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<https://doi.org/10.3389/frsc.2026.1656932>

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RECEIVED 30 June 2025

REVISED 09 April 2026

ACCEPTED 13 April 2026

PUBLISHED 05 May 2026

CITATION

Vitaller del Olmo M, Simeone L,
D'Ippolito B, de Götzen A and
Morelli N (2026) Enabling urban futures
making through early-stage and
punctuated design prototyping: the case
of T-Factor local innovation hubs.
Front. Sustain. Cities 8:1656932.
doi: 10.3389/frsc.2026.1656932

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Enabling urban futures making through early-stage and punctuated design prototyping: the case of T-Factor local innovation hubs

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Futures thinking is a crucial skill for organisations navigating volatile, uncertain, complex, and ambiguous environments. Nonetheless, some researchers and practitioners argue that the insights futures thinking can yield appear obvious, trivial, or overly abstract and stress the need to move towards futures making. This paper examines how early-stage and punctuated prototyping can enhance futures making within urban transformation processes, supporting the co-creation, experimentation and decision-making on futures from local stakeholders. Drawing from the case study of T-Factor, a four-year project aiming to envision and prototype future uses in urban spaces, we find that two essential dimensions of prototyping—filtering and manifesting—can aid stakeholders in thinking about futures throughout the design process and, eventually, enable futures making. The content analysis of our data shows how these two dimensions contribute to futures making by facilitating the materialisation of more concrete, actionable, and engaging representations of the future that can be experienced, performed, assessed, and refined. The paper concludes by proposing practical recommendations for organisations and communities aiming to envision and realise sustainable urban futures through prototyping.

KEYWORDS

early-stage prototyping, futures making, futures thinking, prototyping, urban innovation, urban sustainability

1 Introduction

Private and public organisations managing urban environments tend to address high levels of volatility, uncertainty, complexity, and ambiguity (Taskan et al., 2022), and operate within chaos, instability, and rapid changes (Johansen and Euchner, 2013). Cities face difficulties in effectively establishing innovative policies and actions aimed at climate resilience, such as inclusive decision-making (Mahmoud et al., 2021; Stroink, 2020), upscaling pilot initiatives (Plassnig et al., 2022), aligning citizens and government expectations (Haarbosch et al., 2021), evaluating the impact of strategies and interventions in the long-term (Evans et al., 2025) or implementing changes that lead to long-term visions of urban sustainability (Hommels, 2000; Ceschin and Gaziulusoy, 2016).

Under such conditions, urban governance may benefit from strategies and frameworks that support stakeholders in navigating these complex scenarios and systematically considering long-term possibilities and future developments (Bühning and Liedtka, 2018). In recent years, institutions and organisations have incorporated design practices and approaches to drive innovation towards future sustainable urban adaptation and development (Rogers et al., 2023) and as a leverage point for urban sustainability (Cristiano et al., 2020). Particularly, some have explored design-inspired strategies and tools that support the involvement of different groups of stakeholders in collaboratively envisioning and shaping alternative urban futures, such as “lies” (Rosenbak, 2018), speculative improvisations (Tyszczyk, 2021), or playfulness (Estrada Grajales et al., 2018). Accordingly, many scholars advocate for innovative approaches that enhance the collaborative envisioning and negotiation of urban futures as a path to achieve sustainability (Evans et al., 2016; Leminen et al., 2021).

This future-oriented approach has traditionally been rooted in disciplines and methods that support futures thinking. In this paper, we will use “futures thinking” to refer to those strategic approaches that stem from various disciplinary practices, such as foresight, forecasting, and futuring, and to systematically and critically consider future possibilities that can define preferable developments for people and society (Canina et al., 2022; Peruccon and Simeone, 2023). Futures thinking involves identifying the drivers of current or potential change, developing future scenarios and specific goals, and creating a portfolio of strategic options that can be activated as needed or when opportunities arise (Girotra and Netessine, 2014; Simeone, 2020; Simeone and D'Ippolito, 2022). Despite the promising foundations, futures thinking is sometimes criticised for delivering insights considered obvious or trivial, or too abstract to be operationalised (Anderson, 1997). Some scholars stress the need to shift from “futures thinking” to “futures making” as an approach to a more granular and concrete development of envisioned futures (Comi and Whyte, 2018; Wenzel, 2022). Their studies centre on the sensorial and experiential value of visual artefacts and practices through which the future comes into being, i.e., the use of drawings, sketches, and models at different levels of refinement in strategic planning and foresight (Hodgkinson et al., 2006; Paroutis et al., 2015; Jarzabkowski et al., 2013). This is the case, for example, of speculative design (Dunne and Raby, 2013), a practice that employs material artefacts to critically explore and question future and present alternatives. None of these studies, however, examined the specific role of “design prototyping” - i.e., a practice within a design process that tangibly represents ideas and solutions at different levels of granularity to support the implementation and development of such ideas. Scholars called for more research on the topic in order to explore whether and how design prototyping can support the shift from more abstract practices of futures thinking (i.e., the typical outputs of methods such as trend analysis, scenario planning, visioning) to futures making (i.e., a future-oriented approach whose outputs are granular and concrete plans for action) (Carleton and Cockayne, 2009; Camere and Bordegoni, 2016). To address this call, our study investigates how prototyping can support the materialisation of futures thinking and its actualisation in concrete plans and interventions for urban sustainability.

This research draws on a community case study based on a 4-year-long European research and innovation action (T-Factor) geared towards revitalising districts in European cities (i.e., Milan, London, Kaunas, Amsterdam, Bilbao, and Lisbon) that experienced abandonment and decay. T-Factor’s “local innovation hubs” involved city

stakeholders such as, among others: government organisations, local businesses, and citizens. These local innovation hubs set up and tested facilities and events such as temporary skate parks, maker spaces, farmers’ markets, culture and ecology festivals, and greenhouses, with the ultimate scope of envisioning and prototyping initiatives for more sustainable future uses for their cities. In a traditional design process, prototyping comes after other phases such as carefully studying the environment, framing the problem, and defining a possible solution and an operational plan to develop it; design thinking methodologies are often deployed to formulate these processes (Brown, 2009; Martin, 2009). Once the process is in place, one would work on a prototype to represent the solution at a reasonable fidelity level and test and evaluate its effectiveness. In the context of T-Factor, instead, prototyping was used very early in the urban revitalisation process, at a stage when stakeholders had only a vague idea of the problem(s) and how to address it(them). After this initial phase, the local stakeholders kept working on these prototypes to further their understanding and planning of future developments. We term this more regular and continuous use of prototyping as “punctuated.” This paper reports on our findings and its influence for organisations targeting urban sustainability. Within the paper, we will use the terms “design prototyping” and “prototyping” interchangeably.

The remainder of this paper is structured as follows: the following subsections situate the nature of the problem within existing academic research. The Methodology section describes the context of our case study and our approach to the data collection and analysis. In Section 4 we present the empirical material and examples of how the application of prototyping unfolded in T-Factor’s urban innovation hubs. The Discussion reflects on the observations in contrast with the existing literature on the field, and on the practical implications of the case study for similar future endeavours. The paper concludes with some final remarks on methodological constraints and potential avenues for further research on the topic.

2 Theoretical underpinnings

2.1 Futures thinking and futures making in urban innovation

In recent decades, academic literature has studied practices that explore, envision, and shape future possibilities (van der Duin, 2016; McCausland, 2023). Over time, futures thinking has gained significant traction, especially among businesses and governments in technologically advanced countries (Hines, 2019; Bell, 2017). Recent developments emphasised the opportunity for engaging multiple and diverse stakeholders in collaborative practices of futures thinking (Neuhoff et al., 2023). In the context of these practices, futures thinking can be “colonised” by the voices of more powerful societal actors (Dator, 2005); many scholars have emphasised the need to question one-dimensional viewpoints and value diversity and otherness (Sardar, 1993; Milojevic, 2008). Within the urban domain and often in conjunction with urban innovation projects, numerous initiatives tried to foster futures thinking, also to envision and shape practices for sustainability (Leinen et al., 2021; Evans et al., 2016). O’Sullivan et al. (2023) explored how the collection of sensed and experiential knowledge of communities affected by new urban initiatives may inform the developers and promoters of such initiatives for more impactful

place-making. Relatedly, Rosa et al. (2021) demonstrated the capacity of participatory foresight methods to collect diverse future imaginaries, contributing to research and innovation processes. However, like in these examples, the role of futures thinking within urban innovation is mostly confined to practices of insight generation, abiding by top-down implementation models.

Methods and practices behind futures thinking have been subjected to several critiques, including that their insights remain too generic (Piirainen and Gonzalez, 2015). While authors like Snowden and Boone (2007) critiqued that future thinking may not adequately consider systemic aspects and complexity theories, other scholars also noted how, at times, futures thinking remains too abstract and disconnected from the complex functioning of our societies and our planet's biophysical subsystems and processes (Simon and Deile, 2022). Ramos (2006) emphasised that most future-oriented practices overlook the depth and transformative potential of engaging worldviews and metaphors for constructing futures. Another common critique is related to the difficulty of operationalising the obtained results (Buehring and Bishop, 2020). It has been argued that futures thinking tends to be speculative (Dunne and Raby, 2013) and supports utopian or fantasy plans (Clarke, 1999; Ibach, 2023) rather than actionable blueprints.

Within urban innovation, Neuhoﬀ et al. (2023) questioned the effectiveness of futures thinking practices that focus on envisaging the external world, such as policy agendas and urban planning, and overlook the decisive influence of the individual and the social norms and belief systems ruling their interaction with the world. Relatedly, Ramos (2006), aligned with the poststructuralist ideas of Inayatullah (1999) of deeper cultural and ideological understanding to shape how societies imagine their futures, promoted the co-creation and participatory construction of futures. This idea has grown in popularity, and several authors advocate for the potential of Participatory Design as a medium and a method through which collaborative imagination, democratic engagement and social innovation are enacted and materialised for the exploration of futures (Bannon and Ehn, 2013; Manzini, 2015; DiSalvo, 2009). However, scholars also warned about “pseudoparticipation” or the absence of a more genuine and active inclusion of the full spectrum of stakeholders' experiences and needs in the envisioning and shaping of futures (Evans et al., 2016; Palacin et al., 2020), especially those affected by sustainability challenges (Nikolova, 2014), leading to distorted and exclusive policy making (Michels and De Graaf, 2010) and development practices (Disterheft et al., 2012).

Another critique of futures thinking is related to the temporality of futures thinking processes, lasting relatively short time spans and being disconnected from integral and durable policy-making or urban development procedures (Carlsson-Kanyama et al., 2008). This hinders the possibility for stakeholders to experience, study, and re-negotiate the initiatives conceived to shape the envisioned futures, compromising the learning outcomes and potential impact of such initiatives (Brown et al., 2016; Ravetz and Miles, 2016).

Some researchers proposed a shift to “futures making,” i.e., processes that are concerned with the development, consolidation, and enactment of specific futures by testing and validating the assumptions behind these futures and actively engaging the stakeholders who will be impacted (Whyte et al., 2022). An example of this shift can be found in the work by Haarbosch et al. (2021), who adopted a futures-making approach to study the mismatches between the narratives on the future inspired by energy policy and the ones of the affected citizens, as well as the individual and collective consequences that such

mismatches may unfold in the implementation of the energy transition. Other authors herald the potential of “imaginative future-making that is rooted in envisioning and crafting scenarios” (Durante et al., 2024, p. 508). Here, the word “crafting” characterises the futuring process in relation to its materially grounded, practice-based qualities. Aligning with the work of these authors, we understand futures as provisional and incomplete (Wenzel, 2022; Whyte et al., 2022). Hence, we consider futures making as a form of generative inquiry, that is, as a distributed and reflective process where stakeholders engage with futures in a cognitive, sensorial and empathetic way (Comi and Whyte, 2018).

2.2 Design prototyping as a practice in urban futures making

Oomen et al. (2022) studied different techniques of futuring for contemporary sustainability politics, posing crucial reflections on the influence of the futuring process on the type of futures such processes generate. The authors drew attention to the lack of neutrality in futuring processes when they become performative by inspiring and shaping policy directions and socio-technical developments, insisting on the power dynamics and the perspectives that are (and are not) collected along the process. Thus, exploring a more encompassing toolbox of alternative and inclusive futuring methods and processes is necessary to face complex urban challenges (Oomen et al., 2022; Mangnus et al., 2021).

Research shows that visual artefacts facilitate futures making processes and practices (Ewenstein and Whyte, 2009; Dameron et al., 2015). The artefacts' visual and material aspects are valuable for their performativity, as they allow stakeholders to “perform” futures, bringing them into being (Wenzel, 2022). The artefacts' performativity facilitates the execution of certain actions and sets the focus on what actors “do” and not what they say they will do or wish to do when engaging with futures (Jarzabkowski et al., 2007). These practices may show “the actual and specific ways in which actors produce and enact the future” (Wenzel et al., 2020, p. 1443). In general, these studies have focused on the pictorial, textual and notational components of artefacts that are commonly used for strategising and organising, such as drawings or sketches (Comi and Whyte, 2018), strategic maps (Huff and Jenkins, 2002), PowerPoint presentations (Whyte et al., 2022) or visual templates (Eppler and Platts, 2009). While relatively less explored in the futures literature, some studies have examined less common artefacts, such as LEGO bricks (Roos et al., 2004) or similar materials for models or prototypes that can be physically manipulated, providing a higher level of immersive engagement. One of the design practices that employs artefacts to engage participants with futures is speculative design (Dunne and Raby, 2013). Dunne and Raby emphasised the importance of physical artifacts, storytelling, exhibitions and props that allow people to experience and engage with alternative futures. They perceived such objects as vehicles for public engagement. Yet, their intention is mostly catalytic and provocative. Speculative artefacts open the door to the imagination of transitions but hardly seek to trigger long-term change or political action. In other words, the artifacts function rather for problem-finding than for solution-making.

Prototyping is known for its value for material exploration and the development of ideas. However, the details of this practice for the stakeholders' experience and engagement with futures-making remain unexplored. Prototyping is essential in widely used design and

innovation frameworks, such as Stanford's school (Brown, 2009) or other adaptations of the Design Thinking model (Martin, 2009). These frameworks present the process as linear funnels: at the beginning of the process, designers have multiple ideas; at some point, they settle down on fewer ideas that get more refined and, finally, prototyped at a reasonable level of fidelity. For example, within entrepreneurial processes (especially, those characterised by an agile or lean approach), developing a minimum viable product—i.e., a prototype of the product that has just enough features to be usable, tested and iteratively improved—is vital (Blank, 2013; Shepherd and Gruber, 2021). In all these frameworks, prototyping is applied following an experimental approach (Floyd, 1984), where the prototype serves as a demonstrator, offering information about whether (or not) the chosen solution is adequate and desired.

In the past decade, and given the complexity of our societal challenges, systemic design researchers (e.g., van der Bijl-Brouwer and Malcolm, 2020; Kimbell and Bailey, 2017) and practitioners (e.g., Design Council and the Point People, 2021; Leadbeater and Winhall, 2020) have argued for the value of prototyping for navigating complex, uncertain, and rapidly evolving systems. Most authors agree on the need to redefine the traditional application of prototyping and understanding of prototypes. Some scholars have suggested using prototyping at earlier stages to explore and frame problems (Emilsson et al., 2011), evoke and examine dilemmas (Björgvinsson and Hillgren, 2004), probe uncertain contexts (Chow, 2013), foster idea generation (Halse, 2014), and enhance civic engagement (Jaśkiewicz, 2022). In urban innovation, van den Eijnden et al. (2022) employed waste materials to craft future visions on the challenge of waste in the city of Utrecht with local stakeholders. In the paper, the authors highlight the value of this process in collecting and articulating a variety of perspectives and expectations to foster inclusive urban futures. Most of these cases applied prototyping in the early stages of design processes, relying on the exploratory value of prototypes (Gill et al., 2011). Thus, the focus is not solely set on the envisioned solution but on eliciting knowledge and catalysing ideas or alternatives for the context. These approaches resonate with the value of conceptually rich artifacts employed in design research (Gaver, 2012) for knowledge generation and the emergence of possibilities, alternative routes and imaginative futures. However, unlike prototyping, in most cases, such artifacts hold an epistemic role, advancing theory, hinting at ideas, or describing alternative futures, but they rarely constitute a first step in the physical making of such futures. Specific studies on the practice of prototyping to support the shift from a too abstract futures thinking to a more concrete futures making are sparse (Carleton and Cockayne, 2009; Camere and Bordegoni, 2016). Our paper studies this gap and evaluates the influence of prototyping in the transition from futures thinking to futures making.

The above literature sheds light on two interconnected dimensions of prototyping—filtering and manifesting—as identified in prototyping literature (Lim et al., 2008):

- 1 Filtering is defined as the act of selecting aspects of a design idea, focusing on particular elements or sections of an imagined or desired design space to understand, learn about, or discover.
- 2 Manifesting refers to the act of “physically” externalising and realising, in the most effective and simplest form, the selected aspects of the design space to be tested, explored, or discovered.

This categorisation has been adopted in studies that focused on the development and exploration of envisioned futures (e.g., Camere and Bordegoni, 2016; Kannabiran and Bødker, 2020). In this paper, we apply it to understand how the mechanisms of prototyping may support some of the necessary actions for futures thinking and making. Such actions may be commonly undertaken through the application of other design or management methods (e.g., design research or co-design workshops for project scoping or project framing) and contribute to processes of futures thinking. Our research investigates the added value that the method of design prototyping—through its dimensions of filtering and manifesting—may generate in those urban transition processes for the activation of futures making.

3 Methodology

3.1 The case study

This paper builds on a case study, T-Factor, a design-focused research and innovation initiative funded by the European Commission from 2020 to 2024. Case studies are an established research approach in organisational and management studies (Buchanan, 2012), as they provide valuable and periodic feedback, allow flexibility in adapting research to various types of evidence and data, assess outcomes, test alternative theories, and draw significant conclusions about key themes in a field (Yin, 2009). We selected this methodology for the possibility of identifying key insights through the detailed analysis of T-Factor's application of prototyping (Pettigrew, 1990), and for contributing to theory (Eisenhardt and Graebner, 2007) by exploring real-world contexts (Yin, 2009). After analysing the case and deriving some theoretical insights, we also ran two additional co-creation workshops to consolidate our initial findings.

T-Factor embraces the idea of “meanwhile uses,” i.e., temporary interventions “in underutilised places, such as vacant lots and buildings, which create shared public value” in cities.¹ The project explored this idea in 14 cities: six pilot cities and eight advanced cases. In each of the pilot cities, T-Factor established “local innovation hubs,” that is, spaces where city stakeholders (government organisations, local businesses, citizens, researchers and other experts) collaborated on the envisioning of more sustainable futures in their cities and carrying out initiatives to develop these futures. The project aimed at sustaining temporary uses as “recognised practices of city-making” (T-Factor, 2023). Within the activities of the local innovation hubs, prototyping played an important role, as it was key for the pilots to explore the feasibility and identifying pathways to support and manage such temporary use initiatives for city-making. This unique approach of the hubs to prototyping makes it a relevant case to study the value of prototyping in futures thinking and making. Table 1 provides an overview of the main initiatives implemented to prototype the feasibility and long-term implementation of their targeted goals in relation to temporary uses for city-making, as well as the stakeholders involved and some examples of the prototypes' impact.

¹ definition derived from: www.T-Factor.eu.

TABLE 1 Overview of T-Factor city pilots: context, goals, prototyping initiatives, participants and stakeholders.

Pilot data	Amsterdam	Bilbao	Kaunas	Lisbon	London	Milan
Context	Amsterdam Science Park: large science campus in east Amsterdam, combining universities, research institutes and student housing; focus on urban ecology, biodiversity and climate adaptation in a highly planned environment.	Zorrotzaurre: post-industrial peninsula undergoing long-term transformation into a new mixed-use district; history of abandonment and social struggle; strong cultural and social identity and concern about displacement and “green/growth-led” regeneration.	Aleksotas Innovation Industrial Park/ Kaunas Fortress: Historic fortress and industrial area in Aleksotas district being reconceived as an innovation and industry park (full timeline to 2046); tension between large-scale investment logic and local cultural/ ecological concerns; relative physical separation from city centre.	Trafaria: coastal town on the south bank of the Tagus river, centred around the former Trafaria prison (Antigo Presidio da Trafaria); characterised by working-class and fishing communities, some stigma and neglect, and recent arrival of NOVA University’s campus and cultural actors.	HS2 Euston: major infrastructure project area around Euston station with long histories of social housing and diverse communities; high disruption and contested regeneration; need for mechanisms that articulate local rights to the city in face of national transport agendas.	MIND – Milano Innovation District: large-scale redevelopment of the former Expo 2015 site into a mixed-use innovation district (R&I, healthcare, education, housing); complex public–private governance arrangements and need to build a sense of place and accessibility in a new urban district (timeline to 2031) on the city’s edge.
Main targeted city-making practices	- Enhance urban ecology and biodiversity through temporary uses as driver of regeneration - Foster “do-it-together” eco-practices and human-nature stewardship Develop alternative nature-inclusive imaginaries to the existing masterplan (Field Atlas).	- Trigger collaboration and co-creation alliances between universities and grassroots organisations. - Develop participatory governance for the peninsula’s regeneration. - Explore enabling regulations for temporary uses of spaces in the context.	- Promote a collaborative, creative and community-led future innovation park through physical and digital placemaking. - Develop a people- and planet-centred innovation urban ecosystem. - Ensure values associated with short-distance and multi-function places.	- Build shared, locally rooted identities by activating informal settlement communities. - Promote innovative education and training connected to the partners’ presence in Trafaria. - Make the area an attractive and accessible neighbourhood that puts the heritage of Presidio fort in value.	- Build safe and convivial streets and spaces in the area and integrate temporary uses (“meanwhile uses”) into major urban redevelopment projects. - Promote collaborative and circular economy through arts, culture and heritage. - Develop growing and greening infrastructure and initiatives emerging from real community agency.	- Establish an open, vibrant and collaborative R&I ecosystem in the area. - Support active, healthy and sustainable uses and lifestyles for stakeholders. Promote accessibility and construct a common sense of place and identity for the new district.

(Continued)

TABLE 1 (Continued)

Pilot data	Amsterdam	Bilbao	Kaunas	Lisbon	London	Milan
Key prototyping initiatives	- Wild & Cultivated Gardens: wild and cultivated garden patches and green experiments distributed across the park (mobile green making place); part of a Landscape Festival with daily, weekly, and seasonal “green experiments.” - Do-It-Together (DIT) Eco-Practices/Ecology Hub: collaborative eco-practices combining science, art and citizen engagement (e.g., habitat construction workshops, mapping, biodiversity walks). Field Atlas – Alternative Masterplan: digital/visual atlas exploring alternative ecological futures for the park developed through sensor-based wildlife mapping systems (bioscopium).	- Prototype Sprint: events and activities to promote the construction of student and grassroot initiatives’ prototypes visible in public space, linking university curricula and local initiatives (i.e., refugee camp for plants, cat shelter initiative...). - Civic Design Council: a micro-governance platform for diverse actors (universities, grassroots initiatives, local authorities) to deliberate on regeneration and meanwhile uses. Regulatory Proposals Drafts and Experiments: – drafts of proposals and experiments oriented to more flexible, enabling regulation for temporary occupations and civic initiatives. Discussion and roleplaying of the proposals.	- Kaunas Fortress Community Space: temporary activation of fortress spaces as a community hub for events, workshops and testing new services/technologies for sustainable development of the area (e.g., digital/AR site imagination exercises). - Sandbox Space: experimental “living lab” for people- and planet-centred innovation (e.g., participatory workshop testing services, technologies, governance arrangements). - Open Gallery: multi-functional public art/technology corridor supporting short-distance mobility and cultural use.	Public Cultural Programming: artist residencies, festivals, exhibitions and public events that collect existing and envisioned local narratives and identities (e.g., fishermen’s culture, prison heritage at Antigo Presidio da Trafaria) through podcasts, documentaries, bottom-up museum exhibitions, and other formats. Critical Futures: educational and training formats (workshops, labs, exploratory courses) that connect local communities, local students and researchers around future imaginaries and skills.	- Digital Archiving: participatory archiving of local histories, stories and visual materials to assert community heritage during HS2-driven redevelopment. - Circular Market: market-based prototype supporting collaborative and circular economy, including roles such as a Market Hub Facilitator and links to local makers and traders. - Story Trail: street-level interventions and trails that combine safety/conviviality with local narratives and greening. Community Workbench (co-developed by University of the Arts London MA students + Community Champions; permanently adopted)	- Community House: a meanwhile hub bringing together enterprises, social cooperatives and universities to offer guidance, training and orientation through Futurabili -notably for young people and NEETs (Not in Education, Employment or Training) around future professions, AI and digital manufacturing. - Herbula Wild Garden at MIND: collective and temporary gardening and green experiments that promote everyday ecological practices and healthy lifestyles. Additional temporary events, promoting MIND’s biodiversity identity tangible with stakeholders, e.g., Civic Nature Exhibition, Biodiversity Ambassador Programme for MIND companies.

(Continued)

TABLE 1 (Continued)

Pilot data	Amsterdam	Bilbao	Kaunas	Lisbon	London	Milan
Key participating stakeholders	City of Amsterdam; Amsterdam Science Park management; universities and research institutes (e.g., UvA, AMOLF, Nikhef); Waag Futurelab and other cultural/creative partners; ecologists; local residents and ambassadors; student communities.	Municipality of Bilbao; students from design and architecture schools (Mondragon University; Deusto University; IED Kunsthall); grassroots organisations and civic initiatives active in Zorrotzaurre (e.g., Open Your Kolektiboa); LAND and other design/urbanism partners; local residents and users of existing spaces.	Municipality of Kaunas; Kaunas University of Technology and other higher-education institutions; local cultural operators (e.g., Kaunas 2022 - European Capital of culture legacy org); community groups around the fortress; business and innovation actors connected to the planned park.	Municipality of Almada; NOVA University Lisbon (NOVA FCSH and other units); local residents and associations (e.g., fishermen, cultural groups); artists and curators involved in residencies; T-Factor consortium partners.	London Borough of Camden/ Camden Council; HS2-related bodies; University of the Arts London (UAL) and Design Against Crime; local community organisations (e.g., Community Champions, Old Diorama Arts Centre – ODAC, Fitzrovia Youth in Action – FYA), traders and residents e.g., Our Little Markets CIC. Some established the Meanwhile Uses Working Group (MUWG).	MIND governance (e.g., Lendlease and institutional partners); Municipality of Milan; universities and research institutions located at MIND (e.g., Polifactory from Politecnico di Milano, Università Statale); social cooperatives and third-sector organisations; local youth and NEETs; design and landscape partners such as LAND.
Funding	Horizon 2020 (T-Factor, project-level); co-funding: Municipality of Amsterdam + university partners	Horizon 2020 + Bilbao Ekintza (municipal economic development agency)	Horizon 2020 + Kaunas City Municipality + KTU institutional resources	Horizon 2020 + NOVA University + Municipality of Almada	Horizon 2020 + UAL + London Borough of Camden	Horizon 2020 + Lendlease (private developer co-funding) + Politecnico di Milano
Prototype testing criteria	- Community participation rate - Ecological diversity indicators (Bioscopium data) Policy uptake (landowner meetings, municipal workshop outcomes)	- Number of inter-organisational collaborations formed - Student engagement (quantified: ~90 students, 3 universities) - Regulatory proposal submission	- Citizen inputs integrated into Development Plan documentation - Cross-generational participation level	- Community participation in museum co-creation (number of objects/stories contributed) - Podcast reach and episode completion (12-episode series) - Documentary co-production participation (school, community groups)	- MUWG influence on official regeneration decisions - Community Champions' independent adoption of workbench - Reduction of consultation redundancy	- Biodiversity mapping coverage (iNaturalist data) - Companies enrolled in Biodiversity Ambassador Programme Futurabili engagement numbers and replication rate
Sustainability and durability signals	Bioscopium infrastructure retained as permanent monitoring system; municipality green agenda influence documented; landowner policy workshop outcomes	Regulatory reform proposal submitted; university–community coalitions formalised; project methodology adopted for city planning	Temporary uses written into AIIP Development Plan — strongest institutionalisation of any T-Factor pilot; citizen imagination feeds formal planning documents	'Contos da Trafaria' podcast (12 episodes, digitally archived) and 'At Trafaria 2023' documentary (4 episodes) constitute durable community memory infrastructure; EDA (Essays and Dialogues Association) book published.	Community Workbench permanently adopted by Champions; MUWG expanded definition of 'meanwhile'; consultation synthesis methodology adopted by official regeneration process	Futurabili reaches 2nd edition with expansion to neighbouring municipalities; Herbula biodiversity data feeds MIND sustainability reporting to developer Lendlease

(Continued)

TABLE 1 (Continued)

Pilot data	Amsterdam	Bilbao	Kaunas	Lisbon	London	Milan
Strategic dimension (future city-making)	Inputs to green agenda and ecological policy for Science Park; landowner openness to ecological interventions shifted; formal policy workshop with municipality and all three landowners	T-Factor narrative adopted by Invest Bilbao to activate new city areas; regulatory framework proposal; 50-year regeneration horizon addressed via Theory of Change mapping	Strongest policy embedding; temporary uses incorporated as specific measure within the AIP Development Plan — institutionalised within formal planning instrument	Meanwhile uses function as NOVA's instrument to build community legitimacy and trust. Still, this was the weakest policy embedding of the six pilots: final evaluation explicitly flags 'Trafaia's relationship with institutional regeneration stakeholders as remaining uncertain	MUWG stabilised and expanded its remit through T-Factor engagement; community consultation synthesis fed into formal regeneration process; definition of 'meanwhile' broadened institutionally	Developer adoption: social, inclusion, and environmental priorities elevated on Lendlease's agenda; Futurabili replicated and institutionalised; Bioscopium integrated into biodiversity monitoring for planning

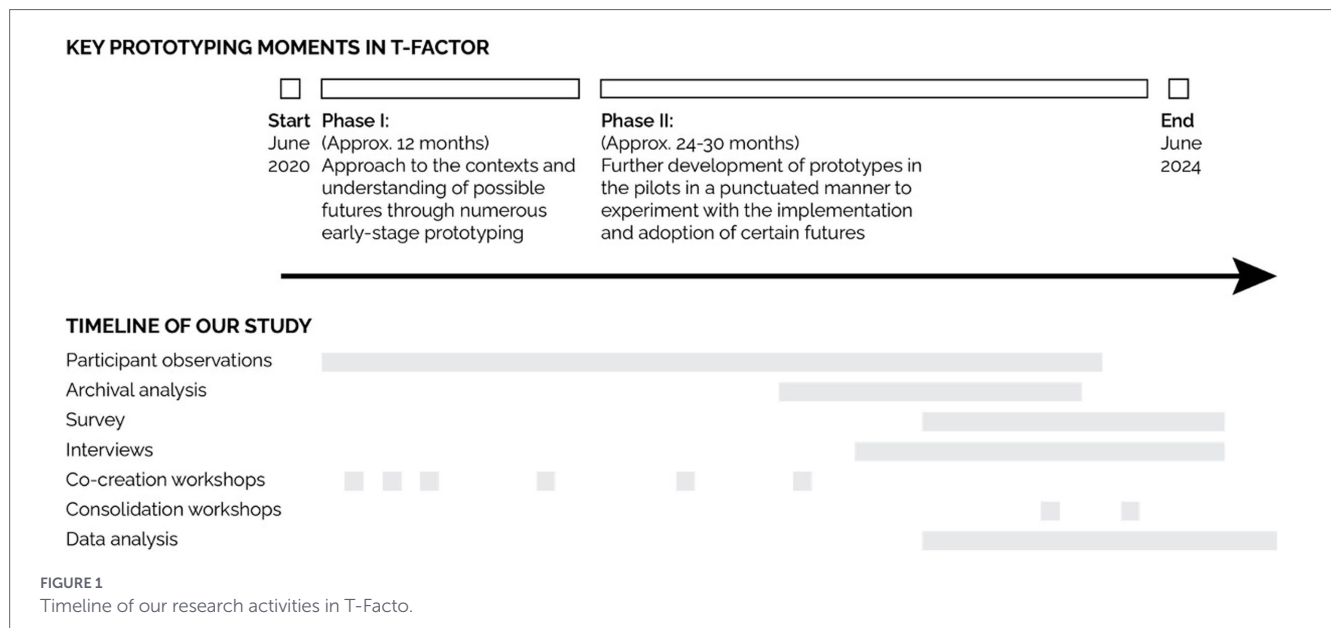
3.2 Data collection and analysis

Three research team members were directly involved in the T-Factor consortium and collected data throughout the entire project and afterwards. They organised and facilitated participatory design workshops, inviting multiple city stakeholders to think about, plan, prototype, and assess interventions in specific city districts (e.g., [Zohar et al., 2023](#)). Being internal to the project, the research team could gather data using multiple methods, including participant observations ([Czarniawska, 2012](#)), co-creation workshops in Amsterdam and Bilbao ([Alter et al., 2019](#)), and interviews with key informants ([Kumar et al., 1993](#)). [Figure 1](#) presents a timeline of the research activities in T-Factor relevant to the data collection.

We gathered and triangulated data from various sources and methods, aiming to minimise single-observation biases. The data collected in the archival analysis, participant observations, and co-creation workshops correspond to the activities run in the six pilot cities of the project. For the interviews, we included the visions of representatives from the six pilot cities and the eight advanced cases (as their hubs had been running for a longer time, their prototypes had been through more rounds of iteration). After our initial analysis, we ran two consolidation workshops to strengthen our findings and their transversal application among other locations. [Table 2](#) provides an overview of how we collected data and its use throughout the analysis.

The analysis of T-Factor's archival material allowed researchers to understand the way in which the project conceptualised and used prototyping. From the directed content analysis ([Hsieh and Shannon, 2005](#)) of the official documentation, we identified T-Factor's approach to prototyping by focusing on the definitions of prototyping that they provided and the prototyping plans of the established cities. Key analytical themes adopted to carry out the textual analysis of the archival material related to the "early exploration of futures through prototyping," "continuous and punctuated futures prototyping," and "portfolio of prototypes towards the future of the city." The results showed how the pilot cities incorporated prototyping from the early project stages and continued using it throughout the entire project. The thematic analysis ([Braun and Clarke, 2006](#)) of data stemming from participant observations of the prototyping interventions and co-creation workshops in T-Factor facilitated the elaboration of a first interpretive framework to better link prototyping and futures thinking and making in the project. At this stage, the team focused on stakeholder engagement with possible future sustainable visions and proposed actions for the city through the prototyping activities. Specifically, this analysis allowed us to formulate initial assumptions about the influence of the filtering and manifesting dimensions of prototyping on the needs of the pilots at different stages of the project. Such assumptions were contrasted and validated through semi-structured interviews and surveys ([Myers, 2013](#)). Their questions focused on gathering participants' perspectives on the influence of the prototyping activities on futures thinking and futures making processes. In addition, the team organised two additional workshops in Copenhagen and one in Malmö to further validate the findings related to the use of prototyping in futures thinking and making across locations and cases.

Aware of the political consequences of participatory futuring in the shaping and making of fair, inclusive and sustainable futures, T-Factor innovation hubs consciously reached out to underrepresented communities to partake in the prototyping activities together.



For example, for outreach and recruitment, the hubs contacted with local agents actively working with underrepresented communities. This effort provided, on the one hand, some guidelines on times and spaces that could reduce participation barriers from experts that have longed interacted with these communities. On the other hand, it facilitated access to groups and communities from a trusted source and contact point. In the activities, these groups had equal voice and power as other groups, ensuring the collection of a multitude of visions and ideas on the cities' futures. Consequently, throughout the research process, we engaged with participants representing different typologies of city stakeholders, such as government representatives, companies, citizens; the research team also ensured a good balance in terms of gender and age.

The internal position of the authors could imply a delicate situation regarding ambiguity and influence within the project activities. Following related literature on how these situations should be handled thoroughly (Clifford, 2003; O'Reilly, 2005), the team implemented three main measures to offset any potential effects of this position. First, the research team openly shared their research intentions and plans with the consortium and other participants (Rabinow et al., 2008). Second, they adhered to their facilitator role in the studied workshops and activities, avoiding influencing major project decisions. Third, two of the researchers conducted the data analysis individually to mitigate interpretative biases (Hammersley, 2006).

4 Findings

4.1 Prototyping in T-Factor

In T-Factor, the project plan conceived prototyping as a core and transversal element. As introduced in the previous section, unlike traditional design processes, in T-Factor, the local design teams started prototyping early to explore the context and engage with local communities for a participatory envisioning of the space's meanwhile uses and future uses. The pilots run prototyping initiatives throughout the

project to envision and experiment with possible uses of the urban space and some of those prototypes were iterated and became initial steps towards the making of the envisioned futures. Our interviewees agreed that the prototyping processes in T-Factor were, essentially, experiments in futures making, as they allowed the local communities to explore together and at times enact future uses of urban spaces undergoing long-term transformation in a provisional and non-binding manner. In the words of one of the interviewees:

In the case of T-Factor, these prototypes, when used, had the effect of demonstrating possible opportunities and actions that could be implemented in a different way [...]. They were really experiments with different arrangements and different resources from what a traditional 'stable' situation can offer.

The interviewees described how these early-stage prototypes - e.g., organising an art festival or building a temporary pavilion to host a community garden - were used to explore and frame problems, ideate, and, later in the process, represent possible solutions. These activities proposed ways to engage local communities in entering the urban space, interacting with it, understanding the purpose of the regeneration, and imagining possible uses for the space. The interviewees stressed that some of these activities unexpectedly clicked with the local communities, so they were iterated and replicated periodically. That is what occurred, for example, in Lisbon, where the team organised a culture festival with some activities around fado and poetry slam to generate engagement with the local communities and, due to its success and good reception among locals, it became a more permanent and stable event. Other activities were not brought forward but were particularly relevant in providing insights and ideas on engaging local communities, unfolding their expectations and needs for the future of the urban space, and presenting the project values and goals. One member of the Lisbon pilot reflected on this issue:

Also, the experiments that were not brought forward made us, and the local actors, understand something useful for the future.

TABLE 2 Data collection and analysis.

Data source	Description	Contribution to the research question
Archival analysis	We conducted a deductive qualitative content analysis of 20 key official deliverables from T-Factor, i.e., written documents describing how T-Factor's overall strategic and operational plan was envisioned, deployed, and assessed.	The textual analysis of the project deliverables confirmed T-Factor's particular approach to prototyping in complex urban projects, from early project stages and punctuated throughout the project duration, and its influence on each pilot. <i>Examples of supporting evidence:</i> Reiterated focus on prototyping activities in the pilot activity plans since the early project stages. Recurring detailed descriptions of prototyping experiments in deliverables, specifying their contribution to the project progress. Frequent references to (planned and deployed) open-ended prototyping and experiments aimed at learning about the pilots' context, co-envisioning possible futures with local actors, and exploring the functioning of possible solutions for the envisioned futures.
Participant observation	The primary source materials in the field comprised notes and around 45 design artefacts, collected over a period of 4 years. These materials were meticulously edited and compiled into a single profile document, where photographs were arranged in sequence with corresponding captions (date, caption). Notes from participant observations were analysed following a thematic analysis, and the design artefacts were organised to align with this narrative.	The themes and codes established from the data stemming from the participant observation and co-creation workshops led to the identification of initial assumptions about the influence of prototyping's filtering and manifesting dimensions at different project stages. <i>Examples of supporting evidence:</i> Data showed how, through early prototyping activities, the local teams collected concrete manifestations of local actors' desired futures. For example, the Amsterdam Science Park invited groups of young students to propose interventions in the space. Proposals such as a phone-free space or a cooking club reflected the participants' needs and wishes, serving as physical proof of concept in decision-making. At later project stages, the teams developed prototypes of solutions that were intended for the realisation of the envisioned futures and evaluated their feasibility and adoption, like in the case of Milan's <i>futurabili</i> (detailed in the Findings section).
T-Factor co-creation workshops	Six co-creation workshops (one per pilot city) engaged 92 participants (representatives of the following city stakeholders: policy makers, government organisations, urban planners and architects, local businesses, citizens, local associations) to conceive, prototype, and evaluate possible future interventions. The workshop activities invited participants to frame the local challenges, identify key communities around the hubs, plan and evaluate the prototyping interventions. Notes from direct observations and outcomes of the workshops were added to the content of our thematic analysis.	The themes and codes established from the co-creation workshops and the participant observation data led to the identification of initial assumptions on the influence of prototyping's filtering and manifesting dimensions at different project stages. <i>Examples of supporting evidence:</i> In the workshops, participants had to conceive and prototype possible interventions for the space. The outcomes from the workshops show how, through the use of tangible materials, participants materialised specific futures for their targeted context, delimiting the extensive possibilities of intervening in the space.
Interviews	35 semi-structured conversations were conducted with various stakeholders involved in city-making and contrasted with our observations and analysis. The topics of the interviews focused on the perceived influence of prototyping at the different project stages in envisioning and concretising alternative futures for urban spaces.	The textual analysis of the interview transcripts validated the impact of the filtering and manifesting dimensions of prototyping throughout different project stages in futures thinking and futures making. <i>Examples of supporting evidence:</i> The interviewees agreed that punctuated prototypes allowed for in-depth discussions on the potential and consequences of implementing concrete future visions in the local context ("[...] those prototypes could feed forward to inform more long-term provisions, so it could feed forward into a sort of a master plan, that would then be further implemented over in decades to come") Project participants also recognised in the interviews the value of early prototypes in aligning and engaging key actors in futures making ("we started to, somehow, already go through this prototyping approach so doing very quick and dirty stuff that could provide some tangibility to people, because while you remain on a very abstract layer, people of course can understand, but then you need to go really on the ground with something more tangible")

(Continued)

TABLE 2 (Continued)

Data source	Description	Contribution to the research question
Survey	63 participants in the co-creation and consolidation workshops responded to an after-workshop. Out of the 114 workshop participants, half of them responded to a voluntary survey designed to validate preliminary results related to the use of prototyping for futures thinking and making. The survey questions focused on the perceived influence of prototyping in collectively envisioning alternative futures for urban spaces.	The textual analysis of the survey responses, in combination with the interview transcripts, validated the impact of the filtering and manifesting dimensions of prototyping throughout different project stages in futures thinking and futures making. <i>Examples of supporting evidence:</i> Survey respondents highlighted the value of prototyping at early stages in discussing future possibilities for a space (“[the prototypes] helped me understand the relationships between stakeholders and more specifically it gave me a clearer idea about how the actors, stakeholders, companies create environmental impact and what potential solutions we can provide”), understanding the context (“Working on the prototype was really helpful because it was a way to make our thoughts tangible and to actually visualise all the small details which influence the system; it was a way to recognise the factors, the cause and the consequences of each flow, helping us with understanding which problem needed solving and which existing resources we’d use”) and uncovering potential solutions for the desired future (“We stepped away from the prototype we had at that point, because we found that most ideas were quite limiting. So by prototyping and visualising it out, it highlighted that there were other parts to work with.”)
Consolidation workshops	Two participatory workshops - one in Copenhagen and one in Malmö - engaged designers, architects, urban planners and citizens into prototyping activities for envisioning the future of the city. The activities were designed to consolidate our initial findings on prototyping in futures thinking and making, explicitly attending to the filtering and manifesting dimensions. The participants were asked to plan and develop prototypes for urban transformations applying the filtering and manifesting dimensions. At the end of the session, a plenary discussion was facilitated using a designed canvas with questions on the application of the dimensions. Notes from direct observations of the activities and the inputs shared through the canvas and plenary discussion were collected for our analysis.	The data collected in these workshops was analysed following a deductive content analysis, using previously identified themes and codes to consolidate our initial assumption on filtering and manifesting in futures thinking and making. <i>Examples of supporting evidence:</i> At the early prototyping activities, one of the participating groups represented in a physical model the city as a human body, with different institutions represented as “organs.” The team applied this metaphor to support their thinking and understanding of the complexity of the service functioning, as sensorially engaging with the elements of the city afforded understandings about their interdependencies and possible leverage points to intervene. During the construction of physical prototypes, the teams engaged in a process of asking critical questions on the futures they were generating, referring to the preferability and possibility of developing certain futures. These questions generated more refined versions of the prototypes.

4.2 Filtering and manifesting in T-Factor prototyping

Table 3 summarises the generalised results from our analysis of prototyping activities in T-Factor, as we found they were similar across the participating pilot cities and strongly matched with the data collected through the consolidation workshops. The table indicates how, in early project stages, the T-Factor pilots had almost endless possibilities of intervening in the targeted urban systems. In typical design processes, this is the stage when the designers start exploring the problem and thinking about possible solutions; generally, many different ideas can be pursued. The answers from the survey indicate how participants perceived the endless space of possibilities as “daunting” and “overwhelming.” At this early stage, the prototypes in all pilot cities were approached from an exploratory approach, aiming for the emergence of possible futures and the discussion of alternatives by the participants. At this point, the possibilities were countless. Yet, the filtering dimension of prototyping forced the pilots to be selective and focus on specific aspects

of the urban context, thus slightly limiting their numerous options and giving them some initial and concrete pathways to activate. In the words of one of the members of the Milan pilot:

To make things tangible and real, the problem often is that we talk about these massive challenges, but then we have no idea as citizens, as communities, on how we can begin addressing them. So in that sense, I think that prototyping is a sort of spark for things to begin to happen

The analysis of the participant observations and workshops shows that, at early stages, the pilots were aware of the complexity of the urban challenges and the need to understand a variety of elements within their urban system. Yet, they were also aware of the impossibility of fully understanding the ever-changing and multi-perspectival system dynamics of entire city districts. The filtering dimension of prototyping facilitated an initial framing of directions in futures thinking and making.

In a complementary way, the manifesting dimension compelled pilots to operationalise and implement a program of

TABLE 3 From futures thinking to futures making through early and punctuated prototyping.

Prototyping	How prototyping dimensions played out in T-Factor	Contribution to futures making
Early-stage prototyping	Filtering: The filtering dimension of prototyping facilitated the pilot teams to overcome the overwhelming, limitless possibilities of intervening in a complex urban system by forcing them to narrow their focus towards more limited possible directions for intervention.	Early-stage prototyping provided a means to strike a balance between delimiting boundless opportunities of system transformation while remaining open and working with a multitude of possible futures.
	Manifesting: Manifesting these interventions resulted in numerous quick, low-fidelity prototypes. Those initial prototypes were presented to local stakeholders, facilitating them to explore and provide feedback on potential alternatives.	Applying early-stage prototyping facilitated futures thinking as the prototypes were concrete and actionable realisations of possible futures that stakeholders could interact with (i.e., moving from futures thinking to futures making).
Punctuated prototyping in later stages	Filtering: At later stages, the filtering dimension of prototyping prompted the pilot teams to selectively focus on specific aspects of the system that required higher-level fidelity in prototyping. The prototypes became fewer, but they were more fully fledged.	Deeper and more elaborate prototypes developed throughout the project facilitated stakeholders in assessing more thoroughly the implications of the envisioned long-term interventions in the system and their future impacts.
	Manifesting: The manifesting dimensions of prototyping supported the development of more elaborate interventions in the system. Stakeholders could then, through these prototypes, get a closer experience of the initially envisioned futures and evaluate their adoption.	By prototyping more fully fledged interventions, the necessary infrastructure and network to generate the desired impact in the system were mobilised, getting some steps closer to the concrete realisation of the envisioned futures.

divergent activities to explore multiple pathways simultaneously. The pilot teams implemented large numbers of low-fidelity exploratory initiatives to quickly test and gain feedback from local actors: “[.] prototyping makes things visible: it makes the barriers visible, and it makes the politics visible to some extent as well, and then we can try and work into that.” The interviews reflect how the pilots appreciated departing from a large number of prototypes, so they did not feel prototypes were binding to only one specific future vision. Instead, they understood these initial prototypes to gather relevant knowledge on the needs and desires of the pilot context from local actors: “[Through the prototypes] we were really exploring the terrain and its qualities and issues from different perspectives.”

The case of the Amsterdam pilot provides a good example of these roles of the filtering and manifesting dimensions in early prototyping. This pilot aimed to transform the Amsterdam Science Park, focusing on contributing to the development of its “socio-technical (ecological) infrastructure” (T-Factor, 2024). Initially, the team did not settle for a specific vision of the future use of the urban space but rather adopted a multidirectional approach. They deployed more than 15 fast and uncomplicated prototypes, i.e., exploratory initiatives that would give them a chance to quickly probe multiple types of infrastructure, from prompt events to permanent community spaces. Examples of these initiatives were the establishment of a mini hortus (greenhouse), a maker space for building animal shelters, and a temporary chill-out and phone-free area (Figure 2). These initiatives could eventually become part of the permanent infrastructure supporting ecology in the park. However, these prototypes

were much more valuable for the pilot team because of the insights they generated. For example, the maker space for animal shelters allowed participants to engage with the area and better understand non-human presence, their relationship with the area, as well as their needs, so they could (and were willing to) contribute to envisioning the park’s future socio-technical (ecological) infrastructure. As one of the organisers voiced:

In the first series of events, we focused on meeting a landscape and its [human and more-than-human] inhabitants in a different way and taking different positions. From these different perceptions and experiences, you start to think differently. And then, once you’re there, you want to act differently. The outcomes of these interventions allowed people to really also move, behave, make, co-create in a way that was different from before.

Our workshops in Copenhagen and Malmö confirmed our understanding of how the filtering and manifesting dimensions of prototyping at early stages facilitate what could be perceived as a creative “blockage” at the beginning of a complex urban design process. Participants were encouraged to apply prototyping to explore the challenge faced when presented with a complex urban transformation brief, and, in their subsequent reflections, they stressed the value of materialisation when addressing complexity. Several participants pointed out that, typically, the end result of urban design processes is not predefined or bounded, like in the case of designing, for example, a chair (where the designer has a clear end goal); with urban design, since the context of intervention is so complex to elaborate, envisioning, testing and deploying possible solutions is a task that the participants perceived as “intimidating” or “overwhelming.” 82.5% of the workshop participants agreed that the use of early-stage prototyping for exploring the challenge supported the initial exploration of the context, making it more manageable and approachable due to the materialisation of

2 We define ‘infrastructure’ as per definition given to the term by T-Factor, that is: the physical and theoretical installations, facilities, and frameworks supporting the services and systems associated to the local innovation hubs of the pilot cities.



FIGURE 2

Prototyping activities during the pilot exercise in Amsterdam. Credits: Stella Zoe Schimdtler (left) and LAND research lab (right).

specific aspects of the urban spaces they targeted. The results also showed a positive impact of the early-stage prototyping in understanding the multiple interdependencies among all the stakeholders involved and in representing the design space as an intricate configuration of systemic properties (e.g., the often conflicting needs and wants of the various city stakeholders, the hidden and overt alliances behind a specific city policy, etc.). In the words of one of the participants:

We had a better understanding of the whole system behind the challenge that we were targeting. We also broadened our perspective and had a more holistic vision of the stakeholders involved. By doing this, we could decide which area of the whole system was more interesting to work with.

Paradoxically, the dimensions of filtering and manifesting tied to prototyping forced the T-Factor pilots to simultaneously (1) limit and confine their initial search of directions for the future of the urban context and (2) explore multiple and divergent directions at once so as to accommodate the conflictual views of the stakeholders (“you could use prototyping to tease out moments of friction, but also to really align on those things”). When combined, these two dimensions of prototyping helped the pilots strike a balance between delimiting the boundless opportunities of transforming urban spaces and embracing uncertainty and surprise.

4.3 Filtering and manifesting of punctuated prototyping in T-Factor

The T-Factor pilots used what they had learned from the early-stage interventions to concretise and periodically assess and reassess their prototypes (Table 3). One of the interviewees explicitly referred to the iterative nature of the process:

Of course, we have our own ideas. But, I mean, the problem is immense and we are just some people and not representative of the challenges and needs that may be in a specific context, so prototyping really worked to test these assumptions and explore people's interest and possible interventions, and based on that, in a second iteration, go deeper into what we thought could work more.

At later stages of the design process, the pilots reduced the number of prototypes. Prototypes started to be conceived less as a means for triggering dialogues, ideas, and possibilities, and more for providing participants with a sensorial experience an understanding of how possible futures might take place in their urban space. The filtering dimension of prototyping drove the pilots to select the specific initiatives that needed to be prototyped at a higher level of fidelity. Through the manifesting dimension, certain initiatives and infrastructure were materialised in the system, crafting the envisioned futures so pilots could test them in the context.

While these results could be observed across pilots, we will use the pilot of Milan as an example. Early-stage prototypes in Milan signalled the need for more meaningful exchanges between the local community and the companies settled in the area under transformation. The project reports indicate that the local young community was particularly vulnerable in the area, struggling to access the job market. The local design team decided to set up “futurabili”,³ an experimental career orientation program in which a local company, supported by a social organisation, offered a series of training experiences for young locals focused on professions for the future in the areas of AI, new materials, rapid prototyping, and Industry 4.0. This initiative was prototyped over time, going through several iterations that built upon the insights and feedback generated from previous ones. At these later stages, the filtering dimension of prototyping forced pilots to attentively select essential aspects of the envisioned future to be tested. In the Milan pilot, some of these aspects included the recruitment of companies offering the training program, the selection process of the young trainees, as well as the definition of the curriculum. Also, some of the four areas initially selected were prioritised, according to the observed demand and availability of both companies and trainees in the initial prototypes.

The manifesting dimension of prototyping encouraged the materialisation of those aspects as almost fully-fledged initiatives so that they could be assessed at a finer level of granularity. In the case of Milan, the training program was, among other aspects, one that could contribute to their envisioned future – namely, “building a shared identity for the district and fostering its accessibility through osmosis

³ <https://mind.t-factor.eu/futurabili-community-house/>

between internal and local realities” (see [T-Factor, 2024](#)). By filtering this aspect and manifesting it in a prototype, the envisioned future became more tangible in all its multidimensionality, allowing the local community and decision-makers to experience its impact and potential in the area.

4.4 Other important considerations about prototyping in futures making from T-Factor

Despite the perceived benefits of applying prototyping for future thinking, T-Factor innovation hubs also acknowledged some difficulties when implementing this type of prototyping initiatives. The most frequently mentioned issue was related to the availability of resources, specifically the budget and time required to develop all these prototypes. Some teams reported that some insights obtained from prototyping activities could not be tested or implemented due to a lack of time. Others agreed that the budget limitation severely constrained some of their prototyping ideas, which had to be downsized in relation to number of participants or scale. Another issue that arose in the interviews was participation fatigue. In long-lasting projects involving local actors and communities, inviting them to participate in continuous prototyping activities can drain their motivation and limit their willingness to join. Related to participation, some pilots also struggled with the inclusion of certain groups, due to either accessibility or availability of the group. In other cases, the pilot teams prepared separated activities for citizens and local organisations and, at different moments, for decision-makers, so that the power dynamics would not compromise the emergence of ideas and perspectives. However, as some pilot teams noticed, this strategy prevented the generation of rich discussions and negotiations. A more detailed description of the tensions and contrasting opinions emerging in the participatory prototyping activities of T-Factor can be found in [Vitalter del Olmo et al. \(2025\)](#).

5 Discussion

The empirical evidence indicated that the prototyping dimensions of filtering and manifesting contribute differently to futures making depending on whether prototyping is undertaken in earlier or later stages of the studied urban transformation processes. Our findings answer the need to move beyond those forms of futures thinking that remain speculative and abstract ([Buehring and Bishop, 2020](#)) and encourage organisations to embrace complexity and treat uncertainty as a resource ([Bühring and Liedtka, 2018](#); [Cagnin, 2018](#)). In line with the work of [Liedtka et al. \(2024\)](#), our case study showcases the effect of early-stage prototyping in uncertain processes: while their work focuses on risk avoidance and cost-reduction in innovative processes, the T-Factor case reflects on the effect of early-stage prototyping for stakeholders to envision and build infrastructure for the future of urban systems. Promoting the active engagement of citizens in imagining and materialising sustainable futures may contribute to address the resistance to in-built urban spaces or, in [Hommels \(2000\)](#) words, the “obduracy” in cities.

In particular, our research evidences how the filtering and manifesting dimensions of prototyping, traditionally studied in the human-computer interaction field ([Lim et al., 2008](#)), can contribute to futures making by leveraging prototyping’s “materialising” nature ([Tschang et al., 2022](#)). The initial prototypes do not need to be high-fidelity or costly; rather, their value lies in their capacity to embody multiple,

even competing, design directions in a provisional and sketch-like manner, which facilitates a preliminary restriction of the immense possibilities of action in the urban space. Such rough and speculative representations help keep the design space open and inclusive, especially in the face of complex urban sustainability challenges. The deliberately unfinished nature of early-stage prototypes invites collaborative imagination, reflection, and collaboration. When prototypes are perceived as rough and open-ended, they encourage stakeholders to see them not as final answers but as vehicles for collaborative imagination and exploratory and democratic engagement with possible futures. While the prototypes resemble speculative probes ([Dunne and Raby, 2013](#)) or artefacts for design research ([Gaver, 2012](#)), with the intention of engaging participants in conversations about possible futures through sensorial materials, prototypes in T-Factor had an enhancing effect of the problem: beyond defining what needed to be addressed, prototypes were conceived as early explorations of materialised solutions towards desired futures.

A punctuated prototyping approach—where multiple iterations were developed throughout the process—enabled a more granular exploration of the solution space and fostered adaptive responses to emerging insights. Through the manifesting dimension of prototypes, the solutions became more concrete and tangible, facilitating the evaluation first of the concept, and, over time, of specific nuances and details of the solutions. Prototyping from earlier to later stages in urban transformation processes can support stakeholders in collaboratively understanding the context, envisioning an array of possible futures, and ultimately building the infrastructure and options needed to enact them. In other words, the development of prototypes facilitates the making of envisioned urban sustainable futures, as they gain in complexity and integrate into existing systems and networks.

The case of T-Factor shows how the filtering and manifesting dimensions of prototyping impacted the pilot teams’ work since early stages of the process, generating tangible externalisations for performing possible urban futures, so that multiple actors could experience, engage, and negotiate these futures ([Evans et al., 2016](#); [Leminen et al., 2021](#)). This capability of prototypes facilitated the pilots’ teams to address some common barriers identified in establishing innovative policies and actions for sustainable urban innovation, such as the inclusion of a greater diversity of actors in decision-making processes ([Evans et al., 2025](#); [Mahmoud et al., 2021](#); [Stroink, 2020](#)) or the alignment of citizens’ and government expectations ([Haarbosch et al., 2021](#)). In later stages, the teams iterated on some of the initial prototypes, developing artefacts and infrastructure that progressively resembled the envisioned urban futures. Prototyping allowed the local teams to simultaneously “build” and “dwell in” futures ([Comi and Whyte, 2018](#)). These results invite us to reflect on the influence of prototyping in another cluster of critical barriers in urban innovation processes related to the implementation and upscaling of mechanisms in the present that lead to the envisioned sustainable futures in the long term ([Evans et al., 2025](#); [Plassnig et al., 2022](#); [Ceschin and Gaziulusoy, 2016](#)). Our work also contributes to existing studies linking the effects of design methods and processes in complex processes addressing sustainability (e.g., [Rogers et al., 2023](#); [Cristiano et al., 2020](#)); our insights also connect with research calling for a toolbox encompassing futuring techniques that, considering their influence in policy-making, could ensure diversity of participation and equitable power dynamics ([Oomen et al., 2022](#); [Mangnus et al., 2021](#)). The fine-grained understanding of the mechanisms behind prototyping of our study

extends the work of scholars that argue for the value of artefacts (and the practices they afford) in generating more precise and actionable blueprints in futures making (Comi and Whyte, 2018; Whyte et al., 2022; Wenzel, 2022; Van den Eijnden et al., 2022). The T-Factor local innovation hubs described in the paper may serve as a reference for future urban innovation processes targeting sustainability and methodologically guide the application of prototyping for futures making. By adopting the dual lenses of filtering and manifesting, practitioners can facilitate groups of citizens, experts, and decision-makers engaging with complexity in a way that highlights certain aspects while temporarily setting others aside—thereby easing the material experience of potential urban futures and contributing to decision-making processes on intricate urban policies and interventions.

Existing research mostly confined prototyping to later phases of design and innovation processes (Brown, 2009; Martin, 2009). Our study suggests that prototyping can be a more continuous activity, starting early in the process and continuing in later phases with some regularity. The continuous engagement with this practice makes it resemble “craft,” whereby thinking about the future is interwoven with visualising and materialising activities. Viewing this process as a craft integrates existing literature (Durante et al., 2024) and shows how forms of futures thinking grounded within local urban contexts and their socio-material intricacies correspond to futures making.

Despite the rich empirical material and the practical contributions produced by this research, the current study presents some limitations. The external validity and generalisability of the results may rise concerns about the extent to which these results can be transferred to other settings, geographical contexts, or academic domains. After all, case studies are inherently context-specific, and the unique characteristics of our case may limit the applicability of the findings to dissimilar environments. Additionally, the limited timeframe of the T-Factor project may have prevented us to capture longer-term development of the prototyping initiatives that were incorporated into existing urban systems. To externally validate our constructs, we collected data via multiple data sources and sought to develop a solid understanding of the results obtained from the single case study; beyond interviews we carried out surveys with the stakeholders engaged in the implementation of the prototyping activities and observed the interactions among workshop participants.

6 Concluding remarks and future research avenues

In an era of volatile, uncertain, complex, and ambiguous urban environments, a systemic consideration of long-term possibilities and future development is imperative. Our paper presents, through the case study of T-Factor local innovation hubs, the potential of prototyping to activate and mobilise collective imagination and creativity in realising desired urban futures. Traditionally, some design and design thinking methods have been leveraged for their capacity to engage participants in processes of urban transformation. However, research has shown how some of these actions may be limited in terms of implementing and constructing envisioned sustainable futures. Prototyping may be a valuable design method to leverage upon for the

concrete making of futures; because prototyping inherently focuses on the materialisation (or manifestation) of specific (filtered) elements of potential futures, it may facilitate collaborative processes that will shift abstract visions of futures into tangible realisations.

Our research suggests that, when prototyping in future-oriented design processes, practitioners could follow these recommendations:

- Start prototyping in the early stages of future-oriented design processes: these prototypes do not need to be expensive or high-fidelity; they do not have to fully represent the final solution. Rather, they can represent and materialise a collection of different and competing design directions in a preliminary and imperfect way.
- Adopt a continuous – or, in our words, “punctuated” – prototyping approach, where multiple prototypes are developed throughout the entire design process. Continuous prototyping is what allows managers and practitioners to understand the problem space and assess potential solutions at a much more fine-grained level.
- Avoid oversimplification. Filtering and manifesting are lenses that enable us to look at the problem and possible solutions from a paradoxical perspective that simultaneously filters out and manifests some key aspects of this complexity; they constitute processes that help elaborate complexity without oversimplifying it.
- ‘Keep it rough’. The incompleteness and openness of early-stage prototypes organically fuel the imagination and stimulates futures thinking of actors interacting with your prototypes. If the prototypes look too polished, participants may perceive the proposed future as imposed and immutable, missing their potential as a form of inquiry to prompt ideas, reflections, and questions.

The limitations of this study present potential avenues for research. Future studies could benefit from conducting longitudinal multiple case studies across different contexts beyond those described in our case, such as long-established governmental institutions, innovation-oriented start-ups and other geographic and cultural contexts. While revealing how futures making practices may lead to the development of envisioned futures, in the future, scholarly attention could be directed towards examining how different types of envisioned futures could be “made” through these practices. We also encourage researchers to build on our results and further explore specific prototyping tools and methods for urban interventions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because the data collected in the study was not nominative or referred to specific individuals, but to the impact that a specific methodology generated in the process of urban innovation. The studies

were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any identifiable images or data included in this article.

Author contributions

MVO: Conceptualization, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. LS: Conceptualization, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. BD'I: Conceptualization, Writing – original draft, Writing – review & editing. AG: Investigation, Writing – review & editing. NM: Investigation, Writing – review & editing.

Funding

The author(s) declared that financial support was received for this work and/or its publication. Part of the research activities studied in this article have been conducted under the funding of the European research and innovation project T-Factor. T-Factor was included under the topic H2020-SC5-2018-2019-2020 - Greening the economy in line with the Sustainable Development Goals and with the project ID 868887. The claims and conclusions expressed in this article are however solely those of the authors and do not necessarily represent those of the European Union nor the T-Factor consortium.

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Conflict of interest

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