensive insight.

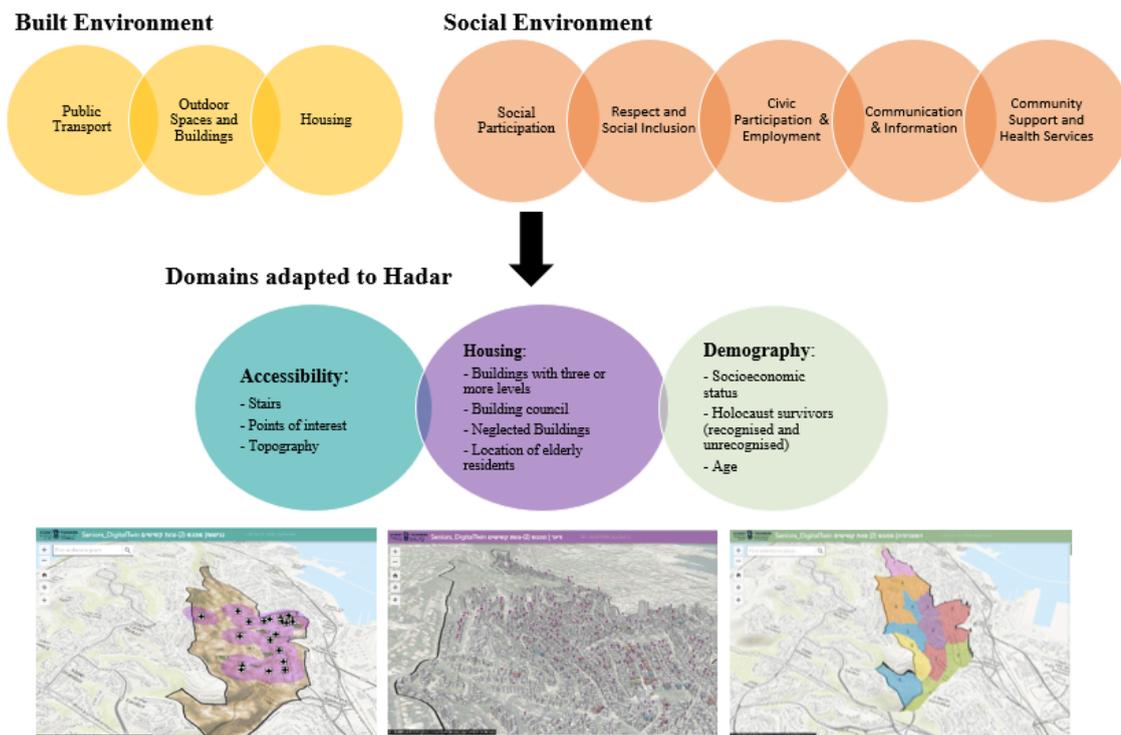


Figure 13

Top: Age friendly built environment and social environment indicators.

Middle: The indicators we adopted for Hadar are divided into three categories: accessibility, housing, and demography.

Bottom: The three scenario models form the Social Urban Digital Twin.

The third milestone: Tacit urban knowledge

Conceptual development of the generic protocol

The third milestone, corresponding with the "ideation" phase of design thinking, focuses on proposing solutions based on tacit knowledge, which is rooted in personal experiences, intuition, and expertise (Mendonça de Sá Araújo et al., 2019). The core participatory design idea of this phase is to bridge stakeholders' tacit knowledge and explicit analytical knowledge (Spinuzzi, 2005). Extracting this tacit urban knowledge is essential for urban co-governance in a manner different from the explicit knowledge in previous milestones. This milestone's structure necessitates a distinct environment and setup. It involves specific methods such as storytelling, interviews, feedback sessions, on-site observations, immersive learning, and interactions with locals to gather this unique knowledge. Integrating the urban digital twin significantly enhances the extraction of tacit knowledge by providing visual representations, comprehensive data integration, and interactive simulations. These approaches offer valuable insights and active engagement,

contributing significantly to the urban co-governance policy-making process. Each method requires specific organization and setup for optimum results.

Implementation of the protocol in the case study

Preparation stage: In our case study, the aim of the milestone was to uncover tacit knowledge within urban co-governance, providing invaluable context that either supports or challenges narratives derived solely from formal data. Stakeholders noted how formal data corroborated their long-held perceptions and intuitions about the neighborhood, offering comprehensive insights through visual data. Their firsthand experiences represent tacit knowledge that exists beyond verbal articulation and that is capable of introducing entirely new perspectives. To underscore and enrich this tacit knowledge, stakeholders proposed a collaborative tour of Hadar, in which all participants engaged directly with older residents and with the urban environment of the neighborhood. In preparation for this tour, we utilized the Survey123 platform of ESRI ArcGIS to capture real-time data during the tour.

Workshop: As part of the regular workshop event, on May 30, 2021, we conducted a tour facilitated by the urban co-governance core team, involving social workers, activist leaders, and municipal employees. The tour, which delved into Hadar's complex topography and the socioeconomic conditions of its older residents, had two primary goals. First, it aimed at unveiling tacit knowledge that was previously inaccessible due to its unquantifiable nature, capturing residents' day-to-day experiences and the expertise of municipal workers, civil society, and NGOs. Second, it emphasized that technological tools should complement rather than replace human understanding, an aspect highlighted by real-world interactions and unexpected insights. The tour included three distinct locations (figure 14). The first showcased local residents living in illegally subdivided apartments, revealing hidden issues not apparent in the formal data (Yossef Ravid, 2023). The second location was the residence of an older resident in a converted storeroom, which further exposed broader problems of low income among many older residents. The third location was a community center run by elderly Arab and Jewish women, which shed light on major neighborhood issues and community-led solutions. Throughout the tour, data gathered using Survey123 was automatically visualized in the SUDT, enriching the urban database with the meaningful insights of stakeholders (Figure 14).

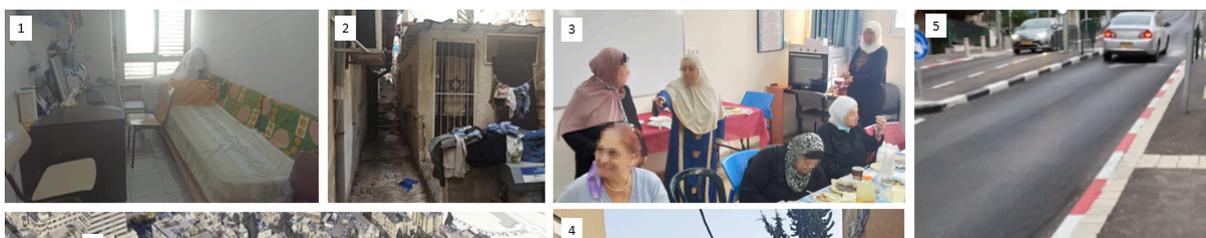


Figure 14

A map of the tour to the following locations: (1) An illegally divided apartment inhabited by local residents. (2) The residence of an older citizen living in a converted storeroom. (3) A community center run by elderly Arab and Jewish women. Photo (4) was taken during the neighborhood tour, and Photo 5 reflects how data gathered using Survey123 was automatically visualized in the Social Urban Digital Twin.

The fourth milestone: Unveiling urbanism complexities

Conceptual basis of the generic protocol

The fourth milestone, corresponding to the "experimentation" phase of design thinking, aims to assist product, design, and development teams in evaluating their concepts and prototypes for a solution. It serves as a fundamental link between knowledge and expert research to further refine crucial urban co-governance issues. Urbanism, emerging from urban studies, unifies the physical and social environments. The previous milestone, which focuses on tacit knowledge, delved into the core issue of urbanism in the context of urban co-governance. The present milestone expands this exploration by integrating formal and informal data sources to articulate hidden and challenging-to-document issues, allowing for a deeper understanding of urban phenomena. Preparing for this milestone involves investigating and understanding the previously discovered tacit knowledge and analyzing study reports and factual papers. Leveraging the urban digital twin, this milestone engages in comprehensive, in-depth visual exploration of the uncovered urban phenomena. The workshop's first segment unveils newly created data layers within the urban digital twin, highlighting identified urban phenomena. The workshop concludes with a focused discussion aimed at identifying the main issue to be addressed by urban policy formulation.

Implementation of the protocol in the case study

Preparation stage: The principal objective of the preparation stage was to investigate the housing situation of undocumented older residents residing in unregistered units, which civic partners, Haifa's social workers, and urban planners have identified as a critical issue. To better understand this complex problem, we analyzed written documentation from various local municipalities in Israel, specifically leveraging data from Moked 106, a municipal hotline for residents to report urban issues and to identify indications of illegally divided housing units. The insights generated by this analysis were then integrated into the SUDT, producing visual representations (Figure 15).

Workshop: The fourth workshop, conducted on June 29, 2021, had two main parts. First, we presented the broader scenario of illegally split housing units in Israel and its impact on public services and city infrastructure. The second part focused on the manifestation of this phenomenon in Hadar, which was presented using the SUDT, emphasizing the newly added layers relating to illegally split housing units and indicators referring to this issue. Following the presentation, a discussion ensued, exploring the insights gained from the integration of informal data provided by social workers and formal data provided by the municipal hotline. Participants highlighted the realization that many more older residents live in the neighborhood than officially documented, particularly solitary residents who may be in need of municipal Welfare Department support. As a result, it was suggested to create more comprehensive mapping and to locate these residents within the neighborhood.

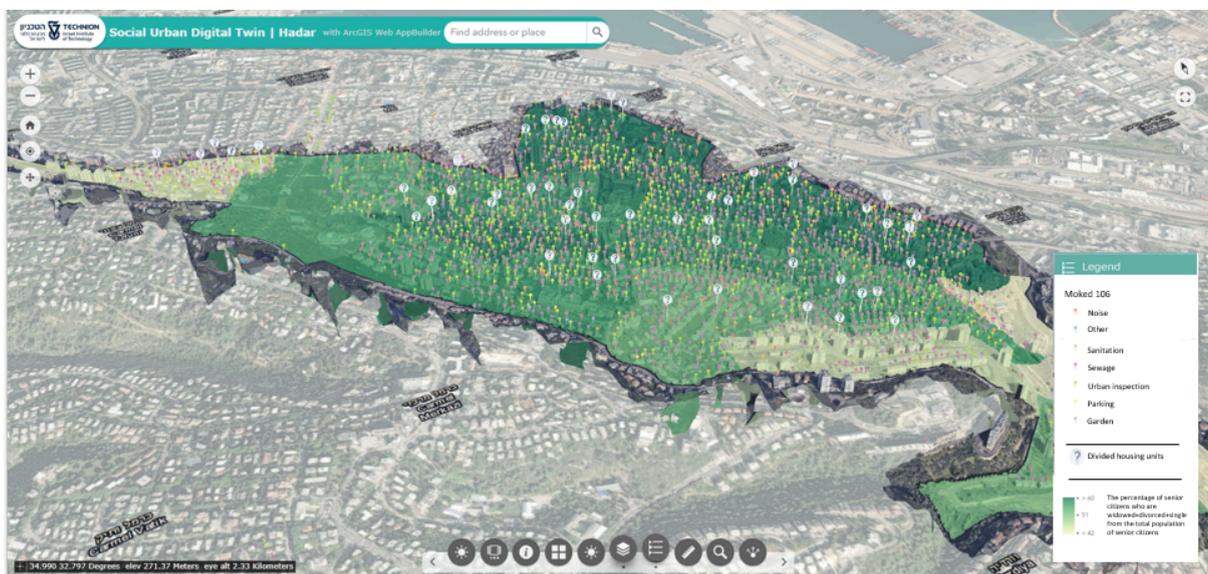


Figure 15
All of the data from Moked 106 and indications of illegally divided housing units.
Source: Hadar Social Urban Digital Twin.

The Fifth Milestone: Urban Policy Formulation

Conceptual Basis of the Generic Protocol

The fifth milestone corresponds to the “evolution” phase in design thinking, which emphasizes testing prototypes with relevant users. At this stage, the goal is to support collaborative governance processes that lead to the formulation of urban policy. Inclusive urban design requires the involvement of stakeholders who bring diverse perspectives and

priorities. While this plurality enriches the process, it also creates tension, as each actor seeks policy outcomes that align with their domain-specific interests.

Thus, urban policy must be formulated and enacted at both macro and micro levels. Policymakers operate on the macro level, designing overarching policies, while municipal professionals and grassroots actors translate these into concrete, localized programs.

To navigate this multi-scalar dynamic, the project team reviewed and analyzed external case studies. The Social Urban Digital Twin (SUDT) was used extensively during this milestone to simulate, monitor, and compare policy scenarios, helping identify the most contextually appropriate policy option for each geographic unit. The primary objective of this phase was to determine the optimal scale for policy formulation—one that meaningfully serves the needs of all stakeholders.

Implementation of the Protocol in the Case Study

Preparation Phase: In the Hadar case study, the main objective was to formulate an urban policy that reconciled the differing priorities of municipal authorities and civil society. While the Municipality of Haifa emphasized a broad, data-driven framework for strategic decision-making, neighborhood-based organizations focused on immediate and tangible action.

We examined global urban strategies that leverage civil society's capacity to map older residents' needs as a way to shape responsive social welfare policies. Using the SUDT, we identified a strong correlation between civil society data and official municipal data—highlighting the potential of cross-sector collaboration as both effective and necessary.

Workshop: The final workshop, held on November 28, 2021, opened with a recap of previous milestones, particularly those related to undocumented and socially isolated older adults. Stakeholders were then invited to propose actions and policies within their respective areas of influence, supported by data tools and analysis.

Two main projects were proposed:

- **“Searching for a Neighbor”** – A targeted initiative to identify and map older residents who are absent from municipal welfare records.

- **“Housekeeper”** – A volunteer-based system for routinely updating the digital platform with the status of neighboring older adults, enabling service provision.

These projects embody a multi-level governance approach, aligning macro-level strategies with micro-level implementation based on the distinct responsibilities and capacities of each stakeholder group.

Stage Three: Reflexive Analysis

The reflexive research process yielded hundreds of pages of transcripts capturing participants' positions, emotions, and insights. Thematic analysis of this material surfaced numerous rich and complex patterns. Here, we focus on two key findings:

- (1) a transformation in participants' relationships with digital technologies—from skepticism to active ownership; and
- (2) the reintegration of spatial thinking into social work practice, catalyzed by the SUDT.

1. From Skepticism to Ownership: Evolving Attitudes Toward Technology

At the outset, many participants—especially social workers and community-based professionals—expressed ambivalence or resistance toward tools such as GIS and the SUDT interface. These platforms were seen as overly technical, inaccessible, or the exclusive domain of experts.

However, as participants engaged with the tools through hands-on, iterative activities, their perspectives began to shift. They recognized conceptual logics already familiar from their own disciplines—such as inductive reasoning, strategic framing, and cyclical exploration. This cognitive familiarity reframed the digital tools not as external impositions, but as intuitive and empowering resources.

The spatial interface became a shared lens for collective sense-making. As one participant noted:

"I always knew this was the reality—but now I can actually see it, clearly, and with others."

This transformation underscores a key principle of smart participation: that genuine civic engagement in the digital age requires not only access to technologies, but also a felt sense of cognitive and emotional ownership. Mediated through the SUDT, the Smart

Participation Protocol helped bridge the socio-technical divide, turning passive users into active co-designers.

2. Spatial Re-Embedding of Social Work: A Return to Place-Based Practice

In parallel, a second transformation emerged. The spatial visualization of social data—particularly indicators concerning older adults—revived dormant practices of community-based, geographically grounded social work. Veteran practitioners described how the digital twin reactivated local modes of intervention rooted in neighborhoods, buildings, and informal support networks.

This re-spatialization was not simply a response to the COVID-19 pandemic, but the result of embedding social indicators within a shared spatial model. The SUDT functioned as more than a visualization tool; it became a reflective surface through which the neighborhood was reimagined as a cohesive social unit.

In this sense, the Smart Participation Protocol did not abstract or diminish lived experience. Rather, it enabled integration between micro-level insights and macro-level strategies—bridging the gap between personal, local knowledge and systemic, institutional planning.

Conclusion

This article introduced the Smart Participation Protocol (SPP)—a novel socio-technical methodology that combines urban digital twin technologies with design thinking to enable collaborative governance in complex urban contexts. Developed through participatory action research in the aging neighborhood of Hadar, Haifa, the SPP addresses a key blind spot in the smart cities discourse: the integration of social welfare and care work into technological urban governance.

Structured around five iterative milestones aligned with design thinking, the protocol merges immersive stakeholder engagement with spatial data modeling via the Social Urban Digital Twin (SUDT). The model incorporates WHO's age-friendly city indicators and integrates data from municipal sources, civil society organizations, and community-level monitoring.

Two primary insights from the reflexive analysis stand out:

First, the power dynamics embedded in partnership-based models highlight the complexities—and limitations—of academic intervention within real-world governance ecosystems.

Second, participants' relationship with technology evolved significantly: once understood through the lens of social science logics, tools previously perceived as alien became sites of enthusiasm, creativity, and ownership.

The Smart Participation Protocol offers a scalable, adaptable framework for inclusive, data-informed urban policy-making. Its implementation in Hadar demonstrates how digital technologies, when embedded in participatory and socially grounded processes, can become catalysts for meaningful urban transformation—particularly in response to the multifaceted challenges of urban aging.

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Ethics approval obtained:

This study was approved by the Technion's Behavioral Sciences Research Ethics Committee (Technion – Israel Institute of Technology), Approval no. 2021-040.

Consent to Participate: Informed consent was obtained from all individual participants included in the study via an online consent form.

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Appendix no 1:

Table 1- Participate Stakeholders in the co-government Urban Aging in the Hadar Neighborhood and their associations to the			
Title	Male/Female	Affiliation	Associations to the Hadar Neighborhood
Social Worker	F	Welfare department	Haifa Municipality
Social Worker	F	Welfare department	Haifa Municipality
Elderly Citizen Dpt	F	Department of aging services	Haifa Municipality
Community Worker Coordinator	M	Hadar neighborhood units	Haifa Municipality
Social Worker	M	Hadar neighborhood units	Haifa Municipality
Social Worker	F	Welfare department	Haifa Municipality
Social Worker	F	community and culture department	Haifa Municipality
NGO CEO	F	Lev chash	Hadar NGO
Community Organizer	F	Dror Israel	Resident and part of Hadar Community organize
Community Organizer	M	Shachaf NGO	Hadar NGO
CEO of Welfare NGO	M	Shachaf NGO	Hadar NGO
Community Organizer	F	Dror Israel	Resident and part of Hadar Community organize
Community Organizer	M	Garin Torani	Resident and part of Hadar Community organize
Community Organizer	F	Garin Torani	Resident and part of Hadar Community organize
Community Organizer	F	Hadar Students Village	Resident and part of Hadar Community organize
Elderly Citizen Activist	M	Residents	Hadar residents
Citizen Activist	F	Residents	Hadar residents
Citizen Activist	F	Residents	Hadar residents

Appendix no 2

Table 2- Social Urban Digital Twin Database. Source: Yossef Ravid & Aharon-Gutman, 2022					
	Organizations	Topic	Data Type	Scale	File Type
Institutional Data	Ministry of Transportation	Public transportation	Bus stops	City of Haifa	SHAPE
			Bus lines	City of Haifa	SHAPE
			Bus routes	City of Haifa	SHAPE
	Ministry of Health	Coronavirus infections	Age	Statistical area	Excel
			Gender	Statistical area	Excel
	Survey of Israel	Geographic information	Topography	City of Haifa	SHAPE
			Land use	Statistical area	SHAPE
			Blocks and plots	Statistical area	SHAPE
			Street names	City of Haifa	SHAPE
	National Insurance Institute	Demography	Number of residents	Statistical area	Excel
			Gender	Statistical area	Excel
			Age 0-17, 18-34, 35-44, 45-54 55-64 65-74 75-84 85+	Statistical area	Excel
		Financial assistance	Income guarantee recipients	Statistical area	Excel
			Senior citizen pension	Statistical area	Excel
			Disability fund	Statistical area	Excel
			Nursing allowance	Statistical area	Excel
		Marital Status	Widow/widower	Statistical area	Excel
			Divorcee	Statistical area	Excel
			Married	Statistical area	Excel
	Unmarried		Statistical area	Excel	
	Haifa Municipality	Property tax	Assets file	street name & address	Excel
Number of persons per residence			street name & address	Excel	
Apartment area			street name & address	Excel	
Age of property owner			street name & address	Excel	
Rental / Ownership			street name & address	Excel	
Type of tax rebate			street name & address	Excel	