Playful, Meaningful - or Both? A Review of the Current State of Digital Participatory Urban Planning Platforms

Luma Fonseca Alves
Department of Geography and Geology
University of Turku
Turku, Finland
luma.fonsecaalves@utu.fi

Manuel F. Baer
Game Technology Center (GTC)
ETH Zurich
Zurich, Switzerland
manbaer@ethz.ch

Samuli Laato
Turku School of Economics
University of Turku
Turku, Finland
samuli.laato@utu.fi

Carolin Klonner
Department of Geography and Geology
University of Turku
Turku, Finland
carolin.klonner@utu.fi

Nora Fagerholm
Department of Geography and Geology
University of Turku
Turku, Finland
ncfage@utu.fi

Abstract

As cities worldwide face unprecedented challenges including rapid urbanisation, climate change, and growing social inequities, digital platforms have emerged as critical environments for engaging citizens in participatory planning. Within such platforms, gamification approaches are adopted to increase engagement. However, no comprehensive assessment of these platforms exists. Through a scoping review of 46 platforms from academic and grey literature, we identify four categories: (1) location-based mobile apps for geospatial data collection, (2) web-based participatory mapping systems, (3) 3D and Virtual reality environments, and (4) AI-powered image generation systems. Our thematic analysis across six dimensions – (a) purpose in urban planning, (b) participation mode, (c) accessibility and reach, (d) location, (e) data dimensions, and (f) gamification features – reveals critical gaps: while feedback mechanisms appear almost universally, advanced gamification remains limited. In addition, many platforms fail to progress beyond prototypes and lack incentives for sustained participation and collecting community-informed data for emergent fields of urban planning, such as the integration of nature-based solutions (NBS). Technical requirements often contradict inclusivity goals, potentially excluding underrepresented populations. Based on these findings, we present 19 design guidelines addressing engagement sustainability, inclusive accessibility, balanced gamification implementation and support of community-based planning. This comprehensive framework informs developers, planners, and researchers in creating more effective gamified digital platforms for democratic and sustainable urban futures.

CCS Concepts

• **Human-centered computing** → *User studies*; • **Applied computing** → Cartography; • **Information systems** → **Geographic information systems**; **Location based services**.

Keywords

Urban planning, participatory platforms, scoping literature review, participatory design, design guidelines

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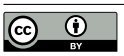
1 Introduction

Cities face an unprecedented challenge: accommodating rapidly growing populations within finite spatial boundaries while maintaining livability, sustainability, and social cohesion. As urban areas become home to 68% of the global population by 2050 [106], the population pressure intensifies – these finite urban areas must serve increasingly diverse user groups with varying needs, cultural backgrounds, and behavioural patterns [30, 111]. To maintain livability amidst emergent social and environmental challenges, cities are increasingly seeking inspiration from established academic frameworks such as Nature-Based Solutions (NBS) [35, 52], Ecosystem Services (ES) [19, 68] including Cultural Ecosystem Services (CES) [85] and Nature's Contributions to People (NCP) [31] to alleviate increasing pressures on ecosystems and social cohesion, mitigate disaster risks, and enhance human well-being [22].

Traditional top-down urban planning approaches, characterised by expert-driven decision-making and limited citizen consultation, have proven insufficient for addressing the complex, multi-stakeholder challenges of contemporary cities [34, 45, 62]. The

Authors' Contact Information: Luma Fonseca Alves, Department of Geography and Geology, University of Turku, Turku, Finland, luma.fonsecaalves@utu.fi; Manuel F. Baer, Game Technology Center (GTC), ETH Zurich, Zurich, Switzerland, manbaer@ethz.ch; Samuli Laato, Turku School of Economics, University of Turku, Turku, Finland, samuli.laato@utu.fi; Carolin Klonner, Department of Geography and Geology, University of Turku, Turku, Finland, carolin.klonner@utu.fi; Nora Fagerholm, Department of Geography and Geology, University of Turku, Turku, Finland, ncfage@utu.fi.



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participatory turn in urban planning aimed to democratise decision-making, but traditional analogue methods have faced persistent limitations in inclusivity, representation, and their ability to capture the dynamic use of urban space [36, 62]. In the past two decades, a new participatory paradigm has gained momentum through the use of digital technologies [17, 21, 63, 116], promising to overcome these limitations in citizen engagement through online platforms, visualisation tools, and crowdsourcing technologies.

However, a critical paradox emerges: while cities increasingly deploy *smart* infrastructure with interconnected sensors and data analytics [53], the development of engaging, accessible platforms for citizen participation in planning livable public spaces significantly lags behind [1, 62]. Existing Digital Participatory Urban Planning Platforms (DPUPP) often suffer from low engagement rates, demographic biases favouring educated and technologically-savvy users, and the inability to sustain long-term participation [1, 21, 97]. In addition, existing tools often reduce complex urban issues to simple voting mechanisms. This is particularly problematic for emerging challenges including the integration of NBS, which require citizens to understand long-term ecological benefits and trade-offs, not just aesthetic preferences.

Gamification, broadly defined as the application of game elements in non-game contexts to increase users' motivation to engage with a respective process in a playful way [44, 56], has emerged as a promising approach to address these engagement challenges. Successful location-based games like Pokémon GO and Ingress have demonstrated the potential of gamified systems to motivate millions of users to explore urban spaces, contribute geographic data, and sustain engagement over extended periods [10, 58, 59]. In academic contexts, gamified crowdsourcing platforms have successfully collected land cover data [11, 14], landscape descriptions [9], and assessed the quality of urban information [23]. Yet, the application of gamification principles specifically in DPUPP remains fragmented and under-theorised. Current research rarely applies gamification's motivational levers to address some of the most pressing urban environmental needs. While gamification has proven effective for simple data collection, its potential to engage citizens in complex, value-laden planning remains underexplored.

This disconnect between gamification's proven potential and its limited implementation in urban planning platforms, especially for addressing emergent urban nature challenges through NBS integration, raises three critical questions regarding the current landscape of digital participatory platforms:

- **(RQ1)** What are the main characteristics of contemporary DPUPPs and what gamification elements do they incorporate?
- **(RQ2)** What gaps exist in current DPUPPs that limit their ability to capture meaningful input about urban spaces, particularly regarding NBS?
- **(RQ3)** How can insights from contemporary DPUPPs inform future platform design and implementations?

To address these questions, this paper presents a scoping review of DPUPPs, analysing both academic literature and grey sources to identify current practices, promising innovations, and critical gaps. We examine 46 platforms across six dimensions: (1) purpose in urban planning, (2) participation mode, (3) accessibility and reach, (4) location, (5) data dimensions, and (6) gamification features. Building on this analysis, we provide design guidelines and recommendations for future DPUPPs to address identified shortcomings while incorporating best practices from successful cases.

2 Background and Related Work

The development of effective DPUPPs requires understanding three interconnected domains: the evolution of participation in planning practice, the specific urban challenges these platforms must address, and the motivational mechanisms that can sustain citizen engagement. This section traces the transformation from analogue to digital planning participation, examines how gamification principles have been applied to spatial crowdsourcing contexts, and analyses the emergent and increasingly relevant frontiers in urban planning with emphasis on the underrepresentation of NBS in current platforms. Together, these perspectives reveal both the promise and limitations of existing approaches, establishing the theoretical foundation for our scoping review.

2.1 From Analogue to Digital Urban Planning

Urban planning has undergone a fundamental transformation over the past century, evolving from expert-driven master planning to increasingly participatory and digitally-mediated processes. The traditional rationalist planning model, dominant through much of the 20th century, positioned planners as technical experts who could apocryphally determine optimal urban configurations objectively [4, 42, 43, 103]. This top-down approach, whilst efficient for large-scale infrastructure development, systematically excluded citizen voices and local knowledge from decision-making processes [49, 62].

The participatory turn in planning sought to democratise urban decision-making [45, 49]. However, traditional participation methods (e.g. public hearings, community workshops) face persistent challenges including low attendance, demographic biases and difficulty incorporating diverse perspectives into final plans [36, 62]. These analogue methods arguably struggle to capture the dynamic, temporal aspects of urban space usage, often reducing complex spatial experiences to static maps and written comments.

The digital revolution since the early 2000s has promised to address these limitations through online platforms, visualisation tools, and crowdsourcing technologies. Public Participation Geographic Information Systems (PPGIS) enable citizens to provide spatially-explicit feedback through interactive maps [19, 20, 91, 92]. Three-dimensional visualisations and virtual reality environments allow stakeholders to experience proposed changes before implementation [17, 87]. Crowdsourcing platforms provide new channels for gathering public sentiment about urban spaces [38, 113–115].

However, many platforms remain consultation-oriented rather than truly participatory [1, 62, 116], collecting citizen input that may or may not influence final decisions [34]. In addition, the *digital divide* excludes populations lacking technological access or skills, potentially exacerbating rather than addressing participation inequities [33, 41, 110]. Most critically, the majority of digital planning platforms fail to sustain engagement beyond initial novelty, resulting in declining participation rates and unrepresentative samples [21, 89, 97, 101]. This engagement challenge has prompted researchers and practitioners to explore motivational design approaches, particularly gamification, as a potential solution.

2.2 Gamification in Spatial Crowdsourcing

Gamification has emerged as a powerful approach to address engagement challenges in digital participation platforms. Defined as "hedonic or entertainment-oriented technologies being re-appropriated for productive use" [56, p. 191], gamification leverages intrinsic and extrinsic motivational mechanisms to encourage desired behaviours [95]. The gamification spectrum ranges from simple *pointsification* – adding points, badges, and leaderboards to existing systems – to fully ludic applications incorporating narratives, avatars, quests, and complex progression systems [44, 56, 71, 99].

In spatial contexts, gamification has proven particularly effective at motivating data collection and exploration behaviours. For example, commercial location-based games such as Pokémon GO demonstrate global engagement and motivate millions of players to walk billions of kilometers whilst capturing location data [10, 58, 60]. Academic gamified crowdsourcing platforms have demonstrated similar potential, albeit at significantly smaller scales. *Smart Citizen* raises awareness for sustainable behaviours and fosters urban co-production by supporting citizens in finding local services, encouraging participation in city events and consultations and taking part in various urban activities [81]. Gamified web-based participatory mapping platforms like *Community PlanIt* focus on assisting urban planning meetings and transforming urban tasks into gamified missions, enabling citizens to engage with local issues or aspirations [75]. Further examples include *Starborn* [11] and *Window Expeditions* [12] which highlight the potential of collecting landcover and landscape perception data, as well as *Arcane Shift* which aims to completely gamify urban data collection [9], albeit never surpassing the prototype phase. These platforms enhance two-way communication between planners and communities by aggregating geographically referenced input with shared concerns or priorities. However, explicit mention of data gleaned from gamified spatial crowdsourcing platforms being directly integrated into real-world policy or decision making processes is lacking.

The meta-analysis of Morschheuser et al. demonstrated the effectiveness of gamification for crowdsourcing [71] and various sources emphasise the potential of gamification to increase engagement in participatory efforts [44, 56, 71, 99]. However, successful gamification requires careful design: poorly implemented game elements can create competition that discourages collaboration, or exclude users who prefer less ludic approaches. Whilst these gamification principles show promise for urban planning contexts, their application must consider the specific challenges cities face, particularly regarding social and environmental sustainability and climate adaptation.

2.3 Emergent and critical frontiers in urban planning

Urban planning is a long-standing and dynamic research field, repeatedly reshaped by shifts in theory, methods, and governance arrangements [42, 43, 103]. Similarly, its core focus has expanded over time, transcending mere land-use, infrastructure and transportation planning to also include lived experiences and sense of place (e.g. [105]), with an increasing emphasis on socio-ecological sustainability and the integration of NBS into urban development [35, 77]. This broadening has also prompted reconsideration of what counts as relevant *planning knowledge* in participatory processes, with citizens increasingly contributing experiential, behavioural, sensory, and ecological perspectives that are difficult to capture through conventional consultation alone [36, 49, 62].

Across contemporary participatory and digitally-mediated approaches, these concerns frequently combine into a set of interlinked dimensions. Alongside general urban space planning (e.g. assessing and envisioning public-space quality through participatory mapping and place-based feedback [19, 92]), urban governance remains central, with attention to transparency, deliberation, and co-production in decision-making [49, 62]. At the same time, planning increasingly attends to *place attachment* and *meanings* of place, which can be uncovered through situated and exploratory engagements with the city [64, 65, 88, 102], *urban mobility*, where movement patterns and accessibility shape everyday opportunities and equity [28], *education and citizen behaviour*, reflecting the need to support more sustainable practices and urban stewardship [81, 94], and the *soundscape* including where acoustic comfort and perceived noise influence urban liveability and wellbeing [7, 115].

Within this broader context, the integration of NBS should be understood as an emergent (yet inseparable) planning dimension rather than an ancillary theme. NBS leverage ecological processes as multifunctional urban infrastructure (e.g. as biodiverse parks, blue-green corridors, constructed wetlands and river restoration projects) for challenges such as climate adaptation, biodiversity loss, and human wellbeing [5, 35, 52, 77]. Their benefits are often framed through ES [68] or, more broadly, NCP [31], including regulating functions (e.g. cooling, runoff reduction) as well as intangible dimensions frequently summarised as CES such as recreation, aesthetic appreciation, cultural heritage, identity, and sense of place [12, 19, 92, 113, 115].

Yet these plural and often intangible values are difficult to operationalise: traditional approaches may under-represent how different groups use and value urban nature. Moreover, digital planning platforms rarely support NBS-specific inputs or CES assessment, treating blue-green spaces as aesthetic amenities or commodified arenas rather than multifunctional, socially differentiated infrastructures [57, 112]. Positioning NBS within the same set of emergent planning dimensions represents a deliberate effort in emphasising the importance of eliciting not only preferences and proposals, but also experiences, behaviours, and socio-ecological trade-offs.

3 Methodology

To assess the current landscape of DPUPPs, we employed a scoping literature review supplemented with grey literature exploration (cf. figure 1). This dual approach was necessary given that innovative planning platforms often emerge from practice rather than academia, whilst theoretical insights commonly remain confined to scholarly publications. We performed manuscript screening and selection processes based on the PRISMA workflow [70] complemented with snowballing [117]. We extract relevant information through a Thematic Analysis (TA) [3, 18] following the six steps by [18]: (1) familiarising ourselves with the data, (2) (iteratively) generating initial codes (3) searching for themes, (4) reviewing themes, (5) defining and naming themes and (6) producing this manuscript.

3.1 Academic and Grey Literature Search

To identify the DPUPPs currently discussed in the literature for promoting participatory urban planning with citizens, we conducted a scoping search on Scopus and Web of Science databases. The search was performed on the 16th October 2025 using the search string below and filtered to only open access peer-reviewed and conference proceeding papers written in English and published between 2015-2025.

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TITLE-ABS-KEY ("digital platforms" OR "digital tools" OR "online tools" OR "software" OR "APP") AND ("participatory" OR "collaborative" OR "engagement" OR "involvement") AND ("urban planning" OR "city planning" OR "urban design" OR "spatial planning" OR "placemaking")
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No "gamification"-related keyword was included in the search string, as one of the goals is to capture the full spectrum of digital technologies currently used in participatory urban planning, and subsequently analyse which of these platforms incorporate gamified elements and to what extent.

The search resulted in a total of 259 papers, 161 on Scopus and 98 on Web of Science. Duplicates were removed resulting in 181 results which were then manually screened to include only those studies that comprise: (1) the development of digital tools or platforms or use of existent ones, rather than purely theoretical frameworks, (2) platforms and tools with explicit participatory elements enabling citizen input and (3) have an urban planning focus, specifically addressing public urban spaces at scales ranging from the local to the city level. From the screening process, 31 papers were retained, as the remaining results did not satisfy the criteria mentioned above. Many of the excluded studies addressed digital platforms or tools generically as recommendations within theoretical frameworks, rather than focusing primarily on their development and/or application in case studies.

In addition, 12 studies were identified through a snowballing process, in which we examined the citations of relevant studies to capture publications not retrieved in the initial database searches. Through this process, we yielded a total of 43 papers, from which 37 unique DPUPPs were identified as having been developed and/or applied within the academic literature.

An additional 9 DPUPPs identified in the grey literature were incorporated into our sample. These comprised in particular commercial platforms and practice-based implementations. The search focused on official websites and publicly accessible project pages. The platforms were identified through targeted Google searches. Search terms included "digital participatory platform", "citizen engagement tool", "co-design platform", "crowdsourcing platform" and "participatory urban planning". Combining academic and grey literature search resulted in a total sample of 46 distinct platforms.

3.2 Data Extraction Framework

To analyse the identified platforms, we developed a comprehensive coding framework capturing both urban planning functionalities and gamification mechanisms. In total, we coded each platform across six primary dimensions:

(1) **Purpose in urban planning:** We examined the specific urban fields toward which user contributions are directed (*general urban space planning*, *NBS integration*, *urban mobility*, *education and citizen behavior*, *soundscape*, *place attachment*, or *governance*). This dimension captures whether platforms support comprehensive urban planning processes, in which users can assess a wide range of urban needs and propose diverse design ideas, or whether they specialise in narrower thematic areas, such as environmental monitoring, mobility behaviors, or acoustic environments. This allows the analysis to reveal how digital participation platforms engage with different facets of urban life and to identify fields where further exploration and tool development are still needed.

(2) **Participation mode:** We assessed how each tool enables users to engage with the participatory process, drawing on the IAP2 Public participation Spectrum levels [51] and adapted here for digital environments. For this review we focused on the following levels: *Information* (platforms that primarily provide knowledge to help users understand urban issues and possible solutions); *Consultation* (platforms that collect citizens' feedback to inform planning decisions); *Collaboration* (platforms that support co-creation of alternative urban scenarios and shared decision-making between citizens and planners). The empowerment level in this framework implies that decision-making authority is fully transferred from city authorities to the public, with the city fully committed to implement outcomes determined by participants. In practice, however, this level of participation is typically restricted to a limited and often representative group of stakeholders engaged in long-term processes, such as advisory boards [108]. The digital participatory tools analysed in this study are not designed to target such exclusive groups, nor have the power alone to remove municipal authorities from the decision-making process altogether. For these reasons, the empowerment level was not included in the classification.
In addition to these levels, user interaction with digital platforms can occur either *asynchronously*, where participants contribute individually at their own pace (e.g. through online surveys), or *synchronously*, where interaction happens in real time (e.g. during workshops and in person or online meetings).

(3) **Accessibility and reach:** We highlighted the different levels of availability and maturity of the platforms by categorising them into *globally available and open access* - freely accessible to any user or organisation around the world without licensing restrictions; *Globally available but licensed* - commercially distributed platforms that require paid subscriptions; *locally available and deployed* - platforms developed or implemented for specific locations, usually within the scope of pilot projects, municipal programs, or local research initiatives and *prototype or piloted* platforms - experimental systems still in testing phases, typically developed in research or educational contexts to evaluate participatory methods before broader release.

(4) **Location:** We extracted the location of development of each platform to analyse the global regions that have contributed

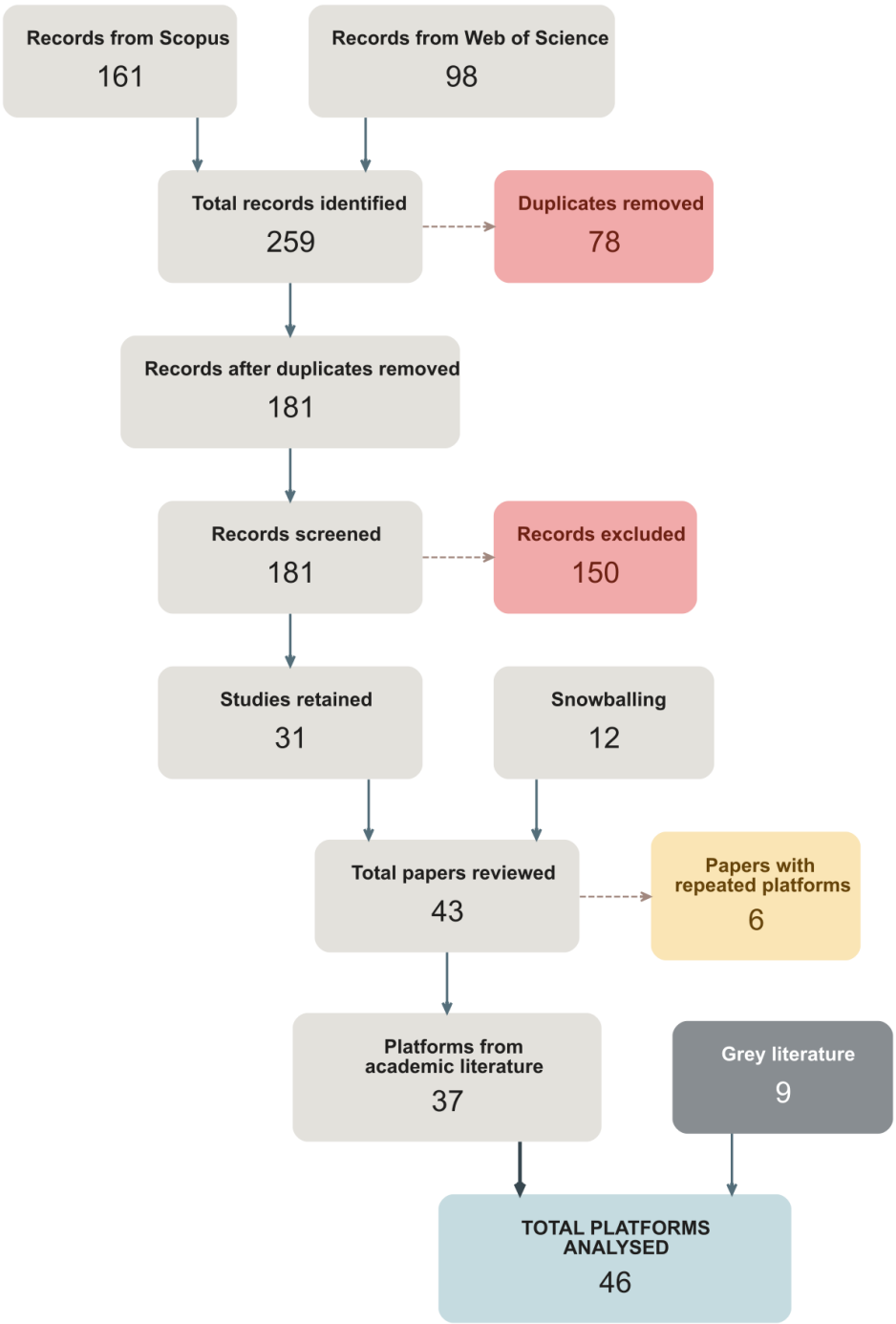

Figure 1: PRISMA diagram showing the identification and extraction workflow of the scoping platform review

most to the current landscape of digital participatory platforms for urban planning. By mapping the origin of these platforms across the globe we can infer where innovation, research, experimentation, and implementation efforts are most concentrated and reported on in this field.

(5) **Data Dimensions:** We identified the nature of user input and the format through which information is collected mediated by the platforms. The identified data types include: *geospatial data*, referring to individuals' geolocation and/or georeferenced markers placed on maps; *structured questions*, encompassing predefined survey formats such as Likert

scales, ratings, or multiple-choice responses; *preferences*, including votes and reactions representing preference expressions regarding different urban plans; *photo upload*, allowing users to share multimedia materials within the tool; *text annotations*, referring to open-ended comments or qualitative reflections linked to specific spatial elements; and *design elements*, which include 2D drawings, placement of 3D objects, or AI-generated images used in co-design and visualisation activities.

(6) **Gamification features:** We identified which gamified elements were present in each system ranging from basic mechanics to more intricate systems that are presented in established gamification taxonomies [44][71]. This categorisation included the following features: *points and scoring systems*, which reward user activity; *leaderboards*, which introduce ranking comparison among participants; *badges and levels*, which represent progress and achievements, *missions and storytelling elements*, which frame participation within a narrative and may introduce challenges, *feedback mechanisms*, which provide users with real-time responses to their actions, *rewards*, which offer tangible or symbolic incentives, *virtual territories* which places users in a digital world they can interact with and manipulate and *avatars*, where users can embody digital characters and make collaboration more personal and relatable.

To ensure coding reliability, two authors independently coded eight randomly selected platforms. Then, the authors discussed the results to identify and resolve differences in interpretation. This process was repeated iteratively until the authors' coding converged and no major discrepancies remained. Once the authors established consistent coding criteria through this calibration process, one author completed the coding for all remaining platforms, with periodic verification checks on ambiguous cases.

4 Findings

Our scoping review identified 46 distinct DPUPP (cf. overview table 1) employing varying degrees of gamification. The type of technologies employed by the platforms fell into four main categories: (1) location-based mobile apps, (2) web-based mapping platforms, (3) 3D virtual environments/VR, (4) and image generative AI. The last category had the fewest examples in the sample, reflecting the fact that it is an emerging technology that has only begun to be applied in the fields of urban planning and design since 2022. Tables 2 and 3, alongside figures 2 and 3, present the platform characteristics according to the dimensions analysed. A detailed extraction table with more information about the platforms and their six dimensions can be found in the table provided in the supplementary materials.

4.1 Purpose in urban planning

Most of the platforms reviewed in this study were intrinsically generalist, addressing a broad range of urban planning issues simultaneously or collecting general citizen feedback on the assessment of public spaces (e.g. *You-Walk UOS* [96] and *City explorer* [80]) and the design of preferred or envisioned scenarios (e.g. *UrbanistAI* [107] and *UCode* [47]). These more generalist platforms do not focus on specific urban and environmental objectives, but aim to capture more diverse perspectives and perceptions about urban open space quality and desired future urban interventions. Their foci are tailored and refined by researchers and planners according to the specific goals and contexts of each participatory process.

Other platforms were built focusing on more specific urban planning and design objectives, such as collect residents' mobility patterns (e.g. *The neighborhood hub prototype* [28]) and map urban soundscapes for improved acoustic comfort (e.g. *Citi-sense platform* [7]). Site exploration platforms such as *Niantic's Ingress* [64], *Pikmin Bloom* [64], *Plant The World* [64], and *Wayfinder Live* [50] have the potential to influence how people use and perceive urban spaces. When applied within the urban planning context, they encourage users to explore landmarks and public spaces, fostering personal place attachment and a deeper connection with the city. At the same time, the geospatial data that can be collected through them can inform planners about citizens' preferred routes, frequently visited locations, and patterns of movement. Platforms that foster education and incentivise citizen behavioural changes were also present in the sample, such as the platform *Sharing Lisboa* [94] that encourages energy-efficient and sustainable practices among residents.

A critical gap emerged regarding the integration of NBS within the reviewed platforms. Despite growing recognition of NBS as vital for climate resilience and public wellbeing, only 5 platforms placed NBS assessment and planning in the main focus of their participatory process. The *Edible City Game* [90] allows participants to incorporate urban agriculture strategies - such as green roofs, community gardens, and urban farms - into their gameplay, also allowing users to assess the impact of their design decisions on environmental indicators like urban heat and distance to the closest green area. *Virtual Green Planner* [79] emphasised NBS interventions by enabling users to place elements like trees, ponds, and planters into digital urban models, with immediate feedback on their functional effects such as shade provision and runoff reduction. *EuPolis* [54] also allowed the inclusion of green features within VR environments. However, these NBS elements were largely treated as visual or symbolic objects rather than components of complex ecological systems.

Among the location-based mobile apps, *Shmapped* [67] and *Smart Citizen* [81] can be highlighted as having the strongest emphasis on urban nature by collecting geolocated user feedback about emotional and perceptual responses to green spaces and incentivising sustainable habits. Thus, collecting valuable data on how people experience and value existing blue-green infrastructure, despite not supporting direct design input. The remaining platforms focused primarily on experiential feedback, gamification, or visual ideation, with limited or no explicit capacity for NBS-specific input.

4.2 Participation mode

The different participation modes supported by the platforms directly impact their reach and mode of interaction between the citizens. Almost all location-based mobile applications and web-based mapping platforms primarily support asynchronous consultation, allowing users to give their contributions at any time and from any location, according to their own convenience. This flexibility can significantly increase the volume and diversity of citizen input, making participation more accessible and inclusive. However, it

Table 1: Overview of DPUPPs identified in the scoping review

Platform Name	Description	Citation
Location-based Mobile Apps		
YouWalk UOS	Mobile app for evaluating quality of urban spaces	[96]
The Neighbourhood Hub	Gamified prototype collecting mobility patterns and preferences for hub placement	[28]
Location Hunting Game	Promotes community exploration through playful urban walks with geo-tagged photos	[102]
Urban Belonging Photo	Studies emotional connection to urban spaces through annotated photos and reflections	[65]
Niantic's Ingress	Location-based game encouraging exploration of landmarks and place attachment	[64]
PikminBloom	Gamified app to promote walking and track pedestrian routes for active mobility planning	[64]
PlantTheWorld	Environmental awareness game linking virtual tree-planting to real-world pledges	[64]
Smart Citizen	Promotes sustainability actions through gamified activities	[81]
Sharing Lisboa	Digital social market supporting urban sustainability and energy efficiency habits	[94]
City Explorer	Enhances urban awareness by collecting location-based input along transit routes	[80]
Shmapped	Records well-being benefits of nature exposure for blue-green infrastructure design	[67]
Wayfinder Live	AR experiences connecting art, play, and urban identity in public spaces	[50]
Pokémon GO	Entertainment app providing insights on public space usage patterns	[88]
Change Explorer	Maps user experiences along transit routes for placemaking	[116]
Citi-Sense	Assesses urban soundscapes and acoustic comfort in public spaces	[7]
Tääsa	Collects perceptual evaluations of built environment qualities	[32]
Web-based Participatory Mapping		
AMACHAN	Collects evaluations of public space quality to identify local priorities	[109]
Geodiscussion	Enables geo-referenced public discussion of urban issues	[69]
Consul Project	Platform for proposing and voting on urban projects in municipal decision-making	[8]
DIPAS System	Collects citizen feedback attached to digital maps during meetings and online sessions	[104]
GeoAnkieta	Gathers residents' preferences through map-based surveys	[13]
OGITO	Facilitates shared real-time mapping in planning workshops	[2]
PubinPlan	Engages youth in spatial planning education through interactive mapping	[98]
CommunityPlanIt	Game-based platform collecting input while teaching planning concepts	[75]
PlanYourPlace	Supports online participation in zoning and city plan design	[100]
Carticipe	Map-based platform for sharing and voting on spatial ideas	[82]
Maptionnaire	Interactive online maps gathering spatial feedback on planning issues	[66]
Crowdbrite	Facilitates collaborative brainstorming during design workshops	[25]
PlaceSpeak	Consult local residents to about interventions happening on their neighborhoods	[84]
Commonplace	Community feedback platform for urban regeneration projects	[24]
GeoCitizen	Supports collaborative mapping, issue reporting, and project monitoring	[37]
3D Environments and Virtual Reality		
Minecraft	Commercial 3D game environment that can be used for co-designing urban spaces	[27] [86]
MetaVerse GENSEN	Platform for customising digital twins and testing design options	[118]
EuPolis	Gamified VR for co-designing nature-based urban solutions	[54] [55]
COHESIVE	VR application supporting collaborative design of healthy public spaces	[26]
Digital Commons	Urban space co-design platform with role-playing and 3D scenarios	[78]
Edible City Game	Serious game for participatory planning of urban green infrastructure	[90]
Virtual Green Planner	3D environment for participatory design of green infrastructure	[79]
Chatty Bench AR	AR interactions promoting community dialogue and reflections on public spaces	[40]
Game4City VR	VR scenarios gathering citizen feedback on urban design alternatives	[93]
Maslow's Palace	VR design workshops encouraging reflection on social inclusion	[15]
UCode	Facilitates large-scale urban idea generation and early-stage design in a 3D environment	[47]
Qua-Kit	Modular 3D environments for collaborative urban design	[74]
Image Generative AI		
UrbanistAI	AI-powered platform for co-creating urban design through generated imagery	[107]
PlaceMakingAI	Facilitates collaborative visual ideation for urban placemaking with AI	[83]
Laneform	AI-generated street design visuals for participatory discussion	[61]

also tends to transform participation into a more individualised activity, where users engage in isolation rather than collectively. As a result, if not integrated with features that facilitate interaction and collaboration in-between participants and among participants and planners - even asynchronously - such as discussion forums, comment threads, or reaction functions present on platforms like *PlanYourPlace* [100] and *CommunityPlanit* [75], these platforms may fall short in fostering dialogue, collective reflection, and mutual learning. Such elements are essential for building consensus, trust, and shared understanding within participatory urban planning processes.

On the other hand, most 3D virtual environments, VR applications, and generative AI platforms are designed primarily for synchronous collaboration, requiring participants to be present (either in person or online) during workshops or meetings to collaborate in real-time with other citizens and, in some cases, with city planners. This mode of interaction can foster a stronger sense of collective engagement, shared decision-making, and community building. However, it also introduces limitations by reducing participant flexibility, as involvement is restricted to those available at specific times and locations, thereby constraining the overall reach and inclusiveness of these platforms. Platforms that support both synchronous and asynchronous collaboration can help mitigate these challenges by combining both worlds. Nonetheless, such hybrid models remain relatively rare, represented in this study only by platforms such as *UCode* [47], *Qua-Kit* [74], *UrbanistAI* [107], and *PlaceMakingAI* [83].

Table 2: Comparison of the dimensions' categories of extracted DPUPPs

Criteria	Location-based mobile apps	Web-based mapping platforms	3D virtual environments and VR	Image GenerativeAI
Purpose in urban planning				
General urban space planning	[96] [80] [116] [32]	[109] [69] [104] [13] [2] [98] [75] [100] [82] [66] [25] [84] [24] [37]	[27] [118] [26] [78] [93] [15] [47] [74]	[107] [83]
NBS integration	[81] [67]		[54] [90] [79]	
Urban mobility	[28] [94]			[61]
Education and citizen behaviour	[64] [64] [81] [94]	[98]		
Soundscape	[7]			
Place attachment	[102] [65] [64] [50] [88]		[118] [40]	
Governance		[8] [75]	[15]	
Participation mode				
Information	[64] [94] [81] [50]	[75] [100] [84]		
Synchronous consultation	[28]	[104] [2] [66]	[93]	
Asynchronous consultation	[96] [102] [65] [64] [64] [64] [81] [94] [80] [67] [88] [116] [7] [32]	[109] [69] [13] [98] [75] [100] [82] [66] [84] [24] [37]	[40]	
Synchronous collaboration	[28] [81]	[25]	[27] [118] [54] [26] [78] [90] [79] [15] [47] [74]	[107] [83]
Asynchronous collaboration		[8] [75] [100] [37]	[47] [74]	[107] [83] [61]
Accessibility and reach				
Global available and open access	[96] [65] [64] [64] [64] [88]	[8] [104] [2] [75] [100] [37]		
Global available but licensed		[109] [66] [25] [84] [24]	[27]	[107] [83] [61]
Local available and deployed	[94] [67] [50]	[69] [13] [82] [98]	[47]	
Prototype level / Piloted	[28] [102] [81] [80] [116] [7] [32]		[118] [54] [26] [78] [90] [79] [40] [93] [15] [74]	
Location				
Asia	[102] [64] [64] [88]		[118] [78]	
Europe	[96] [28] [65] [81] [94] [67] [7] [32]	[69] [8] [104] [13] [2] [98] [82] [66] [24] [37]	[27] [54] [26] [90] [79] [93] [47] [74]	[107] [83]
North America	[64] [64] [80] [88] [116]	[75] [100] [25] [84]		[61]
Oceania	[50]		[40] [15]	
Latin America		[109]		

Table 3: Comparison of extracted DPUPPs regarding data dimensions and gamification features

Criteria	Location-based mobile apps	Web-based mapping platforms	3D virtual environments and VR	Image GenerativeAI
Data dimensions				
Geospatial data	[96] [28] [102] [65] [64] [64] [64] [81] [94] [80] [67] [50] [88] [116] [7] [32]	[109] [69] [8] [104] [13] [2] [98] [75] [100] [82] [66] [25] [84] [24] [37]		
Structured questions	[96] [28] [65] [94] [80] [116] [7] [32]	[109] [13] [66] [24]		
Preferences	[28] [102]	[8] [75] [82] [25] [84] [24] [37]	[78] [90] [93] [47]	[107] [83]
Photo Upload	[96] [65] [116] [32]	[75] [66] [25]		[107]
Audio upload			[40]	[107]
Annotations	[65] [81] [80] [67] [50] [116]	[69] [8] [104] [2] [98] [75] [100] [82] [25] [84] [37]	[27] [54] [26] [78] [90] [15] [47]	[107] [83] [61]
Design elements	[28]	[2] [100]	[27] [118] [54] [26] [78] [90] [79] [93] [15] [47] [74]	[107] [83] [61]
Gamification features				
Points/Score	[28] [64] [64] [81] [94] [80] [50] [88]	[75]	[118] [78]	
Leaderboards	[28] [64] [80] [88]	[75]		
Badges	[64] [64] [81] [88]	[75]	[78]	
Levels	[64] [64] [81] [88]	[37]	[118]	
Progress	[28] [64] [64] [64] [81] [94] [80] [50] [88]	[75]	[118] [78] [90]	
Feedback	[96] [28] [102] [65] [64] [64] [64] [81] [94] [80] [67] [88] [116] [7] [32]	[109] [69] [8] [104] [13] [2] [98] [75] [100] [82] [66] [25] [84] [24] [37]	[118] [54] [26] [78] [90] [79] [40] [93] [15] [47] [74]	[107] [83] [61]
Rewards	[28] [64] [94]		[118]	
Storytelling	[64] [64] [81] [67] [50] [88]	[75]	[27] [118] [54] [78] [90] [40] [15]	
Missions	[28] [64] [64] [64] [81] [80] [88]	[75]	[27] [118] [54] [15]	
Virtual Territories	[28] [102] [64] [64] [64] [50] [88]		[27] [78] [54] [118] [90]	
Avatars	[28] [64] [64] [88]		[118] [54]	

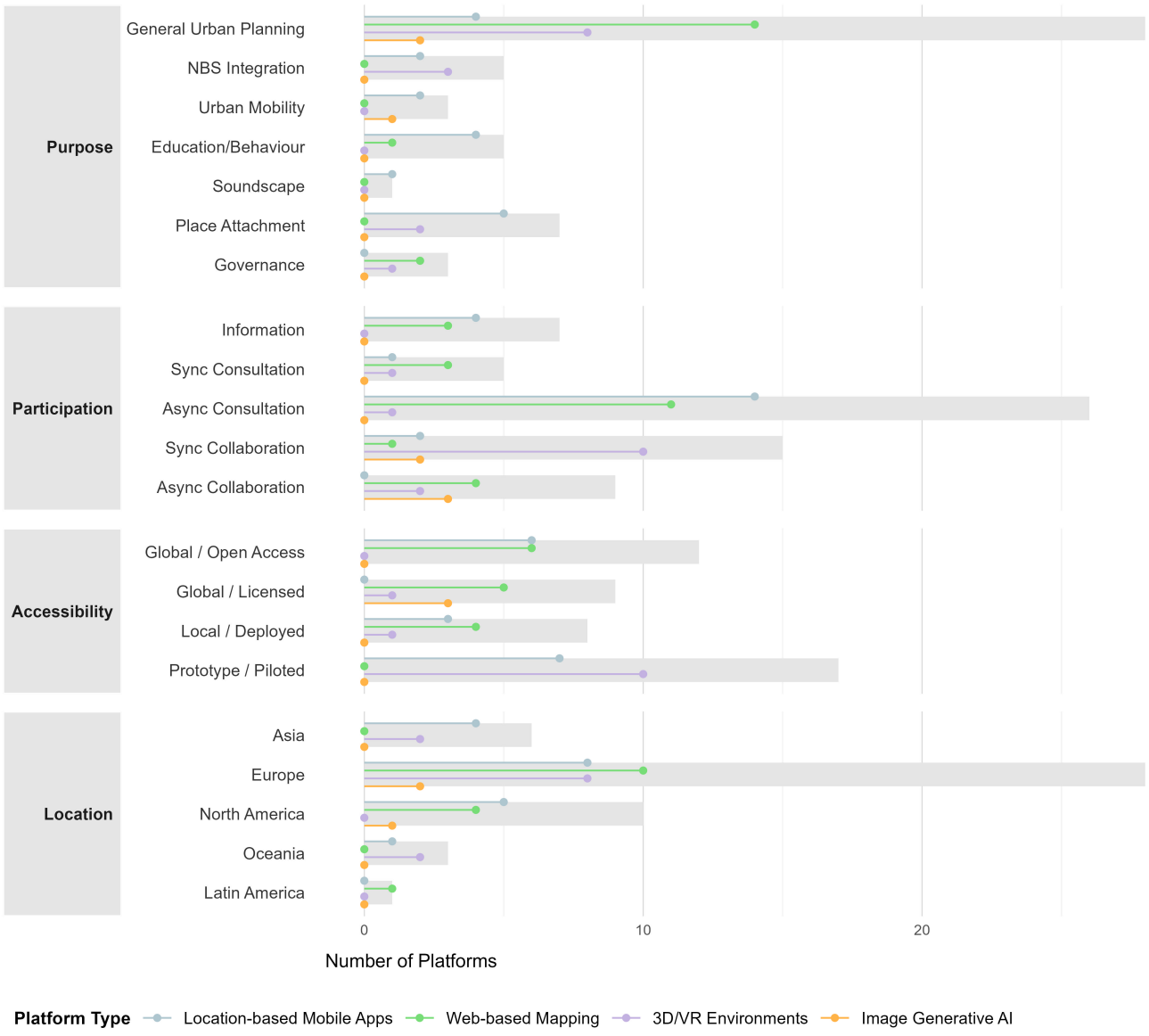

Figure 2: Plot summarising the results of the general characteristics of the identified DPUPPs. Grey bars represent category totals, dots represent specific platform types.

4.3 Accessibility and reach

Analysing current platforms points to a recurring challenge: sustaining participation beyond initial novelty. platforms such as The *Neighborhood Hub* [28], *Location Hunting Game* [102], *Game4City VR* [93], and *Maslow's Palace* [15] did not go beyond the prototype stage, being piloted only within specific research studies and remaining short-lived due to the absence of sustained community engagement, institutional facilitation, or long-term incentives. The considerable concentration of 3D virtual environments and VR applications at this prototype level suggests that these technologies face significant barriers to large-scale adoption and long-term implementation, primarily due to their technical complexity, high resource requirements, and financial investment needed to maintain and update such systems.

Other platforms, such as *Sharing Lisboa* [94] and *GEOAnkieta* [13], were developed only for specific local contexts. Their transferability to other realities and broader impact are limited due to language barriers, regulatory differences, and context-specific interface design without customisation possibilities.

Target audience specifications revealed tensions between stated inclusivity goals and actual reach. Several platforms, such as *UrbanistAI* [107], *Maptionnaire* [66], and *Minecraft* [27, 86], are theoretically widely available but can be limited in practice by the cost for license fees. Besides, platforms that require specialised hardware

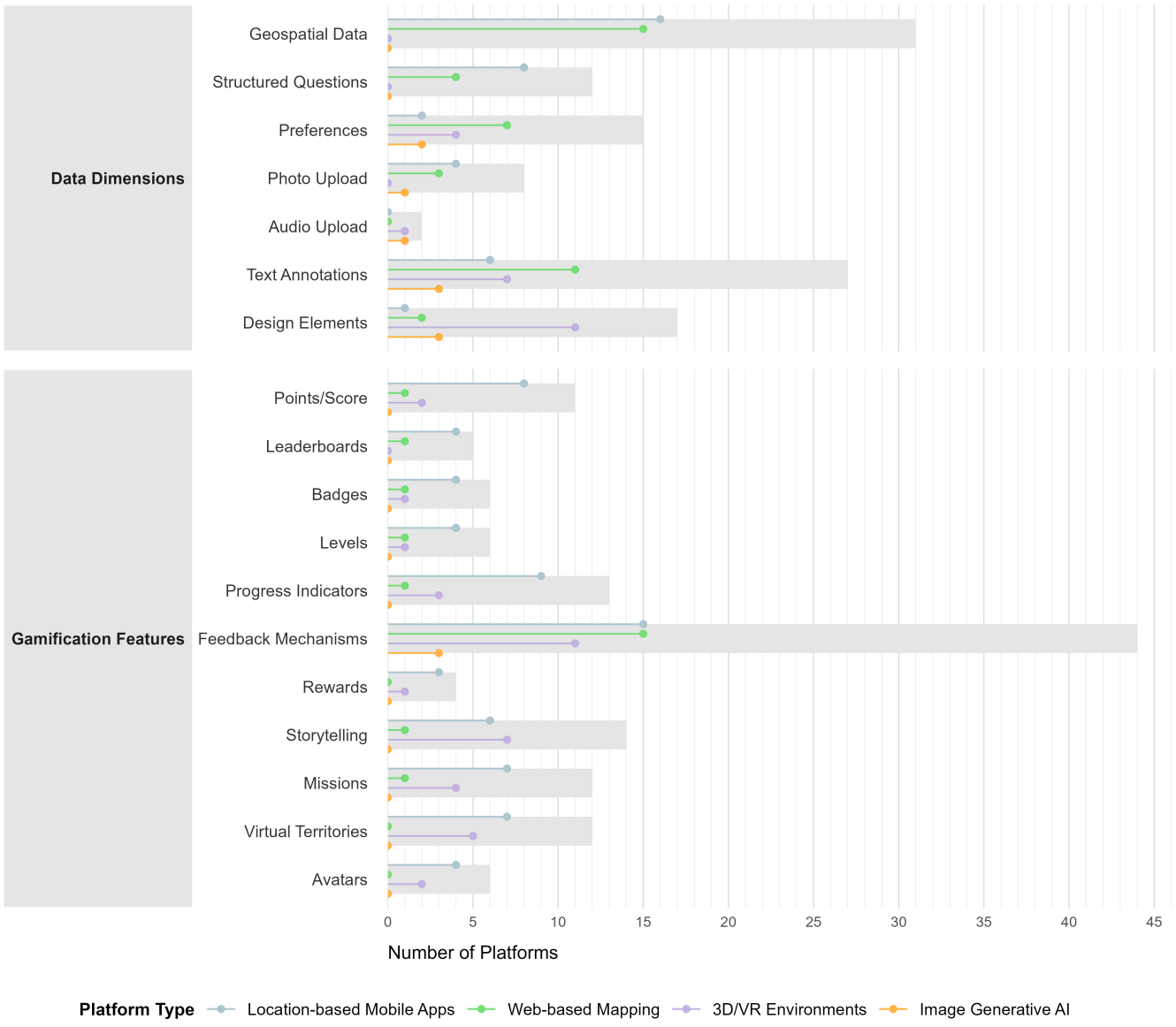

Figure 3: Plot summarising the data and gamification features in the identified DPUPPs. Grey bars represent category totals, dots represent specific platform types.

and computing capacity, such as the VR-based platforms *COHESIVE* [26] and *euPolis* [54] may systematically exclude under-resourced communities. Among the sample of the 3D virtual platforms, only *Digital Commons* [78] explicitly prioritised intergenerational and inclusive engagement, using role-playing games to incorporate diverse perspectives and allowing physical hand-drawn ideas to be digitised - thereby lowering the entry barrier for participants less comfortable with digital environments. While some of the location-based mobile apps lower barriers to public engagement by implementing clean and intuitive user interfaces and allowing access anytime and anywhere, others may favour techy-savy users due to complex elements and over gamified features.

4.4 Location

The reviewed platforms demonstrate that development and application remain concentrated in the global north with a strong bias towards Europe and North America. European initiatives dominate the sample with 26 platforms (e.g. *Smart Citizen* [81], *EuPolis* [54], *Cohesive* [26] and *Citi-sense* [7]), with particularly strong representation from Germany, Spain and Finland. The European Union's

Horizon 2020 programme supported some of the initiatives including *EuPolis* [54] and *COHESIVE* [26]. North American and Asian platforms were also numerous in the sample (16 platforms), emerging primarily from commercial ventures, such as *PlantTheWorld* [64], *PikiminBloom* [64] and *Pokemon GO* [88]. Evidence of the development of these types of digital participatory platforms in regions such as Latin America or Africa remains rare in the analysed platforms, being represented only by *AMACHAN* [109], a web-based participatory mapping platform developed in Mexico.

4.5 Data dimensions

Geospatial data collection was central to location-based mobile apps, such as *You-Walk UoS* [96], *Location Hunting Game* [102] and *The Urban Belonging Photo APP* [65] and web-based mapping platforms such as *AMACHAN* [109] and *OGITO* [2], which can gather geolocated feedback from community-identified issues to inform planning decisions. Moreover, many of these platforms incorporate structured questions such as Likert-scale or multiple-choice items, pre-defined by planners or researchers to target specific information needs and objectives within the planning process. This quantitative input is also often complemented by open text comments, allowing users to provide qualitative feedback and express ideas or concerns more freely.

Several web-based platforms, such as *Maptionnaire* [66], *Crowdbrite* [25] and *Carticipe* [82] allow researchers and planners to flexibly design question inputs and data collection formats, making them a backbone for many public-sector planning consultations.

3D virtual environments and VR, and image generative AI such as *PlanYourPlace* [100], *euPolis* [54], *COHESIVE* [26], *Digital Commons* [78] and *UrbanistAI* [107], dominate the platforms for collaborative design and visualisation offering diverse design elements and tools for sketching ideas, visualising and creating diverse urban scenarios, engaging in role-play and immersing in virtual worlds. The prevalence of 3D and image generative AI in this type of participation mode reflects assumptions that visualisation platforms with immersive, realistic environments enhance comprehension and communication of different design proposals by non-expert users. However, some platforms documented drawbacks: analysis of *COHESIVE* [26] revealed that 3D visualisations of library objects could anchor participants' thinking, limiting their creativity by directing attention to visible features rather than broader ideas; *UrbanistAI* [107] excels at creating visual representations but is less effective at performing in-depth analytical tasks.

4.6 Gamification elements

Our analysis revealed a clear hierarchy in gamification element adoption in the platforms. Feedback mechanisms appeared almost universally in all technology types (44 platforms), constituting the baseline for digital participation by providing users with immediate responses and potentially reinforcing their sense of contribution. Some form of storytelling or narration featured in 14 platforms including *Shmapped* [67] and *Smart Citizen* [81], whilst progress appeared in 13 platforms including *CommunityPlanIt* [75] and *City Explorer* [80], helping to frame participation within a coherent narrative and reinforce continuity. Virtual territories and missions, potentially powerful for fostering ownership and sense of achievement, featured in 12 platforms and were particularly prominent in location-based mobile apps such as *Niantic's Ingress* [64] and *Pikmin Bloom* [64], as well as 3D virtual environments such as *Minecraft* [27] and the *Edible City Game* [90].

Gamification elements designed to foster competition, such as leaderboards, showed limited adoption, appearing in only 5 platforms, including *the Neighbourhood Hub* [28] and *Niantic's Ingress* [64]. Features that provide visual or tangible recognition of user contributions, such as badges and reward systems (e.g. vouchers) were also rare, identified in only 6 and 4 platforms respectively, including *CommunityPlanit* [75], *Smart Citizen* [81] and *Pokémon GO* [88].

Location-based mobile apps were the type of platforms that mostly placed emphasis on user engagement, integrating a wider range of gamification features, such as missions, points, avatars and progress indicators to encourage participation and sustain user interest throughout the planning process. The diversity of gamification features adopted in location-based mobile games contrasts with the reality of the web-based participatory mapping and image generative-AI tools, both of which rely almost exclusively on feedback mechanisms. In web-based participatory mapping platforms, the visual and interactive capabilities were often limited, resulting in survey-like experiences rather than truly engaging interfaces, with exception of the platform *CommunityPlanit* [75] which adopts a wide range of gamification features including points, leaderboards and badges. Meanwhile, generative-AI platforms rely almost exclusively on generated visuals to sustain user engagement.

5 Discussion

Our scoping review of 46 digital participatory urban planning platforms reveals a landscape characterised by both promising innovations and persistent gaps. In this section, we discuss these aspects and, on this basis, propose 19 design guidelines for next-generation platforms.

5.1 Synergies and disconnects between theoretical frameworks, planning practice and platform operationalisation

Academic scholarship on participatory urban planning emphasises inclusivity, contextual relevance, deliberation, engagement, transparency, long-term impact and consensus-building [36, 46, 49, 62, 76]. Digital participatory platforms are frequently positioned as instruments capable of operationalising these principles at scale.

Several platform functionalities reflect core participatory principles. Inclusivity is supported through online access, mobile compatibility, and asynchronous engagement modes that lower temporal and spatial barriers [33] and visualisation platforms that can facilitate comprehension of spatial trade-offs among non-expert participants [17, 87]. Contextual relevance is enabled through place-based inputs and geo-referenced annotations, allowing participants to anchor contributions in lived spatial experience [20, 92]. Engagement is addressed through interactive interfaces, visual feedback, and gamification elements such as progress indicators and missions [56, 71].

However, substantial gaps remain. Principles of trust and transparency require features communicating how citizen input informs planning decisions [49, 62], yet mechanisms linking contributions to binding outcomes are rarely addressed. This absence risks reducing participation to what Arnstein [6] termed *tokenism* or *placation*, the appearance of inclusion without substantive influence. Despite emphasis in participatory theory on deliberation and shared decision-making [36], most platforms aggregate individual inputs rather than facilitate collective sense-making, typically lacking features such as threaded discussions or collaborative workspaces that would enable dialogue and consensus-building [39, 48].

A critical gap concerns the integration of established theoretical frameworks such as NBS, ES and NCP into participatory planning efforts. Contemporary planning scholarship positions socio-ecological sustainability as integral to urban development, with NBS framed as multifunctional infrastructure addressing climate adaptation, biodiversity, and wellbeing [35, 77]. The ES [68] and NCP [31] frameworks provide conceptual foundations for understanding urban nature's plural values, including CES such as recreation, identity, and sense of place [19, 115]. Yet existing platforms rarely support NBS-specific inputs, ES perceptions or NCP assessments. The few platforms addressing NBS often reduce green-blue infrastructure to visual entities rather than components of complex socio-ecological systems, reflecting a broader pattern wherein platforms treat urban nature as aesthetic amenity rather than multifunctional infrastructure [16, 29].

Perhaps most critically, the relationship between platform-generated data and actual planning decisions remains opaque. Explicit documentation of citizen input being directly integrated into policy is notably absent from the analysed sources. This implementation gap represents a fundamental challenge that platform design alone cannot resolve persistent gaps without corresponding institutional commitments [34, 62]. The prevalence of prototype-level platforms that fail to progress beyond pilot phases further illustrates challenges of institutional integration and long-term impact.

5.2 Digitalisation and visualisation technologies' impact on participatory urban planning

Digitalisation transforms not only the scale of participation but also its fundamental character including who can participate, how contributions are mediated, and what knowledge is privileged or excluded.

A central tension permeates digital participatory planning: technologies designed to broaden inclusion may simultaneously create new barriers. The digital divide encompasses differential access to hardware and connectivity, variations in digital literacy, and cultural orientations toward digital interactions [33, 41]. Platforms requiring specialised hardware (e.g. VR headsets), high-bandwidth connectivity or advanced digital literacy may systematically exclude under-resourced communities and low-income groups, elderly populations, or those with lower technological proficiency, often the very demographics most vulnerable to urban transformation. Even accessible mobile platforms presuppose smartphone ownership and sufficient digital literacy, whilst over-gamified designs may alienate participants seeking more deliberative engagement modes [99]. The risk is that digitalisation may inadvertently narrow rather than broaden participant demographics [21, 62].

Conversely, visualisation technologies can offer valuable potential to the participatory process. Immersive 3D environments and AI-generated images, for example, can make abstract spatial proposals tangible and facilitate the understanding of planning constraints, and potential outcomes, fostering inclusivity of non-expert participants. However, pre-designed object libraries can anchor participants' thinking toward visible features rather than systemic considerations, whilst photorealistic AI visualisations risk creating false certainty about inherently uncertain futures. Equally significant is what visualisations commonly omit. Ecological processes, temporal dynamics, and sensory qualities beyond the visual are difficult to represent, potentially reinforcing biases towards visual dimensions over experiential qualities that shape how spaces are inhabited [7, 115].

Location-based mobile applications leverage GPS and AR technologies to situate participation within physical space, enabling contributions anchored to precise locations and collected during actual spatial experiences [10, 58]. Commercial location-based games have demonstrated the capacity of gamified applications to motivate exploration and sustained engagement at unprecedented scales [59, 88], suggesting unrealised potential for participatory planning. Yet in-situ technologies introduce limitations: GPS accuracy degrades in dense urban environments, battery consumption constrains extended sessions, privacy concerns arise from location tracking, and physical presence requirements may exclude those with mobility limitations or safety concerns.

5.3 Gamification elements that are context-specific to participatory urban planning

Gamification scholarship has long noted that many systems rely on feedback-heavy design elements - often summarised as *pointsification* [56, 99] - with mixed evidence across contexts [44, 56, 99]. Reviews of gamified crowdsourcing similarly report that simple reward and feedback structures dominate because they are easy to implement and fit high-throughput contribution goals [71, 72]. Our findings are consistent with the prominence of feedback (44/46 platforms), yet also reveal a notable contrast: traditional gamification features (points, badges, levels, leaderboards) and tangible rewards were comparatively rare, while progress-, mission-, and narrative-based structures were more common. This suggests that participatory planning may discourage winner/loser framings and strong extrinsic incentives, even when such designs are widespread elsewhere [56, 71].

Crucially, participatory urban planning platforms should not be treated as a straightforward extension of generic gamification. Unlike many crowdsourcing contexts that prioritise maximising contribution volume and quality [71, 72], participatory planning demands articulation of situated experiences, values, and trade-offs, as well as imagination of plausible futures for contested spaces. The core challenge is therefore not only eliciting input, but supporting meaning-making and collective legitimacy: participants must feel their contributions are understood, fairly represented, and consequential for decision-making [49]. This shifts attention

from *pointsification* toward mechanisms that ground participation in place, stimulate imagination, and sustain collaboration.

Three patterns appear particularly relevant. (1) Place-based meaning-making: in-situ missions and location-triggered tasks can leverage exploration, sense of place and place attachment to help residents notice overlooked features, reflect on needs, and translate tacit knowledge into shareable data [64, 67, 81, 88]. (2) Future-oriented imagination: 3D/VR and generative visualisations enable citizens to co-create and compare alternatives through sandbox-like interactions and role-playing elements [26, 27, 54, 86, 107]. (3) Cooperation and deliberation: because planning is inherently social and often deals with contested spaces and heterogeneous needs, gameful features that support perspective-taking, negotiation, and shared ownership may be preferable to competition. The results show a relative absence of leaderboards which highlights the need to carefully deliberate if participation should be framed as cooperation or competition [73]. In workshops and collaborative platforms, elements emphasising self-identity and collaboration such as avatars, role-play, and shared building are favourable and can operate as boundary objects for collective sense-making [78, 93].

Overall, the distinctive value of gamification in participatory urban planning lies less in commonly reported elements and more in situated, consequential, and socially constructive play: designs that connect participation to lived experience, enable exploration of futures, and prioritise legitimacy through cooperation, deliberation, and transparent feedback. This also underscores why closing the loop from citizen input to planning outcomes is a central motivational mechanism: if impact is unclear, surface-level rewards may be perceived as cosmetic and risk trivialising participation [49, 95].

5.4 Design Guidelines for next generation platforms

Drawing from successful implementations and identified gaps found during this review, we present a collection of design guidelines for future generation platforms, organised across interconnected categories that meaningfully engage citizens whilst addressing contemporary urban challenges (cf. figure 4).

Sustaining Long-term Engagement

The prevalence of prototype-stage platforms and limited documentation of sustained usage patterns underscores the critical challenge of maintaining participation beyond initial novelty. Future platforms should carefully consider *progressive engagement* that evolves with user expertise and commitment levels as well as *long-term retention mechanics*.

1: Implement adaptive difficulty curves. Rather than static interaction models, platforms should recognise user progression from novice to expert participants. Initial tasks should be simple (e.g. rating spaces, reporting issues) whilst gradually introducing complex activities (e.g. design proposals, trade-off negotiations).

2: Create meaningful feedback loops. Whilst feedback mechanisms appeared almost universally in our sample, their implementation varied dramatically in effectiveness. Platforms must close the loop between citizen input and planning outcomes, explicitly showing how contributions influenced decisions.

3: Design for episodic engagement. Rather than requiring continuous participation, platforms should accommodate varied temporal availability through asynchronous collaboration features, periodic campaigns, and re-engagement mechanisms. In addition, platforms should prioritise contributions to campaigns participants are most interested in. The success of location-based games in maintaining episodic engagement through events and seasonal content offers a continuous temporal perspective often lacking in urban planning. Furthermore, platforms that can adapt to both synchronous and asynchronous participation are better positioned to reach a wider audience and to address participation objectives more deeply.

4: Consider tangible reward systems carefully. Whilst intrinsic motivation should drive civic participation, strategic use of tangible rewards can increase engagement [71]. However, tangible rewards must be implemented cautiously – excessive monetisation risks attracting participation for wrong reasons, potentially degrading data quality and undermining civic motivations. Rewards should complement rather than replace intrinsic motivators, perhaps reserved for particularly effortful contributions or used during critical planning phases requiring broad input.

5: Establish sustained funding models and institutionalisation. The prevalence of discontinued prototypes highlights the challenge of maintaining platforms post-research or pilot phases. Sustainable models might include municipal consortiums sharing development costs, freemium approaches with basic free access, or integration with existing civic technology infrastructure. The long-term institutional context where the platform will be hosted after the initial development and piloting phase should be identified early in a project.

Ensuring Inclusive Accessibility

The tension between stated inclusivity goals and actual demographic reach reveals systemic design failures that future platforms must address through deliberate architectural choices.

6: Adopt progressive enhancement principles. Platforms should function across technological spectrums, from basic mobile browsers to advanced VR systems. Core functionality must remain accessible on low-specification devices whilst optional enhancements reward users with advanced capabilities.

7: Implement multi-modal input mechanisms. Beyond text and clicks, platforms should accept diverse input forms including voice recordings, hand-drawn sketches, photographs, and videos.

8: Design for digital literacy variance. Interfaces must accommodate users ranging from digital natives to those with limited technological experience. This requires progressive disclosure of complexity, accessible design of platform features, extensive onboarding support, and alternatives to purely digital interaction.

9: Prioritise open access and open-source approaches. Platforms should adopt open-source architectures and ensure data collected remains openly accessible to communities, researchers, and planners. Open-source development enables local adaptations, reduces vendor lock-in, and fosters innovation through community contributions. Equally important, citizen-generated data should remain publicly accessible (whilst respecting privacy), preventing commercial appropriation of community knowledge.

Balancing Gamification Elements

Our analysis reveals both the potential and pitfalls of gamification in planning contexts. Future platforms must carefully calibrate

game elements to enhance rather than distract from participatory goals.

10: Align game mechanics with planning objectives. Gamification elements should directly support desired behaviours rather than arbitrary engagement metrics. Points should reward quality contributions rather than quantity; missions should guide exploration of planning alternatives rather than repetitive tasks.

11: Implement collaborative rather than competitive mechanics. Competition can discourage participation from less confident users. Future platforms should emphasise collective achievements, shared goals, and collaborative problem-solving.

12: Avoid over-gamification. Platforms should carefully consider target audiences when implementing gamification mechanics to sustain engagement whilst maintaining overall seriousness appropriate to urban decision-making. Moreover, platforms should avoid reinforcing the digital divide by creating interfaces that favour only tech-savvy users comfortable with highly gamified environments.

Ensuring Data Actionability

The disconnect between data collection capabilities and planning integration highlights the need for platforms that generate actionable insights rather than merely accumulating inputs.

13: Design for planning workflow integration. The use of digital participatory platforms must align with existing planning processes, timelines, and decision points. In addition, data export formats, analytical tools, and reporting mechanisms should be interoperable with planning departments' technical capabilities and regulatory requirements.

14: Balance quantitative metrics with qualitative insights. Whilst structured data facilitates analysis, open-ended inputs capture nuanced local knowledge. Platforms should combine rating systems with narrative descriptions, standardised categories with emergent themes, and statistical summaries with illustrative cases.

15: Enable transparent data governance. Citizens must understand how their contributions will be used, who has access, and what privacy protections exist. Platforms should implement clear data policies, user control over personal information, and mechanisms for collective data stewardship.

Sustaining Collaborative Practices

Some of the analysed platforms still place strong emphasis on one-way communication, despite growing evidence that two-way, collaborative practices can make participatory processes more inclusive, democratic, and empowering for citizens.

16: Go beyond one-way direction information. Platforms should move beyond unidirectional information sharing, from planners to citizens or vice versa, and instead foster two-way communication. This involves integrating features such as discussion forums, comment threads, reaction functions and visual feedback that make participants' contributions and ideas visible, valued and shareable from the early stages of decision-making.

17: Sustain collaboration even in asynchronous participation. To maintain collaboration on-going platforms should incorporate interaction features, even if asynchronously, such as shared workspaces, reaction functions or delayed comment exchanges. This allows participants to engage at their own pace while still contributing to a collective process, strengthening community bonds while supporting different participation rhythms.

Integrating Nature-Based Solutions

The limited integration of NBS features across reviewed platforms represents a critical gap given urban climate and environmental challenges. Future platforms must move towards recognising NBS as important urban dimensions.

18: Embed NBS co-benefits visualisation. Platforms should aim to make the often invisible ecological benefits of NBS - such as biodiversity enhancement, stormwater management, and microclimatic cooling - more visible and understandable to citizens. This can be achieved through real-time feedback on the performance and impacts of these solutions, as well as by visually representing and contextualising them in tangible and explicit ways within the digital environment.

19: Support community-based NBS planning. Platforms should not only enable citizens to document and evaluate existing NBS through structured observation protocols but also provide opportunities for co-creation, allowing citizens and planners to jointly ideate and design these solutions even before their implementation. Without the integration of citizens and stakeholders perceptual knowledge, we fail to plan and design genuinely multifunctional NBS.

5.5 Limitations and Future Research Directions

Several limitations bound our findings. The rapid evolution of digital technologies means that our snapshot may quickly become outdated, particularly given the emerging integration of artificial intelligence in platforms developed post-2022. The limited documentation of long-term usage patterns and planning outcomes restricts our ability to assess actual impact beyond design intentions. The focus on English-language sources may have excluded relevant platforms from non-English contexts. Further, the thematic coding of the platforms is not exempt from the influence of the researchers´ cultural, personal and professional background. These positionalities inevitably may have shaped how platforms features were interpreted and categorised, despite efforts to maintain systematic and transparent coding procedures.

Future research should pursue longitudinal studies tracking platform usage and planning outcomes over extended periods. Comparative analyses across cultural contexts could reveal how local factors shape platform effectiveness. Experimental studies comparing different gamification approaches within controlled planning scenarios would provide causal evidence for design decisions. Investigation of hybrid physical-digital approaches merits particular attention for inclusive engagement.

Platforms incorporating emergent AI-approaches demonstrate AI's potential for translating abstract concepts into visual representations, yet questions remain about algorithmic bias, creative constraints, and the authenticity of AI-mediated participation. Future studies must examine how AI tools shape rather than simply support participatory processes.

The geographical concentration of platforms in Europe and North America raises questions about digital participation models' universality. Future research must examine how cultural, infrastructural, and institutional differences shape platform effectiveness across diverse urban contexts, particularly in the Global South where documentation remains limited.

Figure 4: Visual summary of the 19 identified guidelines for digital participatory urban planning. Each tile represents one guideline with colours representing guideline categories. Full guideline descriptions can be found in section 5.4.

6 Conclusions - Towards Playful Yet Meaningful Urban Futures

This work makes three principal contributions to the intersection of urban planning, citizen participation, and gamification research. First, we provide the most comprehensive taxonomy to date of DPUPPs, categorising 46 platforms across six dimensions. This framework bridges previously disconnected domains of game design, civic technology, and urban planning scholarship, offering a common vocabulary for interdisciplinary dialogue. Second, we identify critical gaps that limit current platforms' effectiveness. Third, through our design guidelines and recommendations, we demonstrate how scoping analyses can inform practical platform development. By synthesising lessons from successful implementations whilst learning from documented failures, we provide actionable guidance for municipalities, developers, and researchers working to enhance digital participation.

Our study also extends existing participation taxonomies to account for digital and gamified systems' unique characteristics and its temporal and interactional dynamics. The distinctions between synchronous/asynchronous modes and integration of data dimension types and game mechanics provide nuanced analytical lenses for examining and designing participatory systems that goes beyond linear participation ladders and better reflect the hybrid, mediated nature of contemporary digital participation.

As cities confront unprecedented challenges from climate change, over social inequality, to rapid technological disruption, the need for inclusive, effective participatory planning becomes ever more critical. Our analysis reveals that whilst digital platforms offer powerful capabilities for engaging citizens, realising this potential requires careful attention to design details, institutional contexts, and diverse user needs. The path forward lies neither in uncritical adoption of gamification nor in dismissing playful approaches as trivialising serious urban challenges. Instead, successful platforms will thoughtfully integrate game design insights with planning expertise, technological capabilities with human-centered design, and global connectivity with local specificity. The platforms we reviewed represent early experiments in this integration, providing valuable lessons for the next generation of platforms.

Ultimately, the goal is not simply to build better platforms but to foster more democratic, sustainable, and equitable cities. Digital platforms are means to this end, not ends in themselves. By learning from current implementations, addressing identified gaps, and following evidence-based guidelines, municipalities and developers can create platforms that transform citizen participation from occasional consultation to sustained collaboration in shaping urban futures.

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References

[1] David Adade and Walter Timo de Vries. 2025. A systematic review of digital twins' potential for citizen participation and influence in land use agenda-setting. *Discov. Sustain.* 6, 1 (April 2025), 1–21. doi:10.1007/s43621-025-01204-x

[2] Rosa Aguilar, Luis Calisto, Johannes Flacke, Aulia Akbar, and Karin Pfeffer. 2021. OGITO, an Open Geospatial Interactive Tool to Support Collaborative Spatial Planning with a Maptable. *Computers, Environment and Urban Systems* 86 (2021). doi:10.1016/j.compenvurbsys.2020.101591

[3] Sirwan Khalid Ahmed, Ribwar Arsalan Mohammed, Abdulqadir J Nashwan, Radhwan Hussein Ibrahim, Araz Qadir Abdalla, Barzan Mohammed M. Ameen, and Renas Mohammed Khdhir. 2025. Using thematic analysis in qualitative research. *J. Med. Surg. Public Health* 6, 100198 (Aug. 2025), 100198. doi:10.1016/j.glmedi.2025.100198

[4] Byeongsun Ahn. 2024. What changes over time? Planning history and institutional change from a policy design perspective. *Eur. Plan. Stud.* (July 2024), 1–20. doi:10.1080/09654313.2024.2377796

[5] Erik Andersson, Johannes Langemeyer, Sara Borgström, Timon McPhearson, Dagmar Haase, Jakub Kronenberg, David N Barton, Mckenna Davis, Sandra Naumann, Lina Röschel, and Francesc Baró. 2019. Enabling green and blue infrastructure to improve contributions to human well-being and equity in urban systems. *Bioscience* 69, 7 (July 2019), 566–574. doi:10.1093/biosci/biz058

[6] Sherry R Arnstein. 1969. A ladder of citizen participation. *J. Am. Inst. Plann.* 35, 4 (July 1969), 216–224. doi:10.1080/01944366908977225

[7] Itziar Aspuru, Igone García, Karmele Herranz, and Alvaro Santander. 2016. CITI-SENSE: Methods and Tools for Empowering Citizens to Observe Acoustic Comfort in Outdoor Public Spaces. *Noise Mapping* 3, 1 (2016). doi:10.1515/noise-2016-0003

[8] Cem Ataman, Simon Tangi Perrault, and Bige Tunçer. 2024. Fostering Inclusive Urban Design and Planning: Enhanced Trust and Reliability through Descriptive Instructions for Digital Citizen Participation. *Journal of Urban Technology* 31, 4-5 (2024), 25–48. doi:10.1080/10630732.2024.2421729

[9] Manuel Baer. 2024. Designing and implementing a global multilingual real-time location-based game as a novel highly gamified spatial crowdsourcing platform.. In *GamiFIN*. 88–109.

[10] Manuel Baer, Thomas Tregel, Samuli Laato, and Heinrich Söbke. 2022. Virtually (re)constructed reality: the representation of physical space in commercial location-based games. In *Proceedings of the 25th International Academic Mindtrek Conference*. ACM, New York, NY, USA. doi:10.1145/3569219.3569339

[11] Manuel Baer, Flurina M Wartmann, and Ross S Purves. 2019. StarBorn: Towards making in-situ land cover data generation fun with a location based game. *Trans. GIS* (2019), 1–21. doi:10.1111/tgis.12543

[12] Manuel F Baer and Ross S Purves. 2022. Window Expeditions: A playful approach to crowdsourcing natural language descriptions of everyday lived landscapes. *Appl. Geogr.* 148, 102802 (Nov. 2022), 102802. doi:10.1016/j.apgeog.2022.102802

[13] Edyta Bakowska-Waldmann and Tomasz Kaczmarek. 2021. The Use of PPGIS: Towards Reaching a Meaningful Public Participation in Spatial Planning. *ISPRS International Journal of Geo-Information* 10, 9 (2021). doi:10.3390/ijgi10090581

[14] Juan Carlos Laso Bayas, Linda See, Steffen Fritz, Tobias Sturn, Christoph Perger, Martina Dürauer, Mathias Karner, Inian Moorthy, Dmitry Schepaschenko, Dahlia Domian, and Ian McCallum. 2016. Crowdsourcing in-situ data on land cover and land use using gamification and mobile technology. *Remote Sensing* 8, 11 (2016), 1–18. doi:10.3390/rs8110905

[15] Hamish Beattie, Daniel Brown, and Sara Kindon. 2020. Solidarity through Difference: Speculative Participatory Serious Urban Gaming (SPS-UG). *International Journal of Architectural Computing* 18, 2 (June 2020), 141–154. doi:10.1177/1478077120924337

[16] Sara Biancifiori, Sara Torabi Moghadam, and Patrizia Lombardi. 2025. Participatory Digital Solutions for Nature-Based Solution Urban Projects: A Systematic PRISMA Literature Review. *Sustainability* 17, 17 (Jan. 2025), 7945. doi:10.3390/su17177945

[17] Ian D Bishop. 2011. Landscape planning is not a game: Should it be? *Landsc. Urban Plan.* 100, 4 (April 2011), 390–392. doi:10.1016/j.landurbplan.2011.01.003

[18] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 2 (Jan. 2006), 77–101. doi:10.1191/1478088706qp063oa

[19] Greg Brown and Nora Fagerholm. 2015. Empirical PPGIS/PGIS mapping of ecosystem services: A review and evaluation. *Ecosystem Services* 13 (2015), 119–133. doi:10.1016/j.ecoser.2014.10.007

[20] Greg Brown and Marketta Kyttä. 2014. Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. *Appl. Geogr.* 46 (2014), 122–136. doi:10.1016/j.apgeog.2013.11.004

[21] Martina Bubalo, Boris T van Zanten, and Peter H Verburg. 2019. Crowdsourcing geo-information on landscape perceptions and preferences: A review. *Landsc. Urban Plan.* 184, January (April 2019), 101–111. doi:10.1016/j.landurbplan.2019.

01.001

[22] Judy Bush and Andréanne Doyon. 2019. Building Urban Resilience with Nature-Based Solutions: How Can Urban Planning Contribute? *Cities* 95 (Dec. 2019), 102483. doi:10.1016/j.cities.2019.102483

[23] Irene Celino, Dario Cerizza, Simone Contessa, Marta Corubolo, Daniele Dellaglio, Emanuele Della Valle, and Stefano Fumeo. 2012. Urbanopoly - A social and location-based game with a purpose to crowdsource your urban data. In *Proceedings - 2012 ASE/IEEE International Conference on Privacy, Security, Risk and Trust and 2012 ASE/IEEE International Conference on Social Computing, SocialCom/PASSAT 2012*. 910–913. doi:10.1109/SocialCom-PASSAT.2012.138

[24] CommonPlace. 2025. *CommonPlace - Powering Positive Participation.* https://www.commonplace.is/

[25] Crowdbrite. 2025. *Crowdbrite solutions.* https://www.crowdbrite.com/

[26] Gamze Dane, Suzan Evers, Pauline van den Berg, Alexander Klippel, Timon Verduijn, Jan Oliver Wallgrün, and Theo Arentze. 2024. Experiencing the Future: Evaluating a New Framework for the Participatory Co-Design of Healthy Public Spaces Using Immersive Virtual Reality. *Computers, Environment and Urban Systems* 114 (Dec. 2024), 102194. doi:10.1016/j.compenvurbsys.2024.102194

[27] Italo Sousa de Sena, Lasith Niroshan, Jonas Rosecky, Vojtech Bruza, Micheal Butler, and Chiara Cocco. 2025. A Playful Participatory Planning System (P-PPS): A Framework for Collecting and Analyzing Player-Generated Spatial Data from Minecraft Worlds. *Isprs International Journal of Geo-Information* 14, 6 (May 2025), 210. doi:10.3390/ijgi14060210

[28] Matti Drechsel, Nick Forster, Dominik Berger, Gerhard Schubert, and Frank Petzold. 2023. Mobilizing Publics Reconsidering Digital Design as a Catalyst in Co-Creation Processes *(Proceedings of the International Conference on Education and Research in Computer Aided Architectural Design in Europe, Vol. 1).* 671–680. doi:10.52842/conf.ecaade.2023.1.671

[29] Lene Lundøy Drengenes and Håvard Haarstad. 2025. Digitally Mediated Nature: Assessing the Role of Digital Tools in Employing Nature-Based Solutions to Urban Sustainability. *Journal of Urban Technology* 0, 0 (Oct. 2025), 1–20. doi:10.1080/10630732.2025.2539660

[30] Jiunn-Der Duh, Vivek Shandas, Heejun Chang, and Linda A George. 2008. Rates of urbanisation and the resiliency of air and water quality. *Sci. Total Environ.* 400, 1-3 (Aug. 2008), 238–256. doi:10.1016/j.scitotenv.2008.05.002

[31] Sandra Díaz, Unai Pascual, Marie Stenseke, Berta Martín-López, Robert T Watson, Zsolt Molnár, Rosemary Hill, Kai M A Chan, Ivar A Baste, Kate A Brauman, Stephen Polasky, Andrew Church, Mark Lonsdale, Anne Larigauderie, Paul W Leadley, Alexander P E van Oudenhoven, Felice van der Plaat, Matthias Schröter, Sandra Lavorel, Yildiz Aumeeruddy-Thomas, Elena Bukvareva, Kirsten Davies, Sebsebe Demissew, Gunay Erpul, Pierre Failler, Carlos A Guerra, Chad L Hewitt, Hans Keune, Sarah Lindley, and Yoshihisa Shirayama. 2018. Assessing nature's contributions to people. *Science* 359, 6373 (Jan. 2018), 270–272. doi:10.1126/science.aap8826

[32] Titiana Petra Ertiö, Sampo Ruoppila, and Sarah-Kristin Thiel. 2016. Motivations to Use a Mobile Participation Application. In *Electronic Participation*, Efthimios Tambouris, Panos Panagiotopoulos, Øystein Sæbø, Maria A. Wimmer, Theresa A. Pardo, Yannis Charalabidis, Delfina Sá Soares, and Tomasz Janowski (Eds.). Springer International Publishing, Cham, 138–150. doi:10.1007/978-3-319-45074-2_11

[33] Titiana-Petra Ertiö. 2015. Participatory apps for urban planning—space for improvement. *Plan. Pr. Res.* 30, 3 (May 2015), 303–321. doi:10.1080/02697459.2015.1052942

[34] Enzo Falco and Reinout Kleinhans. 2018. Digital participatory platforms for co-production in urban development: A systematic review. *Int. J. E-plan. Res.* 7, 3 (July 2018), 52–79. doi:10.4018/ijepr.2018070105

[35] Niki Frantzeskaki. 2019. Seven lessons for planning nature-based solutions in cities. *Environ. Sci. Policy* 93 (March 2019), 101–111. doi:10.1016/j.envsci.2018.12.033

[36] Archon Fung. 2006. Varieties of participation in complex governance. *Public Adm. Rev.* 66, s1 (Dec. 2006), 66–75. doi:10.1111/j.1540-6210.2006.00667.x

[37] GeoCitizen. 2025. *GeoCitizen - Enabling Participation.* https://geocitizen.org/

[38] Andrea Ghermandi and Michael Sinclair. 2019. Passive crowdsourcing of social media in environmental research: A systematic map. *Glob. Environ. Change* 55, January (2019), 36–47. doi:10.1016/j.gloenvcha.2019.02.003

[39] J. E. Goncalves, G. Slingerland, S. Sarabi, and G. Dane. 2026. Process First, Tools Second: A Conceptual Framework to Embed Digital Participation in Planning Processes for Citizen Empowerment. *Cities* 170 (March 2026), 106645. doi:10.1016/j.cities.2025.106645

[40] Kavita Gonsalves, Marcus Foth, and Glenda Amayo Caldwell. 2021. Radical Placemaking: Utilizing Low-Tech AR/VR to Engage in Communal Placemaking during a Pandemic. *Interaction Design and Architecture(s)* 48 (June 2021), 143–164. doi:10.55612/s-5002-048-007

[41] Michael F Goodchild. 2007. Citizens as sensors: the world of volunteered geography. *GeoJournal* 69, 4 (2007), 211–221. doi:10.1007/s10708-007-9111-y

[42] Milad Haghani, Soheil Sabri, Chris De Gruyter, Ali Ardeshiri, Zahra Shahhoseini, Thomas W Sanchez, and Michele Acuto. 2023. The landscape and evolution of urban planning science. *Cities* 136, 104261 (May 2023), 104261. doi:10.1016/j.cities.2023.104261

[43] P Hall. 1998. *Cities in Civilization.* Pantheon Books.

[44] Juho Hamari, Jonna Koivisto, and Harri Sarsa. 2014. Does Gamification Work? – A Literature Review of Empirical Studies on Gamification. In *2014 47th Hawaii International Conference on System Sciences*. 3025–3034. doi:10.1109/HICSS.2014.377

[45] Stéphanie Hasler, Jérôme Chenal, and Marc Soutter. 2017. Digital tools as a means to foster inclusive, data-informed urban planning. *Civ. Eng. Arch.* 5, 6 (Dec. 2017), 230–239. doi:10.13189/cea.2017.050605

[46] Mathias Hofmann, Sander Münster, and Jörg Rainer Noennig. 2019. A Theoretical Framework for the Evaluation of Massive Digital Participation Systems in Urban Planning. *Journal of Geovisualization and Spatial Analysis* 4, 1 (Dec. 2019), 3. doi:10.1007/s41651-019-0040-3

[47] Mathias Hofmann, Sander Münster, and Jörg Rainer Noennig. 2020. A Theoretical Framework for the Evaluation of Massive Digital Participation Systems in Urban Planning. *Journal of Geovisualization and Spatial Analysis* 4, 1 (2020). doi:10.1007/s41651-019-0040-3

[48] Donagh Horgan and Branka Dimitrijević. 2019. Frameworks for Citizens Participation in Planning: From Conversational to Smart Tools. *Sustainable Cities and Society* 48 (July 2019), 101550. doi:10.1016/j.scs.2019.101550

[49] Judith E Innes and David E Booher. 2004. Reframing public participation: strategies for the 21st century. *Plan. Theory Pract.* 5, 4 (Dec. 2004), 419–436. doi:10.1080/1464935042000293170

[50] Troy Innocent and Dale Leorke. 2019. Heightened Intensity: Reflecting on Player Experiences in Wayfinder Live. *Convergence* 25, 1 (Feb. 2019), 18–39. doi:10.1177/1354856518822427

[51] International Association for Public Participation (IAP2). 2024. IAP2's Public Participation Spectrum. https://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/iap2_spectrum_2024.pdf (c) International Association for Public Participation www.iap2.org.

[52] Nadja Kabisch, Niki Frantzeskaki, Stephan Pauleit, Sandra Naumann, Mckenna Davis, Martina Artmann, Dagmar Haase, Sonja Knapp, Horst Korn, Jutta Stadler, Karin Zaunberger, and Aletta Bonn. 2016. Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society* 21, 2 (2016). doi:10.5751/ES-08373-210239

[53] Jens Kandt and Michael Batty. 2021. Smart cities, big data and urban policy: Towards urban analytics for the long run. *Cities* 109, 102992 (Feb. 2021), 102992. doi:10.1016/j.cities.2020.102992

[54] Ioannis Kavouras, Ioannis Rallis, Emmanuel S. Sardis, Eftychios E. Protopapadakis, Anastasios D. Doulamis, and Nikolaos D. Doulamis. 2025. Empowering Communities through Gamified Urban Design Solutions. *Smart Cities* 8, 2 (2025). doi:10.3390/smartcities8020044

[55] Ioannis Kavouras, Emmanuel S. Sardis, Eftychios E. Protopapadakis, Ioannis Rallis, Anastasios D. Doulamis, and Nikolaos D. Doulamis. 2023. A Low-Cost Gamified Urban Planning Methodology Enhanced with Co-Creation and Participatory Approaches. *Sustainability (Switzerland)* 15, 3 (2023). doi:10.3390/su15032297

[56] Jonna Koivisto and Juho Hamari. 2019. The rise of motivational information systems: A review of gamification research. *Int. J. Inf. Manage.* 45, July 2018 (2019), 191–210. doi:10.1016/j.ijinfomgt.2018.10.013

[57] Jakub Kronenberg. 2025. From neoliberal urban green space production and consumption to urban greening as part of a degrowth agenda. *Cities* 159, 105739 (April 2025), 105739. doi:10.1016/j.cities.2025.105739

[58] Samuli Laato, Sampsa Rauti, Tarja Pietarinen, and Teemu H Laine. 2019. Analysis of the quality of points of interest in the most popular location-based games. *ACM International Conference Proceeding Series* (2019), 153–160. doi:10.1145/3345252.3345286

[59] Samuli Laato, Sara Siqueira, Manuel Baer, Konstantinos Papangelis, Bastian Kordyaka, Timo Nummenmaa, and Juho Hamari. 2025. User Motivations to Participate in Crowdsourcing and Contribute User-generated Content on Location-based Media: A Literature Review. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*. 1–20.

[60] Samuli Laato and Thomas Tregel. 2023. Into the Unown: Improving location-based gamified crowdsourcing solutions for geo data gathering. *Entertain. Comput.* 46, 100575 (May 2023), 100575. doi:10.1016/j.entcom.2023.100575

[61] Laneform. 2025. *Laneform - Rapidly reimagine urban spaces.* https://www.laneform.com/

[62] Crystal Legacy. 2017. Is there a crisis of participatory planning? *Plan. Theory* 16, 4 (Nov. 2017), 425–442. doi:10.1177/1473095216667433

[63] Andrew Lovett, Katy Appleton, Barty Warren-Kretzschmar, and Christina Von Haaren. 2015. Using 3D visualization methods in landscape planning: An evaluation of options and practical issues. *Landsc. Urban Plan.* 142 (Oct. 2015), 85–94. doi:10.1016/j.landurbplan.2015.02.021

[64] Amari Low, Jane Turner, and Marcus Foth. 2022. Pla(y)Cemaking With Care: Locative Mobile Games as Agents of Place Cultivation. In *Proceedings of the 25th International Academic Mindtrek Conference (Academic Mindtrek '22)*. Association for Computing Machinery, New York, NY, USA, 135–146. doi:10.1145/3569219.3569311

[65] Anders Koed Madsen, Sofie Burgos-Thorsen, Carlo De Gaetano, Drude Ehn, Maarten Groen, Sabine Niederer, Kathrine Norsk, and Thorben Simonsen. 2023. The Urban Belonging Photo App: A Toolkit for Studying Place Attachments with Digital and Participatory Methods. *Methodological Innovations* 16, 3 (Nov. 2023), 292–314. doi:10.1177/20597991231185351

[66] Maptionnaire. 2025. *Stop Guessing. Start Community Mapping.* https://www.maptionnaire.com/

[67] Kirsten McEwan, Miles Richardson, Paul Brindley, David Sheffield, Crawford Tait, Steve Johnson, Hana Sutch, and Fiona J Ferguson. 2020. Shmapped: Development of an App to Record and Promote the Well-Being Benefits of Noticing Urban Nature. *Translational Behavioral Medicine* 10, 3 (Aug. 2020), 723–733. doi:10.1093/tbm/ibz027

[68] MEA. 2005. *Millennium Ecosystem Assessment (MEA).* Technical Report. Island Press. doi:10.3897/zookeys.715.13865

[69] Marek Młodkowski and Piotr L. Jankowski. 2024. Usability of PPGIS Tools Exemplified by Geodiscussion - a Tool for Public Participation in Shaping Public Space. *Open Geosciences* 16, 1 (2024). doi:10.1515/geo-2022-0668

[70] David Moher, Alessandro Liberati, Jennifer Tetzlaff, Douglas G Altman, and PRISMA Group. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J. Clin. Epidemiol.* 62, 10 (Oct. 2009), 1006–1012. doi:10.1016/j.jclinepi.2009.06.005

[71] Benedikt Morschheuser, Juho Hamari, and Jonna Koivisto. 2016. Gamification in crowdsourcing: A review. *Proceedings of the Annual Hawaii International Conference on System Sciences* 2016-March, October 2017 (2016), 4375–4384. doi:10.1109/HICSS.2016.543

[72] Benedikt Morschheuser, Juho Hamari, Jonna Koivisto, and Alexander Maedche. 2017. Gamified crowdsourcing: Conceptualization, literature review, and future agenda. *International Journal of Human-Computer Studies* 106 (2017), 26–43.

[73] Benedikt Morschheuser, Juho Hamari, and Alexander Maedche. 2019. Cooperation or competition – When do people contribute more? A field experiment on gamification of crowdsourcing. *International Journal of Human Computer Studies* 127, October 2018 (2019), 7–24. doi:10.1016/j.ijhcs.2018.10.001

[74] Johannes Müller, Hangxin Lu, Artem Chirkin, Bernhard Klein, and Gerhard N. Schmitt. 2018. Citizen Design Science: A Strategy for Crowd-Creative Urban Design. *Cities (London, England)* 72 (2018), 181–188. doi:10.1016/j.cities.2017.08.018

[75] Sander Münster, Christopher Georgi, Katrina Heijne, Kevin Klamert, Jörg Rainer Noennig, Matthias Pump, Benjamin Stelzle, and Han van der Meer. 2017. How to Involve Inhabitants in Urban Design Planning by Using Digital Tools? An Overview on a State of the Art, Key Challenges and Promising Approaches *(Procedia Computer Science, Vol. 112).* 2391–2405. doi:10.1016/j.procs.2017.08.102

[76] Lucy Natarajan and Sara Hassan. 2024. 9DF: A Nine-Dimensional Framework for Community Engagement. *Town Planning Review* 95, 3 (May 2024), 283–306. doi:10.3828/tpr.2024.8

[77] Carsten Nesshöver, Timo Assmuth, Katherine N Irvine, Graciela M Rusch, Kerry A Waylen, Ben Delbaere, Dagmar Haase, Lawrence Jones-Walters, Hans Keune, Eszter Kovacs, Kinga Krauze, Mart Külvik, Freddy Rey, Jiska van Dijk, Odd Inge Vistad, Mark E Wilkinson, and Heidi Wittmer. 2017. The science, policy and practice of nature-based solutions: An interdisciplinary perspective. *Sci. Total Environ.* 579 (Feb. 2017), 1215–1227. doi:10.1016/j.scitotenv.2016.11.106

[78] Provides Ng, Shutong Zhu, Yuechun Li, and Jeroen B. van Ameijde. 2024. Digitally Gamified Co-Creation: Enhancing Community Engagement in Urban Design through a Participant-Centric Framework. *Design Science* 10 (2024). doi:10.1017/dsj.2024.17

[79] Pilvi Nummi, Viktorija Prilenska, Kristi Grisakov, Henna Fabritius, Laugren Ilves, Petri Kangassalo, Aija Staffans, and Xunran Tan. 2022. Narrowing the Implementation Gap: User-Centered Design of New E-Planning Tools. *International Journal of E-Planning Research* 11, 1 (2022). doi:10.4018/IJEPR.315804

[80] Carolyn Pang, Carman Neustaedter, Karyn Moffatt, Kate Hennessy, and Rui Pan. 2020. The Role of a Location-Based City Exploration Game in Digital Placemaking. *Behaviour & Information Technology* 39, 6 (June 2020), 624–647. doi:10.1080/0144929X.2019.1697899

[81] Irina Paraschivoiu and Thomas Layer-Wagner. 2021. Placemaking for Urban Sustainability: Designing a Gamified App for Long-term, Pro-environmental Participation. In *Extended Abstracts of the 2021 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '21).* Association for Computing Machinery, New York, NY, USA, 186–191. doi:10.1145/3450337.3483482

[82] Participedia. 2025. *Carticipe/Debatomap.* https://participedia.net/method/carticipe

[83] PlaceMakingAI. 2025. *PlaceMakingAI - The New AI-Driven Real Estate Landscape.* https://www.placemaking.ai/

[84] PlaceSpeak. 2025. *PlaceSpeak - Citizen engagement you can trust.* https://www.placespeak.com/en/

[85] Mary M Pleasant, Steven A Gray, Christopher Lepczyk, Anthea Fernandes, Nathan Hunter, and Derek Ford. 2014. Managing cultural ecosystem services. *Ecosystem Services* 8 (2014), 141–147. doi:10.1016/j.ecoser.2014.03.006

[86] Alenka Poplin, Bruno de Andrade, and Ítalo de Sen. 2023. Let's Discuss Our City! Engaging Youth in the Co-Creation of Living Environments with Digital Serious Geogames and Gamified Storytelling. *Environment and Planning B: Urban Analytics and City Science* 50, 4 (May 2023), 1087–1103. doi:10.1177/23998083221133828

[87] M E Portman, A Natapov, and D Fisher-Gewirtzman. 2015. To go where no man has gone before: Virtual reality in architecture, landscape architecture and environmental planning. *Comput. Environ. Urban Syst.* 54 (Nov. 2015), 376–384. doi:10.1016/j.compenvurbsys.2015.05.001

[88] Ruth Potts and Lachlan Yee. 2019. Pokémon Go-ing or Staying: Exploring the Effect of Age and Gender on Augmented Reality Game Player Experiences in Public Spaces. *Journal of Urban Design* 24, 6 (Nov. 2019), 878–895. doi:10.1080/13574809.2018.1557513

[89] Jennifer Preece and Ben Shneiderman. 2009. The reader-to-leader framework: Motivating technology-mediated social participation. *AIS Trans. Hum.-Comput. Interact.* 1, 1 (2009), 13–32.

[90] Josep Pueyo, Joaquim Comas, Ina Säumel, J. A.C. Castellar, Lucia Alexandra Popartan, Vicenç Acuña, and Lluís Corominas. 2023. Design of a Serious Game for Participatory Planning of Nature-Based Solutions: The Experience of the Edible City Game. *Nature-Based Solutions* 3 (2023). doi:10.1016/j.nbsj.2023.100059

[91] Christopher M Raymond, Nora Fagerholm, and Marketta Kyttä. 2020. Honouring the participatory mapping contributions and enduring legacy of Professor Gregory G. Brown. *Appl. Geogr.* 116 (2020). doi:10.1016/j.apgeog.2020.102155

[92] Christopher M Raymond, Sarah Gottwald, Jenni Kuoppa, and Marketta Kyttä. 2016. Integrating multiple elements of environmental justice into urban blue space planning using public participation geographic information systems. *Landsc. Urban Plan.* 153 (Sept. 2016), 198–208. doi:10.1016/j.landurbplan.2016.05.005

[93] Ernest Redondo, Héctor Zapata, Isidro Navarro, David Fonseca, Lluís Gimenez, Miguel Ángel Pérez, and Mónica Sánchez-Sepúlveda. 2020. GAME4CITY. Gamification for Citizens Through the Use of Virtual Reality Made Available to the Masses. Viability Study in Two Public Events. In *Learning and Collaboration Technologies. Human and Technology Ecosystems*, Panayiotis Zaphiris and Andri Ioannou (Eds.). Springer International Publishing, Cham, 315–332. doi:10.1007/978-3-030-50506-6_23

[94] Catarina C. Rolim and Patrícia Baptista. 2021. Sharing Lisboa: A Digital Social Market to Promote Sustainable and Energy Efficient Behaviours. *Climate* 9, 2 (Feb. 2021), 34. doi:10.3390/cli9020034

[95] Richard M Ryan and Edward L Deci. 2000. Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemp. Educ. Psychol.* 25, 1 (2000), 54–67. doi:10.1006/ceps.1999.1020

[96] Ashraf M. Salama and Madhavi Prashant Patil. 2025. A mobile application tool for co-assessing urban open spaces–a test case of the Grey's Monument, Newcastle, UK. *Journal of Urban Design* 30, 4 (2025), 493 – 519. doi:10.1080/13574809.2024.2363818

[97] Henry Sauermanna and Chiara Franzonib. 2015. Crowd science user contribution patterns and their implications. *Proc. Natl. Acad. Sci. U. S. A.* 112, 3 (2015), 679–684. doi:10.1073/pnas.1408907112

[98] Sven Schmuderer, Roland Zink, and Werner Gamerith. 2019. Citizen Participation via Digital Maps: A Comparison of Current Applications. *GI_Forum* 7, 2 (2019), 34–46. doi:10.1553/GISCIENCE2019_02_S34

[99] Katie Seaborn and Deborah I Fels. 2015. Gamification in theory and action: A survey. *Int. J. Hum. Comput. Stud.* 74 (2015), 14–31. doi:10.1016/j.ijhcs.2014.09.006

[100] Stefan Steiniger, Mohammad Ebrahim Poorazizi, and Andrew J.S. Hunter. 2016. Planning with Citizens: Implementation of an e-Planning Platform and Analysis of Research Needs. *Urban Planning* 1, 2 (2016), 49–64. doi:10.17645/up.v1i2.607

[101] Osamuyimen Stewart, David Lubensky, and Juan M Huerta. 2010. Crowdsourcing participation inequality: a SCOUT model for the enterprise domain. In *Proceedings of the ACM SIGKDD Workshop on Human Computation.* ACM, New York, NY, USA. doi:10.1145/1837885.1837895

[102] Salma Tabi and Yasushi Ikeda. 2023. Location Hunting Game: Developing an Application to Promote Gameful Hybrid Machi-Aruki Town Exploration. *Urban Science* 7, 4 (2023). doi:10.3390/urbansci7040126

[103] Nigel Taylor. 1998. *Urban planning theory since 1945.* SAGE Publications, Thousand Oaks, CA. doi:10.4135/9781446218648

[104] Rosa Thoneick. 2021. Integrating Online and Onsite Participation in Urban Planning: Assessment of a Digital Participation System. 20 pages. doi:10.4018/IJEPR.2021010101

[105] Y F Tuan. 1977. *Space and Place: The Perspective of Experience.* E. Arnold.

[106] UN-HABITAT. 2021. *World cities report 2020: The value of sustainable urbanization.* United Nations, New York, NY.

[107] UrbanistAI. 2025. *UrbanistAI - The platform to reimagine the future of our cities.* https://site.urbanistai.com/

[108] OITA US EPA. 2014. Public Participation Guide: Selecting the Right Level of Public Participation. https://www.epa.gov/international-cooperation/public-participation-guide-selecting-right-level-public-participation.

[109] Sergio Alvarado Vazquez, Frank Olaf Ostermann, Ana Mafalda Madureira, and Karin Pfeffer. 2025. Using a Digital Participatory Platform to Evaluate Public Space Quality. *GeoJournal* 90, 3 (2025). doi:10.1007/s10708-025-11383-9

[110] Jeroen Verplanke, Michael K McCall, Claudia Uberhuaga, Giacomo Rambaldi, and Muki Haklay. 2016. A Shared Perspective for PGIS and VGI. *Cartogr. J.* 53, 4 (2016), 1–10. doi:10.1080/00087041.2016.1227552

[111] Kun Wang, Zhihao Sun, Meng Cai, Lingbo Liu, Hao Wu, and Zhenghong Peng. 2022. Impacts of urban blue-green space on residents' health: A bibliometric review. *Int. J. Environ. Res. Public Health* 19, 23 (Dec. 2022), 16192. doi:10.3390/ijerph192316192

[112] Ronghua Wang, Jingwei Zhao, Michael J Meitner, Yue Hu, and Xiaolin Xu. 2019. Characteristics of urban green spaces in relation to aesthetic preference and stress recovery. *Urban Forestry & Urban Greening* 41 (May 2019), 6–13. doi:10.1016/j.ufug.2019.03.005

[113] F M Wartmann, M F Baer, K T Hegetschweiler, C Fischer, M Hunziker, and R S Purves. 2021. Assessing the potential of social media for estimating recreational use of urban and peri-urban forests. *Urban For. Urban Greening* 64, July (2021), 127261. doi:10.1016/j.ufug.2021.127261

[114] Flurina M Wartmann, Olga Koblet, and Ross S Purves. 2021. Assessing experienced tranquillity through natural language processing and landscape ecology measures. *Landsc. Ecol.* 36, 8 (2021), 2347–2365. doi:10.1007/s10980-020-01181-8

[115] Flurina M Wartmann, Koen F Tieskens, Boris T van Zanten, and Peter H Verburg. 2019. Exploring tranquillity experienced in landscapes based on social media. *Appl. Geogr.* 113, November (2019), 102112. doi:10.1016/j.apgeog.2019.102112

[116] Alexander Wilson, Mark Tewdwr-Jones, and Rob Comber. 2019. Urban Planning, Public Participation and Digital Technology: App Development as a Method of Generating Citizen Involvement in Local Planning Processes. *Environment and Planning B: Urban Analytics and City Science* 46, 2 (Feb. 2019), 286–302. doi:10.1177/2399808317712515

[117] Claes Wohlin. 2014. Guidelines for snowballing in systematic literature studies and a replication in software engineering. In *Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering*. ACM, New York, NY, USA. doi:10.1145/2601248.2601268

[118] Yanhua Yao, Zheyu Li, and Sai Ma. 2025. Exploring Gamification's Role in Shaping Socially Sustainable Urban Spaces: A Case Study of Gensen in SOLANA, Beijing. *Buildings* 15, 12 (2025). doi:10.3390/buildings15121969

Supplementary Material

Table S1: Overview of digital participatory urban planning platforms identified in the scoping review

Tool Type	Name & Citation	Purpose in urban planning	Participation mode	Data dimensions	Gamification features
Location-based mobile games	**YouWalk UOS** [96]	Evaluates the quality of urban open spaces based on users' functional, social, and perceptual experiences.	**Consultation** – citizens assess open spaces by visiting sites or selecting preloaded images and submitting ratings through the app.	Likert-scale ratings, photos, and text feedback.	Minimal; survey-like feedback only.
	The neighborhood hub prototype [28]	Collects residents' mobility patterns and preferences for hub placement.	**Consultation and collaboration** – residents participate in workshops, then use a gamified mobile app to submit preferences and evaluate others' ideas.	Structured questions, geolocation, design scenarios, and votes.	Avatars, points, leaderboards, progress, feedback, missions.
	Location Hunting Game [102]	Promotes community exploration and awareness of local issues through playful urban walks.	**Consultation** – participants walk or cycle, upload geo-tagged photos, and guess locations of others' submissions via an online map.	Geotagged photos, voting reactions, comments.	Feedback and virtual territories.
	The urban belonging PhotoApp [65]	Studies citizens' emotional connection to urban spaces by gathering annotated photos and reflections.	**Consultation** – participants take photos of meaningful sites, annotate them with feelings, and react to others' submissions.	Photos, annotations, geolocation, Likert scales.	Feedback.
	Niantic's Ingress [64]	Encourages exploration of landmarks and generates spatial data for potential planning analysis.	**Consultation** – players physically visit real-world points of interest and engage with virtual "portals."	Geospatial data.	Points, leaderboards, levels, storytelling, missions, feedback.
	PikminBloom [64]	Promotes walking and records frequent pedestrian routes, supporting active mobility planning.	**Information and consultation** – users walk while the app runs in the background, tracking routes and rewarding activity.	Geospatial tracking data.	Points, levels, badges, storytelling, progress, feedback, avatar, competition
	PlantThe World [64]	Fosters environmental engagement by linking virtual tree-planting to real-world ecological pledges.	**Consultation** – players walk through cities to collect seeds and plant virtual trees that symbolize environmental actions.	Geospatial data and user activity logs.	Storytelling, missions, rankings, avatars, rewards, feedback, competition
	Smart Citizen [81]	Promotes local engagement and sustainability actions through gamified activities.	**Information, consultation, and collaboration** – users receive sustainability prompts, report local issues, and co-produce improvement ideas via the app.	Geolocation, text annotations, behavioral data.	Points, badges, levels, storytelling, missions, feedback.
	Sharing Lisboa [94]	Encourages energy-efficient and sustainable practices among residents through digital incentives.	**Information and consultation** – users perform sustainable actions, submit evidence, and earn digital rewards.	Self-reported actions, geolocation, engagement data.	Points, rewards, progress, feedback.
	City explorer [80]	Enhances urban awareness by collecting location-based citizen input along transit routes.	**Consultation** – users share and comment on geolocated posts about neighborhood highlights or issues.	Geotagged posts, structured questions, comments.	Points, leaderboards, progress, missions, competition.
	Shmapped [67]	Records well-being benefits of nature exposure to guide blue-green infrastructure design.	**Consultation** – users respond to prompts about mood and surroundings when visiting green areas.	GPS location, text feedback, mood data.	Storytelling and feedback.
	Wayfinder Live [50]	Activates public spaces through augmented reality experiences that connect art, play, and urban identity.	**Information and consultation** – players scan urban QR codes during city events to unlock AR animations, share insights, and discuss place identity.	Geolocation data, scanned codes, text feedback.	Points, storytelling, progress, competition, virtual territories.
	Pókemon-Go [88]	Provides insight into how diverse groups use and experience public spaces through gameplay patterns.	**Consultation** – players explore real environments to capture virtual creatures, generating geolocation data that reveal urban movement patterns.	Geospatial tracking and behavioral data.	Points, leaderboards, badges, storytelling, missions, competition, avatar.
	Change explorer [116]	Enhances community awareness and placemaking along transit routes by mapping user experiences.	**Consultation** – residents report highlights and concerns on an interactive map and comment on others' inputs during daily commutes.	Geo-tagged comments, photos, structured survey data.	Points, leaderboards, progress, missions, competition.

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Tool Type	Name & Citation	Purpose in urban planning	Participation mode	Data dimensions	Gamification features
	Citi-Sense [7]	Engages citizens in assessing and mapping urban soundscapes for improved acoustic comfort.	**Consultation** – users record sounds and rate comfort levels in various public spaces.	Geolocation and sound perception data.	Feedback.
	Tääsa [32]	Collects citizens' perceptual evaluations of built environment qualities (safety, aesthetics, comfort).	**Consultation** – individuals upload geotagged photos and rate places using predefined categories.	Geolocation, perceptual ratings, photos.	Feedback.
Web-based participatory mapping	**Amachan** [109]	Collects citizens' evaluations of public-space quality to identify local priorities.	**Consultation** – participants complete online map questionnaires, marking locations and rating qualities.	Spatial survey data, georeferenced perceptions.	Feedback.
	Geodiscussion administrative Panel [69]	Enables geo-referenced public discussion of urban issues for planning input.	**Consultation** – residents asynchronously post comments or suggestions linked to map locations.	Text comments tied to coordinates.	Feedback.
	Consul Project [8]	Enables citizens to propose and vote on urban projects in municipal decision-making.	**Collaboration** – users submit and discuss proposals online, then vote on preferred options.	Text proposals, voting data, location tags.	Feedback, leaderboards, progress.
	DIPAS System [104]	Collects citizen feedback during public meetings and online sessions.	**Consultation** – participants place digital stickers and write comments on shared online maps during workshops or remote sessions.	Text comments, spatial markers.	Feedback.
	GEOAnkieta [13]	Gathers residents' preferences and knowledge to inform local plans.	**Consultation** – users draw areas or routes on maps and rate them through structured questions.	Geotagged drawings, satisfaction ratings.	Feedback.
	OGITO [2]	Facilitates shared real-time mapping and idea generation in planning workshops.	**Consultation** – multiple users collaboratively draw, annotate, and edit maps on a shared digital table.	GIS layers, annotations, design elements.	Feedback.
	PubinPlan [98]	Engages youth in spatial planning education through interactive map posts.	**Consultation** – students log in to place geo-referenced pins and comments about local development.	Text annotations, geolocated posts.	Feedback.
	Community PlanIt [75]	Collects input on community plans while teaching planning concepts.	**Information and collaboration** – players complete online missions, quizzes, and discussions, earning coins to allocate to projects.	Votes, text input, geodata, photos.	Points, leaderboards, storytelling, missions, progress.
	PlanYourPlace [100]	Supports online participation in zoning and plan design.	**Information and collaboration** – citizens review plan documents, comment on maps, and propose design alternatives online.	Text comments, geolocation, design sketches.	Feedback, missions, rankings.
	Carticipe [82]	Allows citizens to share and vote on spatial ideas about city development.	**Consultation** – users drop pins, comment, and vote on others' proposals through a city-specific map.	Geolocated pins, votes, text.	Feedback.
	Maptionnaire [66]	Gathers spatial feedback on planning issues through interactive online maps.	**Consultation** – participants answer map-based surveys by placing points, lines, or polygons and completing questions.	Spatial geometries, survey responses, multimedia.	Feedback.
	Crowdbrite [25]	Facilitates collaborative brainstorming during design workshops.	**Collaboration** – participants post virtual sticky notes, images, and comments on shared online boards.	Geolocated notes, images, polls.	Feedback.
	PlaceSpeak [84]	Consult local residents to about interventions happening on their neighborhoods	**Information and consultation** – residents register their address, view local projects, and comment or respond to surveys.	Text, polls, geolocated verification.	Feedback.
	Commonplace [24]	Enables community feedback for urban regeneration and infrastructure projects.	**Consultation** – users post comments on maps and complete structured surveys asynchronously.	Geolocated text, structured survey data, upvotes.	Feedback.
	GeoCitizen [37]	Supports collaborative mapping, issue reporting, and project monitoring.	**Consultation and collaboration** – residents place pins, share ideas, and vote on community proposals through a public map interface.	Texts, geolocated pins, polls.	Feedback, badges, levels.

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Tool Type	Name & Citation	Purpose in urban planning	Participation mode	Data dimensions	Gamification features
3D environments and Virtual Reality	**Minecraft** [27]; [86]	Enables citizens to co-design urban spaces in a widely deployed and commercialized 3D game environment.	**Collaboration** – participants build virtual models of their neighborhoods individually or in workshops, sharing proposals online.	3D spatial models, in-game chat, design layers.	Storytelling, missions, virtual territories, competition.
	Metaverse GENSEN platfom [118]	Allows citizens to customize digital twins of urban areas and test design options.	**Collaboration** – users manipulate 3D objects, experiment with layouts, and interact in a shared metaverse space.	3D object placement, social interaction data.	Points, levels, avatars, missions, storytelling, rewards, feedback.
	EuPolis [54]	Engages communities in co-designing nature-based urban solutions.	**Collaboration** – citizens join role-playing game workshops, using a 3D virtual environment to allocate green elements and resources.	3D design inputs, resource allocation, narrative feedback.	Missions, storytelling, avatars, rewards, feedback.
	COHESIVE [26]	Uses VR to support collaborative design of healthy public spaces.	**Collaboration** – small groups use VR headsets to explore urban scenarios and select preferred design alternatives.	3D design options, qualitative responses, interaction logs.	Feedback.
	Digital Commons [78]	Involves communities in urban space co-design and decision-making through 3D scenarios.	**Collaboration** – participants co-create and evaluate 3D design ideas during facilitated workshops.	3D mockups, voting data, text annotations.	Points, badges, storytelling, feedback, progress.
	Edible City Game [90]	Facilitates participatory planning of urban agriculture and edible landscapes.	**Collaboration** – participants assume roles (citizens, planners, entrepreneurs) and co-design edible city scenarios during workshops.	Visual mockups, text annotations, voting polls.	Progress, storytelling, feedback, virtual territories.
	Virtual Green Planner [79]	Supports participatory design of urban green infrastructure in a 3D environment.	**Collaboration** – workshop participants add green elements to digital neighborhood models and test configurations.	3D design data, visual mockups, saved variants.	Feedback.
	Chatty Bench project AR [40]	Promotes community dialogue and reflection on public spaces through AR interactions.	**Consultation** – citizens scan QR codes at benches to launch AR dialogues and share comments.	Qualitative feedback, audio interaction, geolocation.	Storytelling, feedback.
	Game4City VR [93]	Presents alternative urban design scenarios to gather citizen feedback.	**Information and consultation** – citizens experience 3D scenarios using VR headsets at public events and vote for preferred designs.	3D visualization, votes.	Feedback.
	Maslow´s Palace [15]	Encourages reflection on social inclusion through participatory VR design workshops.	**Collaboration** – participants interact in 3D urban environments to design spaces addressing different community needs.	Spatial design outputs, qualitative input.	Storytelling, missions, feedback.
	U_Code [47]	Facilitates large-scale urban idea generation in 3D environments and early-stage design collaboration.	**Collaboration** – citizens sketch on 2D/3D maps, post ideas, comment, and vote asynchronously online.	Text ideas, sketches, polls, votes.	Feedback.
	Quick Urban Analysis Kit (Qua-Kit) [74]	Supports collaborative urban design through modular 3D modeling and analysis.	**Collaboration** – individuals or groups modify 3D blocks in digital city models during workshops or online sessions.	3D spatial design data, analytics.	Feedback.
Image GenerativeAI	**UrbanistAI** [107]	Supports participatory placemaking by enabling communities to co-create urban design ideas using AI-generated imagery.	**Collaboration** – participants co-design spaces during workshops or individually online, generating AI-assisted visual proposals and voting on options.	AI-generated images, voting data, qualitative feedback, audios and image upload	Feedback.
	PlacemakingAI [83]	Facilitates collaborative visual ideation for urban design and community placemaking.	**Collaboration** – participants use an online interface during workshops to generate and discuss AI-created images of public space scenarios.	AI-generated images, discussion notes, polls.	Feedback.
	Laneform [61]	Assists in reimagining street designs through AI-generated visuals for participatory discussion.	**Involvement and collaboration** – practitioners or citizens create AI-generated street images and provide comments, reactions, or votes on proposed layouts.	AI-generated renderings, text feedback, reaction stickers, voting polls.	Feedback.