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Enhancing Citizen Participation in Citizen-Centered Smart Cities: Insights from Two European Case Studies

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Abstract: Citizen participation plays a critical role in the transformation towards citizen-centered smart cities, ensuring resilience, inclusivity, and responsiveness to community needs. Smart cities, while often associated with technological infrastructures and digital tools, also adopt a human-cepntered perspective that emphasizes the social and participatory dimensions of smart urban development. Engaging residents in these initiatives not only facilitates the acquisition of valuable insights but also strengthens the foundation for equitable urban development. However, the participatory process often encounters significant barriers that hinder its effectiveness, posing challenges to the creation of truly inclusive and citizen-centered smart cities. This paper analyzes the participatory processes and outcomes of two case studies, URBANAGE and drOp, both of which follow a Human-Centered Design approach and have implemented targeted actions to address participation challenges. This article explains the methodologies and processes followed in these projects and identifies key lessons learnt from their experiences and examining the impact of participatory processes on project outcomes. Lastly, it proposes practical guidelines to enhance the effectiveness of citizen involvement in future smart city initiatives. Despite their focus on different citizen groups and objectives, both case studies faced similar obstacles in fostering meaningful participation and awareness.

Keywords: human-centered design; participation; engagement; smart cities; co-creation; citizen

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1. Introduction

Definitions of smart cities in scientific literature often focus on the role of information and communication technologies (ICTs). However, this heavy reliance on technology brings about the challenge of the digital divide, as it assumes that smart city residents possess a high level of technological literacy [1]. While smart cities are frequently associated with digital technologies, such as the collection of sensor data [2], their "smart" attributes also include broader concepts like awareness and self-sufficiency [3]. Consequently, a more human-centered perspective on smart cities is gaining traction [4], one that highlights the social dimensions of urban life and prioritizes the role of citizens at the core of smart city development [5]. This creates a more responsive city, complementing technological aspects with the city's capacity to listen, adapt, and co-evolve with its citizens through continuous feedback loops, participatory processes, and inclusive decision-making [6].

According to a perspective outlined in Cities and Citizens in 2033 [7], an intelligent city can be described as a smart ecosystem where individual intelligence extends beyond personal boundaries, permeating the entire urban community to enhance overall quality of life. This definition emphasizes the role of the community, not merely as a large group of service users and a source of data crucial to technological advancements, but as empowered individuals actively participating in the co-creation of the city they envision and require [8].

Citizen-centered cities are urban environments designed to prioritize the needs, aspirations, and well-being of their inhabitants, placing citizens at the core of decision-making and development processes [5]. Focusing on social well-being is a fundamental goal of citizen-centered cities, which aim to improve quality of life, well-being, and satisfaction in urban settings by designing spaces and solutions both for and with the people who live in or pass through them [9]. The creation of citizen-centered cities can be facilitated through participatory initiatives that promote active citizen participation. These initiatives provide significant benefits for individuals, communities, and authorities, such as adopting multi-directional problem-solving approaches, fostering community empowerment, strengthening social cohesion, building resilient communities, raising awareness, increasing accountability, encouraging inclusivity and diversity, and fostering innovative ideas (e.g., [5,10]) since they involve citizens all along the initiatives.

These cities are based on principles such as inclusivity, ensuring access to resources and opportunities for all residents regardless of background; sustainability, balancing economic growth with environmental stewardship to support long-term resilience, participatory governance, involving citizens in shaping policies and urban planning through co-creation and dialogue, and Human-Centered Design (HCD), making them adaptable to diverse needs of the community. By integrating these principles, citizen-centered cities strive to empower communities, build trust, and create vibrant, livable spaces that reflect the collective vision of their inhabitants.

However, implementing citizen participation initiatives is not without challenges. These processes often encounter internal and external barriers that can hinder their effectiveness. The main participation barriers identified in the literature include ensuring representativeness, addressing expertise gaps, mitigating political interference, managing power dynamics, overcoming time constraints, dealing with limited resources, and effectively leveraging technology [11–14]. These barriers often limit the success of a participatory process and while each of these barriers presents unique challenges, understanding them individually provides greater insight into how they limit participation and how they might be addressed. Representativeness is a challenge, as ensuring diverse and informed participation that reflects the entire community is difficult [13,15,16]. The expertise gap limits citizen contributions, as many lack the technical knowledge required for urban planning [12]. Political interference and a lack of systematic frameworks undermine genuine engagement and the collection of citizen input [16]. Power structures and institutional complexities create mistrust, reduce transparency, and hinder participation [10,16]. Time constraints and competing commitments make it hard for residents to engage actively [15]. Limited resources exacerbate disparities, with disadvantaged communities struggling to participate effectively [15]. Finally, a technology-first mindset prioritizes existing solutions over citizen-driven approaches, complicating data collection and integration [11,15].

Given the multifaceted nature of participation barriers, analyzing and evaluating these processes is essential for understanding their effectiveness. This analysis provides a critical feedback loop for policymakers, project designers, and urban planners, helping them refine participation frameworks to overcome these barriers. By examining both the processes and their outcomes, valuable insights can be gained to improve future participation initiatives and better align them with the needs and aspirations of communities. In this context, the

study aims to explore two case studies that have tried to overcome the barriers of citizen participation through an HCD approach, by introducing how HCD can effectively address these barriers, offering a framework to foster greater citizen engagement and contribute to the creation of citizen-centered smart cities.

HCD provides an approach where the user, or in this case the citizen, becomes the central aspect of the process and its principal goal is to develop solutions that cater to their needs [17]. It is founded by five main principles [18]: understanding of people and environments, involvement of people through the process, user-centered evaluation, iteration, and multi-disciplinary skills. Understanding of people and environments focuses on empathizing and comprehending citizens' behaviors, needs, and contexts to ensure solutions are meaningful and relevant. The involvement of people through the process, fostered by collaborative and co-creation methodologies, emphasizes active citizen participation at every stage of design and decision-making. User-centered evaluation prioritizes iterative testing and feedback from citizens, ensuring that the solutions align closely with their needs. Iteration underlines the importance of refining solutions through repeated cycles of testing, feedback, and improvement, while respecting the timelines and resources available. Lastly, multi-disciplinary skills bring together diverse expertise and cross-domain interactions to address complex challenges from diverse perspectives and create comprehensive, citizen-centered solutions. By following these five main principles, every process creates solutions tailored to the community and their real needs, while also enabling the overcoming of barriers that hinder citizen participation [17].

Regarding participation barriers, the HCD approach's focus on inclusivity ensures that representativeness is prioritized, using methods to engage diverse community members and amplify the voices of underrepresented groups. Through its emphasis on empathy and co-creation, HCD bridges expertise gaps by enabling non-technical participants to contribute meaningfully, often translating complex concepts into accessible formats. The iterative and collaborative nature of HCD mitigates the effects of political interference and power imbalances by fostering transparency, trust, and shared ownership of the process. Additionally, HCD accommodates time and resource constraints by tailoring engagement methods to fit the realities of participants' lives, ensuring flexible and adaptable processes. Unlike a technology-first approach, HCD integrates technology as a tool rather than the driver, enabling solutions to emerge from citizen-driven insights and ensuring these tools support rather than hinder participation.

Considering this context, the primary objectives of this research are as follows:

- Objective 1: explore how HCD applies specifically to citizen participation in different smart city contexts.
- Objective 2: examine two case studies to examine the practical outcomes of such an application.

2. Materials and Methods

This study focuses on a qualitative perspective that includes the conduct of a descriptive–analytical method to collect and analyze data from two case studies [19] financed by Horizon Europe: URBANAGE and drOp. These two processes aim to regenerate neighborhoods by improving the quality of life of their citizens. Central to these case studies is a participatory approach, where citizens are not only beneficiaries but also active stakeholders in the regeneration process. Both processes emphasize co-creation among stakeholders, ensuring that solutions are developed collaboratively. The study examines how these case studies apply an HCD approach, examining the methodologies used, the challenges faced, and the outcomes achieved. Each case was independently examined and analyzed to gain a comprehensive understanding of the participatory processes in-

volved. The methodological approach facilitated a detailed and exhaustive description of the cases, providing insight into the context and highlighting the particular characteristics of each case. Such an approach proved valuable for identifying challenges common to both phenomena and for assessing the applicability of this methodology across different cases.

2.1. Methodological Process

The methodological process followed in this study was structured in a sequence of four steps, as shown in Figure 1. It began with the definition of the study phenomena, establishing the thematic scope and research questions for both cases. This was followed by a detailed description of the two case studies, URBANAGE and drOp, focusing on their goals, implementation strategies, and outcomes. The two case studies were purposively selected for their citizen-centered approach to smart cities through a shared HCD framework, applied in contrasting contexts: one focusing on a digital tool for inclusive urban planning, the other on a methodology for renovating social neighborhoods, allowing for analysis of the framework's adaptability, scalability, and conceptual robustness. The results were then analyzed to identify commonalities and differences, extracting meaningful lessons from both cases. Finally, the findings were synthesized to draw broader conclusions, assess the methodology's validity, and propose directions for future research.

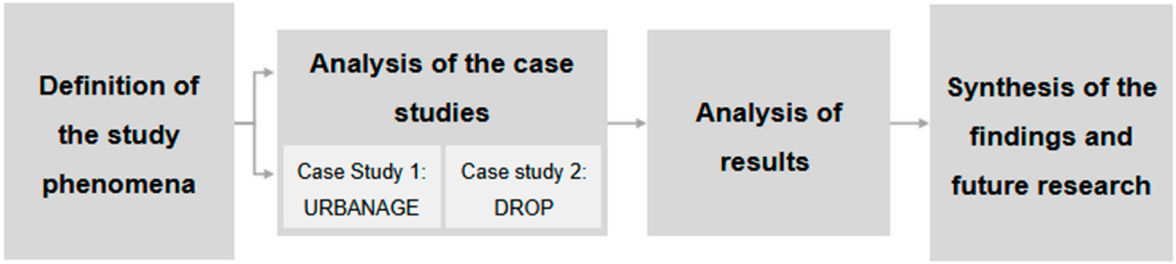

Figure 1. Methodological approach of the study.

2.2. Sample of the Study

In both projects, the sample of participants considered for analysis includes citizens who were part of the core working group, as well as civil servants from the respective municipal governments. Regarding the working groups of citizens, Figure 2 presents the demographic characteristics of each group.

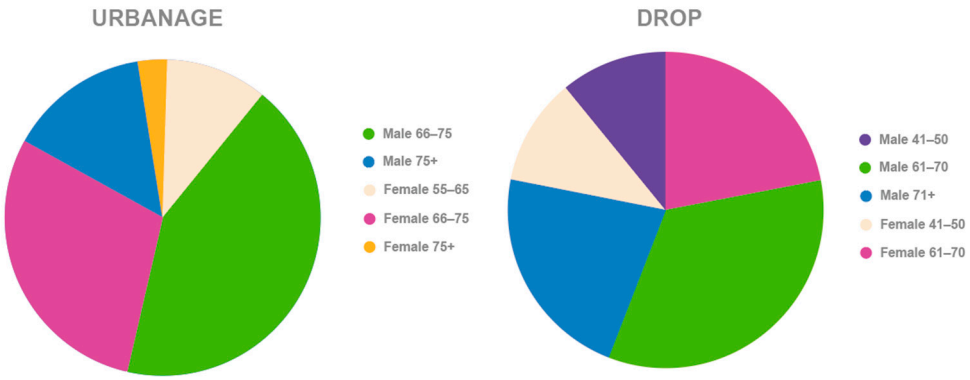

Figure 2. Citizen sample of both case studies.

2.3. Data Collection Methods

Understanding complex social phenomena requires both contextual depth and the voices of those directly involved. This study employs a qualitative methodological ap-

proach that combines three primary methods for data collection: a documental analysis, participatory observation and semi-structured interviews.

- Documental analysis: The documental analysis offers a comprehensive review of the literature, relevant reports, policy documents, and other written materials relevant to the cases under examination [20]. This method allows for the identification of key themes, and frameworks that shape the participatory processes under study. In this study, documental analysis was employed to examine the available documentation related to both processes. This approach allowed for a systematic and in-depth exploration of existing records, providing insights into the structure, development, and outcomes of each process.
- Participatory observation: Participatory observation is a method where the research team actively engages with the participants while simultaneously observing their interactions and behavior [21]. In this case, this method is used in the participatory workshops held in both projects to interact with and better understand participants and their demands.
- Semi-structured interviews: Semi-structured interviews were conducted with a range of key stakeholders, including practitioners, decision-makers, and community representatives. This approach was chosen to elicit in-depth, nuanced accounts that reflect diverse perspectives and firsthand insights [22]. Specifically, the interviews in both projects were conducted with both citizens and civil servants with the aim of evaluating their experience in the participatory process and its outcomes.

Together, these methods enable a rich and multidimensional understanding of the participatory mechanisms and their implications in practice [23]. This provides a robust foundation for assessing barriers to participation and strategies for enhancing citizen engagement in participatory initiatives.

2.4. Data Analysis

The collected data were analyzed using a thematic analysis approach, a widely used method in qualitative research that facilitates the identification, organization, and interpretation of patterns of meaning across a dataset [24]. This process entailed a systematic coding of qualitative data derived from the documentary sources, observation data and the interview transcripts to identify key themes and patterns related to the participatory processes. Particular attention was given to comparing and contrasting the two selected cases, with the aim of uncovering not only shared challenges and enabling factors but also case-specific dynamics that reflect contextual particularities. Through this comparative lens, the analysis sought to identify common barriers, emerging best practices, and innovative or unique approaches embedded in each participatory initiative. To enhance the credibility and rigor of the findings, triangulation was employed, cross validating the findings from documentary analysis, observation and interviews. This methodological strategy contributed to a more nuanced and trustworthy account of the participatory processes, grounded in both textual evidence and stakeholder perspectives.

3. Results

This section describes both case studies, highlighting the HCD process as key in overcoming participation barriers, outlining the actions taken in both of them as well as the results obtained.

3.1. Case Study Overview: URBANAGE & drOp

Both analyzed case studies employ a shared approach, prioritizing the involvement of their target groups at the core of the co-creation process. This method enables the effective

allocation of resources, positioning the needs and concerns of the target audience at the forefront of the decision-making process.

URBANAGE aims to empower urban planners and policymakers to leverage innovative technologies in order to make more inclusive and data-driven decisions. This initiative seeks to cultivate the development of age-friendly cities by introducing a co-created decision-support ecosystem, which brings together key stakeholders, including public officials and end-users, particularly older adults. Through this collaborative process, URBANAGE has developed specialized tools rooted in cutting-edge technologies, tailored to the needs of Santander City in Spain.

Two innovative tools have been co-created and implemented in Santander as a result of the URBANAGE project. The first tool is an age-friendly route planner, specifically designed to cater to the needs of older adults. The second tool is a simulation platform for long-term urban planning, intended for civil servants. These tools exemplify the project's commitment to fostering inclusive and responsive urban planning practices.

The second case study discussed in this paper is drOp. The primary objective of drOp is to create an Integrated Renovation Methodology (IRM) designed to convert social housing districts into inclusive, smart neighborhoods. To accomplish this, the project adopts a human-centered approach and integrates advanced technologies to foster economic growth. This methodology is being implemented in a pilot case within the Santa Ana neighborhood of Ermua, Spain.

As an outcome of drOp, seven distinct initiatives have been developed in co-creation with citizens and are currently in the process of implementation. These initiatives are designed to contribute to the regeneration of the neighborhood through the enhancement of urban spaces, the strengthening of community ties, the promotion of economic development, and the advancement of social innovation, among other objectives.

This section gives an overview of both case studies (see Table 1), while the following sections explain each case in detail.

Table 1. Overview of the case studies.

	URBANAGE	**drOp**
General objective of the project	Assess the potential benefits, risks and impacts of implementing a long-term sustainable framework for data-driven decision-making in the field of urban planning for ageing well in cities	Design an integrated renovation methodology aimed at transforming neighborhoods through the combination of social innovation and local economic development
Duration of the project	February 2021–January 2024	October 2022–September 2025
Aim of the participatory process	Identify the needs and requirements of older people to use the city services and spaces and the challenges and the barriers civil servants find to reply to them	Identify the specific needs of the neighborhood and collaboratively co-create diverse solutions with its residents
Target audience	Older adults & civil servants	Entire neighborhood
Scale	City	Neighborhood
Geographical location	Santander	Santa Ana, Ermua
Results of the participatory process	The participatory process resulted in identifying the digital tools that could be useful for older adults in their daily lives and for civil servants to better plan age-friendly cities.	The participatory process resulted in the development and implementation of different initiatives

Both case studies follow an HCD approach. The main focus of the HCD approach is to engage users and stakeholders in the creation of solutions that address user needs while remaining practical and viable in the market [25]. This approach prioritizes designing products, services, spaces, or systems that genuinely respond to the preferences and needs of their target users, following four main stages (see Figure 3): understand, define, create and evaluate [17]. The process ultimately results in outcomes that are meaningful, effective, and feasible, aligning with user requirements. Each stage is divided into divergent and convergent sub-steps, where activities are guided by a human-centered perspective while accounting for real-world constraints such as time and resources [26].

Figure 3. Phases of an HCD process.

Building on this process, the following sections examine each phase of the two case studies, detailing the steps undertaken and the key outcomes associated with each stage.

3.2. Phase 1: Understand

In the Understand stage, the emphasis lies in developing a grounded comprehension of the problem, the needs of the users, and the broader context in which the project unfolds. This involves careful exploration of stakeholders and communication strategies to ensure that the participatory process is inclusive, transparent, and meaningful from the outset. In the two case studies presented here, this phase was shaped by distinct but complementary approaches: in URBANAGE, it entailed identifying and mapping relevant stakeholders to support the design of age-friendly urban policies, while in drOp, it focused on establishing clear, accessible communication to facilitate residents' understanding and engagement. This section details the evaluation activities conducted during this phase in both cases and presents the main findings.

3.2.1. URBANAGE: Preparing the Participatory Process

This initial stage of URBANAGE laid the groundwork for subsequent focus group discussions and co-creation activities with end-users by establishing a comprehensive understanding of the relevant stakeholders for a project such as URBANAGE. It focused on identifying both those who can influence or contribute to the project and those whose needs and perspectives should be considered in the design and implementation of age-friendly urban policies.

URBANAGE targeted two main stakeholder groups: older adults and civil servants. To ensure inclusivity, older adult participants needed to reflect the diversity of ageing populations, considering factors such as age, gender, ability, digital literacy, socio-economic status, and, where applicable, race and ethnicity. For the civil servant group, representation across the domains outlined in the Global Age-Friendly Cities: A Guide was essential. This included professionals in urban planning, particularly those involved in outdoor environments, housing, and transport, as well as public servants in departments traditionally linked to older citizens, such as social services. Although the latter may not directly influence planning decisions, they provide essential insights into older adults' needs. Departments responsible for communication, citizen engagement, and information were also key, given their role in ensuring participatory and informed processes.

As a result, a stakeholder mapping was created. This stakeholder mapping process not only clarified the categories of actors to involve but also supported pilot sites in identifying the individuals and institutions most relevant to achieving URBANAGE's objectives. As an initial outcome, the mapping served as a strategic resource to guide inclusive engagement throughout the project's development.

3.2.2. drOp: Communicating the Participatory Process

This initial phase of drOp focused on ensuring effective and accessible communication with participants to support their meaningful involvement in the project. Recognizing that residents are experts in their lived experiences but may lack technical knowledge, the process prioritized clarity and inclusion. Planners and designers facilitated understanding by avoiding technical jargon and using diagrams, visuals, and illustrations to present the project's scope and potential outcomes in a comprehensible way.

To maintain transparency and engagement throughout the process, key decisions and updates were communicated through infographics distributed as printed pamphlets and displayed in the neighborhood office. These visual tools helped simplify complex content and foster a consistent flow of information with the community.

Additionally, AI-generated images depicting the neighborhood under various future scenarios—such as increased green spaces or the integration of smart technologies—supported residents in visualizing the implications of different planning decisions. By making the abstract tangible, these images enabled participants to better understand and contribute to shaping the project's direction.

As a result, the Understand phase effectively bridged the expertise gap between professionals and residents, enabling a more inclusive and informed participation process. Through accessible communication and visualization tools, participants were empowered to engage with the project from the outset, co-creating a shared vision for the future of their neighborhood.

3.3. Phase 2: Define

In the Define stage, the focus shifts to synthesizing the insights gathered during the initial phase in order to clearly frame the challenge and structure the participatory process. In the two case studies discussed here, this phase was approached through complementary strategies: in URBANAGE, it involved conducting focus groups to explore the barriers and motivations influencing older adults' civic participation, with particular attention to digital engagement; in drOp, it centered on the creation of a collaborative governance structure to support shared decision-making and sustained community involvement. This section describes the activities carried out in both contexts and presents the key findings emerging from this phase.

3.3.1. URBANAGE: Conducting Focus Groups

This second phase of URBANAGE focused on gathering diverse perspectives through focus group discussions held in Santander (see Figure 4). These sessions were designed to explore the needs, experiences, and attitudes of older adults, particularly regarding their engagement in civic activities and their interaction with digital technologies.

The main objective was to identify the motivations, challenges, and barriers that shape older adults' participation in public decision-making processes. Special attention was given to understanding how digital tools and gamification techniques could enhance their engagement, and which elements were perceived as most relevant and motivating in this context.

The process combined literature review, the development of a shared methodology and protocol, train-the-trainer workshops for local teams, and the execution and analysis

of the focus groups. This ensured consistency across sites while allowing for the collection of locally grounded insights.

Figure 4. Overview of one of the focus groups [27].

As a result, the Define phase provided a nuanced understanding of the factors influencing older adults' civic engagement in different urban contexts. These insights are essential to tailoring participation strategies that are both inclusive and responsive to the needs and expectations of ageing populations, particularly in relation to digital inclusion and motivational approaches

3.3.2. drOp: Defining a Collaborative Structure

The second phase of drOp focused on establishing a collaborative framework to guide the participatory process. This framework, the Local Task Force (LTF), brought together community members, key stakeholders, the project team, and local authorities, structuring their involvement across three levels: a coordination structure, an executive commission, and an extended commission (see Figure 5). Each level represented different degrees of responsibility and engagement, ensuring balanced participation and shared decision-making.

Figure 5. Structure of the Local Task Force [28].

The LTF functioned as a local coalition dedicated to addressing neighborhood challenges through collective action. It provided a structured space for dialogue, promoted consensus-building, and acted as a mechanism for integrating bottom-up initiatives into formal planning processes.

As a result, the Define phase laid the institutional foundation for inclusive and transparent collaboration. By establishing a clear and participatory governance structure, it ensured that decision-making was informed by a wide range of perspectives, enhancing both the legitimacy and the effectiveness of the project.

3.4. Phase 3: Create

In the Create stage, the emphasis is placed on generating ideas and collaboratively developing potential solutions through co-creation sessions and iterative design processes. This phase foregrounds creativity, dialogue, and mutual learning to translate defined challenges into actionable outcomes. In the two case studies examined, this stage was shaped by distinct yet aligned practices: in URBANAGE, co-creation sessions facilitated collaboration between older adults and civil servants to define user requirements and develop practical tools tailored to age-friendly urban contexts; in drOp, the focus was on co-designing neighborhood projects with residents through flexible, context-sensitive sessions that encouraged open expression and collective prioritization. This section outlines the activities carried out during this phase and presents the main findings from each case.

3.4.1. URBANAGE: Holding Co-Creation Sessions

The third phase of URBANAGE centered on co-creation sessions designed to bring together older adults and civil servants in a collaborative environment to develop solutions tailored to the challenges identified in previous stages. These sessions supported the definition of user requirements, the refinement of use cases, and the development of practical tools such as data sources, visualizations, simulation models, and AI applications relevant to age-friendly urban environments.

The co-creation process unfolded in three sessions (see Figure 6). The first focused on gathering insights from older adults about their needs, challenges, and expectations in relation to accessible urban living. The second session engaged civil servants from pilot cities to assess the feasibility of the initial requirements, identify existing initiatives, and explore institutional capacities and constraints. The third session brought both groups together to prioritize user requirements, validate findings, and examine communication preferences and technical limitations.

Figure 6. Summary of the co-creation sessions in Santander [27].

As a result, the Create phase enabled a participatory and iterative design process that ensured solutions were both relevant to older citizens and feasible for local administrations. By fostering structured dialogue and negotiation, it reinforced shared ownership, improved the alignment between citizen needs and institutional capabilities, and laid the groundwork for inclusive and practical urban innovations.

3.4.2. drOp: Co-Creating the Neighborhood

The third phase of drOp focused on engaging residents and stakeholders in the design of neighborhood projects through co-creation sessions grounded in HCD principles. These sessions provided open and adaptable formats for dialogue, allowing participants to express their needs and aspirations freely (see Figure 7). The flexible design of the sessions ensured that they could be adjusted to participants' contexts, fostering genuine and sustained engagement.

Figure 7. Overview of some of the co-creation sessions [28].

Held within the neighborhood to guarantee accessibility, the sessions encouraged continuous resident involvement. Participants actively contributed to identifying, evaluating, and prioritizing the projects to be co-designed, ensuring that proposed initiatives reflected the everyday realities and desires of the community. In some sessions, digital tools were employed by facilitators to collect and manage data in real time. This approach enhanced efficiency, enabling residents to focus on content while reducing the need for extensive post-session processing.

As a result, the Create phase strengthened the participatory process by fostering meaningful collaboration between residents and project teams. It ensured that co-designed solutions were not only context-specific and inclusive but also grounded in local knowledge, reinforcing a sense of ownership and facilitating more effective implementation.

3.5. Phase 4: Evaluate

Finally, the Evaluate stage tests these solutions with users through usability testing, feedback loops, and iterative improvements, ensuring the designs are effective, feasible, and aligned with user needs before broader implementation. In URBANAGE, evaluation centered on user experience and impact assessment of co-created digital tools, with older adults and civil servants actively involved in a structured, multi-dimensional process. In drOp, the focus shifted toward assessing the participatory methodology as a foundational element of urban transformation, highlighting how citizens and civil servants perceived and experienced the process of co-creation. This section presents the evaluation activities conducted in both case studies and highlights the principal findings.

3.5.1. URBANAGE: Assessing the Outcome of the Project

The final phase of the URBANAGE project focused on evaluating the impact and relevance of the developed digital tools through a user-centered assessment approach. Aligned with the HCD principle of user-centered evaluation, this phase prioritized the active involvement of older adults and civil servants in validating project outcomes. By centering the lived experiences and expectations of these user groups, the evaluation process sought to ensure the solutions were both meaningful and applicable in real urban contexts. Through iterative feedback loops, collaborative validation mechanisms, and customized instruments for user input, the project aimed to enhance inclusivity, trust, and practical impact.

This evaluative process was integral to assessing the social dimension of two digital tools co-developed in Santander: an age-friendly route planner (see Figure 8) and a simulation tool for long-term urban planning (see Figure 9). While the technical dimension focused on the operability of these solutions, the social dimension explored their capacity to enhance public space engagement for older adults and decision-making for civil servants. The methodology was structured into three stages: baseline assessment, iterative testing, and final assessment; providing a systematic framework to track user perceptions and changes over time.

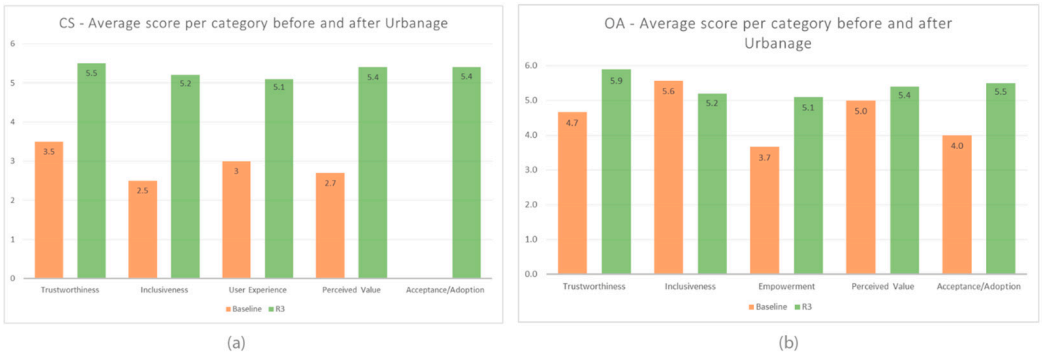

Figure 8. Comparison by category between the baseline and the final release of the age-friendly route planner, one of the digital tools developed by URBANAGE [27]; (**a**) civil servants; (**b**) older adults.

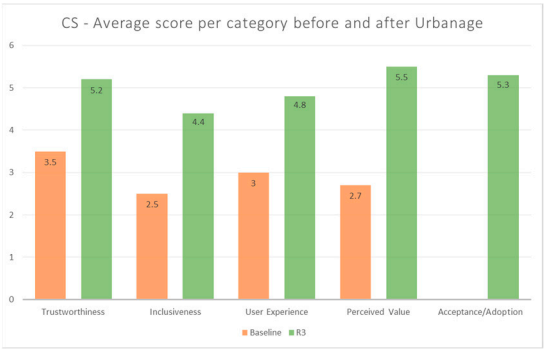

Figure 9. Comparison by category between the baseline and the final release of long-term urban planning tool, one of the digital tools developed by URBANAGE [27].

The evaluation criteria were drawn from theoretical models such as the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology. Categories including Perceived Value, User Experience, Trustworthiness, Acceptance/Adoption, Inclusiveness, and Empowerment framed the assessment, ensuring a multidimensional understanding of user interaction with the tools. Data collection targeted both civil servants and older adults, employing surveys and guided workshops that accompanied each release of the tools.

The following figures reflect the change in the different categories of both older adults (OA) and civil servants (CS) experience after testing and using the urban digital tools developed through the URBANAGE project.

The results revealed significant improvements across most categories for both user groups, particularly in perceived value and trust. This underscores the positive influence of co-creation, with participants reporting a stronger sense of ownership and greater confidence in the tools' relevance and functionality. However, a marginal decline in the Inclusiveness category among older adults highlighted persistent challenges. Specifically, the digital format of the new tools did not align with the varied communication habits of some users, pointing to broader issues of digital accessibility and the need for context-sensitive solutions.

As a result, the evaluation stage confirmed the utility and acceptance of URBANAGE's digital tools while also underscoring the necessity of nuanced, inclusive design practices. More importantly, it revealed the added value of evaluating the participatory process itself—not merely the tools' outputs. The engagement and empowerment fostered through co-creation contributed directly to the quality and uptake of the final solutions. Thus, future initiatives would benefit from incorporating participatory process evaluation from the outset, enabling a deeper understanding of how stakeholder involvement influ-

ences outcomes and ensuring more robust, adaptable, and inclusive innovations in urban digital governance.

3.5.2. drOp: Assessing the Process

The evaluation phase of the drOp project was conceived as an integral component from the very outset, with the explicit goal of assessing not only the tools or outcomes but the participatory methodology itself. Building upon insights from precedent projects such as URBANAGE, drOp places particular emphasis on understanding the quality and effectiveness of its participatory strategies. Given that the project is still underway, the focus of the evaluation lies primarily in scrutinizing the engagement processes and participatory dynamics that underpin the transformation of the Santa Ana neighborhood in Ermua. This reflects a deliberate commitment to ensuring that participation is not merely instrumental but foundational to achieving inclusive and contextually grounded smart neighborhoods.

In the pilot case of Ermua, the evaluation centered on the participatory methodology employed throughout the co-creation process, rather than the final outcomes of the interventions. The methodology was designed to capture the perspectives and experiences of two principal stakeholder groups—citizens and civil servants—who were directly involved in the implementation and facilitation of the participatory process. To structure the evaluation, drOp adopted an analytical framework based on established theories in participation and social research, which allowed for a systematic exploration of three interrelated categories: Perceived Value, Acceptance, and Empowerment.

For civil servants, the evaluation focused on the perceived usefulness and ease of use of the participatory methodology (see Figure 10). Their input was gathered through targeted interviews aimed at understanding the practical aspects of its implementation and the kinds of support required to ensure effective application. The results revealed a high level of perceived usefulness, with moderate ease of use that improved significantly when facilitation support was available. This suggests that while the methodology was considered valuable for fostering citizen engagement, its successful deployment required structured guidance and capacity-building measures.

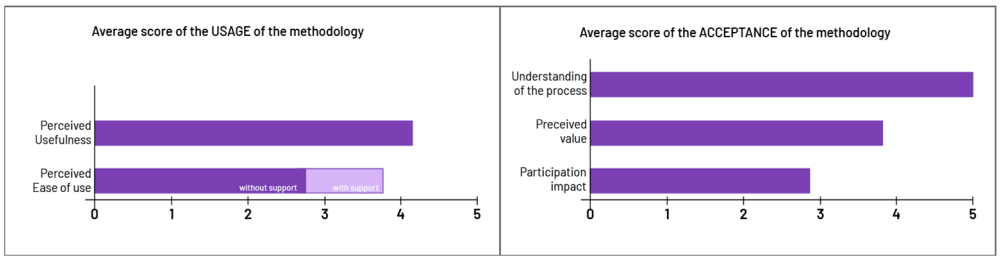

Figure 10. Average score of the assessment of the methodology developed in drOp [28].

Citizens were engaged through both surveys and interviews to explore their perceptions of the process and their evolving sense of empowerment. The assessment of Acceptance captured how participants understood the participatory process and how they perceived its value and potential impact. Participants reported a strong understanding of the process and high perceived value. However, the perceived impact of participation was more modest, not due to dissatisfaction with the results, but due to a shared perception that a broader engagement of the community would have led to greater transformation. This highlights a recurrent challenge in participatory design: translating individual satisfaction into collective impact through wider inclusion.

The following figures reflect the results in the different categories of both citizens and civil servants' experiences after being part of the participation process on the drOp project.

In terms of Empowerment, the evaluation documented a significant shift in the attitudes of citizens towards municipal-led initiatives (see Figure 11). At the beginning of the process, there was notable skepticism regarding institutional participation, despite strong community ties and a sense of belonging. Following their involvement in the co-creation activities, citizens demonstrated a more positive view of participatory governance and expressed a clear willingness to engage in similar processes in the future. This evolution illustrates how well-structured participatory approaches can serve as catalysts for reshaping perceptions and fostering greater civic trust.

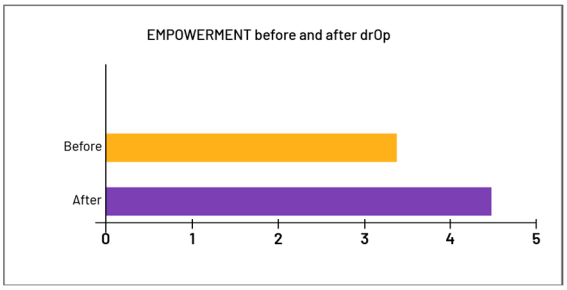

Figure 11. Average score of the empowerment of citizens before and after drOp [28].

The evaluation of the drOp methodology underscores the multifaceted value of participatory approaches in urban innovation. While civil servants recognized the methodology as a useful tool, and citizens appreciated its relevance and outcomes, the process also illuminated areas for refinement, particularly the need to broaden and diversify participation. Moreover, by foregrounding the participatory process as an object of evaluation, drOp contributes to a more nuanced understanding of the mechanisms that underpin meaningful citizen engagement. As such, this evaluative approach provides critical insights for future projects, reinforcing the need to embed participatory process assessment from the beginning to ensure adaptive, inclusive, and context-sensitive urban transformation.

4. Discussion

The discussion section delves into the application of an HCD approach in two distinct case studies: URBANAGE and drOp. Both projects are framed within the Horizon Europe funding framework, yet each represents a unique aspect of urban transformation, ranging from the creation of age-friendly cities to the renovation of social housing neighborhoods. While both initiatives share a common commitment to inclusivity, collaboration, and user-centered innovation, they each engage with different challenges and solutions within the broader context of urban development.

4.1. HCD for Age-Friendly Cities: Insights from URBANAGE

The URBANAGE project exemplifies how an HCD approach can enhance urban planning processes to create age-friendly cities. Rather than simply deploying disruptive technologies, the project integrates the principles of HCD to place the needs, challenges, and aspirations of older adults and public servants at the forefront of decision-making. By fostering an inclusive and participatory framework, URBANAGE ensures that technological solutions are grounded in the lived experiences and practical needs of the community, leading to more effective and sustainable urban transformations.

The process begins with the careful preparation of the participatory framework, which lays the foundation for meaningful engagement. Stakeholder mapping plays a critical role in identifying diverse participants, including older adults from various demographic and social backgrounds, as well as civil servants representing key domains such as urban planning, social services, and citizen engagement. This preparatory phase aligns with the

HCD principle of understanding users and their environment, ensuring that all relevant voices are included and their unique needs considered.

Focus groups represent the next stage of the process, providing an opportunity to explore the motivations, barriers, and perceptions of older adults regarding their participation in urban planning. These sessions delve into how gamification techniques and digital tools can enhance engagement, while also identifying factors that encourage or hinder involvement. The iterative design of the focus groups, including literature reviews, tailored protocols, and data analysis, reflects the HCD principles of fostering empathy and collaboration by deeply understanding the community's perspectives.

The co-creation sessions serve as the cornerstone of the URBANAGE methodology, enabling iterative dialogue and collaboration between older adults, civil servants, and project teams. Through multiple sessions, the project identifies user requirements, validates feasibility, and prioritizes solutions. The first session (CC1) focuses on older adults' needs and challenges, while the second session (CC2) gathers insights from civil servants on technical constraints and existing initiatives. The final session (CC3) brings these groups together, promoting mutual understanding, negotiation, and the refinement of user requirements. This structured yet flexible approach demonstrates the HCD principle of iterative problem-solving, ensuring that solutions are co-developed and validated by end-users.

URBANAGE highlights the value of HCD in integrating diverse perspectives and fostering a shared sense of ownership over urban planning initiatives. By combining participatory practices with advanced technologies like AI and simulation models, the project creates a decision-support ecosystem that is not only innovative but also deeply aligned with the needs of its stakeholders. This methodology underscores the transformative potential of HCD in driving inclusive, evidence-based urban planning for age-friendly cities.

4.2. HCD for Inclusive and Smart Neighbourhoods: Insights from drOp

drOp demonstrates the transformative potential of employing an HCD approach in urban renovation initiatives, where the focus is not solely on technological advancements but on creating resilient, inclusive, and adaptive neighborhoods. In this context, technology becomes an enabler of community-driven transformation, facilitating communication, collaboration, and informed decision-making, rather than dictating the direction of change. This aligns with the evolving notion of smart cities, where the emphasis shifts from technology-centric urbanization to a more people-centric approach that prioritizes the needs, aspirations, and agency of residents [5,29,30].

Through the integration of HCD principles, drOp illustrates how advanced technologies can be effectively embedded into urban renovation initiatives while respecting the lived experiences of the community. Smart technologies such as data collection tools, interactive digital platforms, and AI-driven simulations are used not to impose predetermined solutions but to foster dialogue and ensure that technological interventions are grounded in the real-world needs of the citizens [31]. For example, AI-generated models help residents visualize and understand potential changes to their environment, empowering them to participate actively in the decision-making process. These technologies are not the end goal but rather tools that support inclusive governance and co-creation, ensuring that the transformation of urban spaces reflects the values and priorities of the people who inhabit them.

Next, the establishment of an LTF underscores the importance of collaborative governance. By structuring decision-making processes across various levels and stakeholder groups, the project ensures that residents, local authorities, and experts work collectively toward shared goals. This approach aligns with the HCD principles of fostering multidisciplinary collaboration and empowering users, as residents are not only consulted but

actively involved in shaping the project's direction. This decentralization of power is a key aspect of HCD, as it ensures that the solutions developed are deeply rooted in the local context and genuinely serve the people that are designed for [32]. The collaboration of diverse groups also fosters a culture of mutual respect and trust, further supporting the empowerment of users and the co-creation of meaningful, equitable solutions [26].

Finally, the co-creation sessions encapsulate the essence of HCD, offering open-ended, adaptable spaces for dialogue and collaboration. These sessions prioritize inclusivity and accessibility, ensuring that all voices are heard and valued. By employing digital tools to streamline data collection and analysis, the project demonstrates a commitment to efficiency without compromising the participatory ethos. Residents are empowered to evaluate and prioritize initiatives, ensuring that the outcomes reflect their needs and aspirations.

In essence, the drOp project exemplifies how HCD principles can be systematically embedded into smart city development, ensuring that technological advancements and social innovation are driven by the priorities of the community. This approach not only enhances the relevance and sustainability of the outcomes but also fosters a sense of ownership and agency among residents, paving the way for more inclusive and resilient urban environments.

4.3. Contrasting Approaches to HCD: Comparative Analysis of Both Case Studies

Both URBANAGE and drOp exemplify the transformative potential of HCD in fostering inclusive urban development, yet they approach their respective contexts with distinct focuses. URBANAGE centers its efforts on integrating advanced technologies into urban planning for age-friendly cities, emphasizing the importance of evidence-based decision-making rooted in the lived experiences of older adults and civil servants. In contrast, drOp is primarily concerned with renovating social housing districts into inclusive smart neighborhoods, placing a stronger emphasis on the participatory process itself as the project is still ongoing.

URBANAGE establishes a robust participatory framework through detailed stakeholder mapping, ensuring diverse representation from older adults and civil servants across relevant domains. It further explores motivations and barriers to engagement through focus groups, which delve into how digital tools and gamification can enhance participation. Co-creation sessions serve as the project's cornerstone, iteratively refining solutions based on user feedback and facilitating collaboration between stakeholders. This structured approach underscores URBANAGE's commitment to using HCD principles to co-develop innovative, evidence-based planning tools that reflect the community's needs and aspirations.

Conversely, drOp begins with an emphasis on clear communication to bridge knowledge gaps and foster transparency among residents. The use of visual aids, such as AI-generated images of potential neighborhood scenarios, allows participants to envision project outcomes, aligning with the HCD principle of understanding users and their environment. The establishment of an LTF ensures collaborative governance, empowering residents to actively participate in decision-making processes alongside local authorities and experts. Its co-creation sessions, designed for inclusivity and accessibility, focus on evaluating and prioritizing initiatives while employing digital tools to streamline data management. These mechanisms reflect drOp's dedication to refining the participatory process itself and fostering a sense of ownership among residents.

In summary, while both projects leverage HCD to ensure inclusivity and user-centered innovation, URBANAGE prioritizes integrating advanced technologies into urban planning outcomes, and drOp focuses on the participatory processes underpinning urban renovation. Together, they illustrate how HCD can be adapted to address diverse challenges in urban

development, ensuring that technological advancements and social innovation are deeply rooted in the needs and aspirations of the community.

Despite their valuable contributions, both URBANAGE and drOp face certain limitations that may affect the broader applicability of their findings. In the case of URBANAGE, while the focus on evidence-based decision-making is commendable, the heavy reliance on technological solutions may not be universally adaptable, particularly in contexts where digital literacy is low or access to technology is limited. Furthermore, the ongoing nature of drOp means that its results are still in flux, and there is insufficient long-term data to fully evaluate the sustainability and success of its participatory frameworks. In practice, however, the insights gained from both projects could be applied by urban planners and policymakers seeking to integrate HCD into city development by ensuring that technological interventions are complemented with strong, inclusive participatory processes.

5. Conclusions

Although the methodologies of the two case studies differ, they both adhere to the core principles of Human-Centered Design (HCD). Each approach prioritizes the individuals affected by the issue, focusing on understanding their needs from the case studies inception and involving residents throughout the entire process. This approach ensures that the process is more attuned to the participants, enhancing the participatory experience and creating more customized solutions to the city's current challenges.

However, despite these efforts, several barriers to effective citizen participation remain. As identified in the literature, key challenges include ensuring representativeness, addressing expertise gaps, mitigating political interference, managing power dynamics, overcoming time constraints, dealing with limited resources, and effectively leveraging technology. While there is still considerable progress needed to fully overcome these obstacles, this paper outlines the key lessons learned from the development and evaluation of the two participatory processes. It also offers several guidelines for practitioners aiming to design genuinely citizen-centered smart cities that tackle these participation barriers head-on.

- **Ensuring Representativeness and Addressing Expertise Gaps.**

Both case studies adhere to the core principles of Human-Centered Design (HCD), prioritizing the individuals affected by the issue and involving residents throughout the entire process. This approach ensures that the process is more attuned to the participants, enhancing the participatory experience and creating more customized solutions to the city's current challenges. The URBANAGE evaluation highlighted that proactive engagement fosters trust and increases the likelihood of widespread adoption and perceived value. However, it also revealed a slight decline in inclusiveness among older adults due to the digital nature of the new tool, emphasizing the need to consider personal circumstances and context over chronological age. Providing training and educational resources can empower citizens with the knowledge and skills needed to participate effectively, further bridging the expertise gap.

- **Mitigating Political Interference and Managing Power Dynamics.**

Establishing a framework for sustained and multi-level engagement is crucial. This framework should be consistent and transparent, offering clear support and adequate resources. By co-creating a clear structure among all interested parties, defining the roles of each stakeholder, and outlining the decision-making process, the barriers related to power structures and political interference can be mitigated. The drOp evaluation showed that civil servants found the methodology highly useful, with ease of use improving when support was provided. Regular updates and assessment panels for discussion can also

help maintain transparency and trust, reducing the influence of political interference and power imbalances.

- **Overcoming Time Constraints and Dealing with Limited Resources.**

To address time constraints and limited resources, it is essential to offer engagement activities that cater to the needs of the entire community. Creating a variety of participatory choices and activities allows citizens to contribute at different commitment levels. By consolidating discussions into fewer gatherings and adapting activities to the participants, the process becomes more efficient and practical, making better use of time and resources. The drOp evaluation indicated that while citizens valued the process and its outcomes, broader participation would have significantly enhanced the impact. Leveraging existing community spaces and resources can help minimize costs and logistical challenges, ensuring that participation is accessible to all.

- **Effectively Leveraging Technology.**

Technology should be an enabler of the process rather than the actual outcome. Integrating new technologies in citizen engagement requires a thoughtful approach, especially for individuals who are less digitally savvy. Clear communication about the added value of technology and its practical benefits can help build trust and acceptance among participants. The URBANAGE evaluation underscored the importance of addressing disparities in access to and use of digital technology. A dual-track policy that includes both digital and non-digital alternatives ensures inclusivity, preventing the exclusion of those who are unwilling or unable to adopt new technological tools. Providing technical support and training can also help bridge the digital divide, ensuring that all participants can engage effectively.

- **Transparency and Communication.**

Being transparent and clearly communicating the real impact of citizens' decisions is vital. A communication campaign throughout the process bolsters motivation and a sense of usefulness among participants. Clear, continuous communication in non-technical language ensures that the community feels included and valued. The drOp evaluation highlighted that citizens' perceptions of municipal-led initiatives evolved positively, with increased willingness to participate in future processes. Leaving room for feedback with every communication allows residents to share their input, increasing representativeness and reducing mistrust in the decision-making organs. Celebrating successes and acknowledging contributions can help maintain engagement and build a sense of community ownership over the process.

By addressing these barriers, practitioners can design genuinely citizen-centered smart cities that effectively tackle the obstacles to successful citizen participation. This holistic approach not only enhances the participatory process but also fosters a more inclusive, empowered, and resilient community.

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the case of the drOp project the datasets presented in this article are not readily available because they are part of an ongoing study. Requests to access the datasets should be directed to the authors.

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Abbreviations

The following abbreviations are used in this manuscript:

HCD	Human-Centered Design
LTF	Local Task Force
CC	Co-Creation

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